Exploring the interaction of coping strategies and executive functioning on emotional outcomes in clinical and non-clinical populations

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Thesis submitted in partial fulfillment of the degree of Doctor of Clinical Psychology

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Student number: 100187974

Date of submission: 2nd March 2020

Word Count: 38, 227 (excluding appendices)

Thesis abstract

Context: The existing literature indicates executive functioning (EF) deficits are related to a range of coping strategies, which in turn have been related to emotion regulation (ER) difficulties. However, less is known about the specific interactions between these constructs with attempts made to integrate theoretical models of EF or ER for neurological conditions.

Aim: The broad aim of this portfolio is to explore ways specific EF domains interact with coping strategies in predicting ER difficulties. This will further inform existing clinical models of adjustment difficulties following Acquired Brain Injury (ABI) and Multiple Sclerosis (MS). Two papers are presented: a systematic review which explores relationships between EFs and mood outcomes via coping styles, and a quantitative study which explored interactional effects between aspects of dispositional mindfulness and EFs on ER difficulties.

Results: Findings from the systematic review provide support for a range of adaptive coping strategies mediating and moderating relationships between specific EFs and mood outcomes for Multiple Sclerosis. The evidence for ABI is mixed and inconclusive, possible due to heterogeneity in brain injury samples whose patterns of cognitive issues could for some be protective but for others be problematic for ER. Findings from the empirical paper indicate some specific EF abilities related to cognitive flexibility may play a role in ER, and therefore may be of clinical relevance to clinical populations.

Conclusions: The findings of this portfolio indicate potential positive implications for adaptive coping strategies when accounting for EF deficits, alongside findings of cognitive flexibility being associated with specific aspects of mindfulness and ER. However, further research is needed to verify and replicate those findings with better quality study designs and clinical populations where EF difficulties are apparent. Only by addressing these areas of future research can clinical recommendations regarding specific coping strategies be made for EF difficulties.

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Acknowledgements

I would like to thank my supervisors, Dr Fergus Gracey and Dr Naoko Kishita for their invaluable knowledge and support throughout the whole process. It has been a privilege to work alongside you both, and the commitment and contributions you make to your respective fields is inspirational. I also want to acknowledge the support and help received from my colleague Wiki Tay who sadly passed away. You will be missed, but forever remembered.

I would also like to acknowledge my family and wife Daisy for "holding the fort" in the last few years. There have been some incredibly tough moments, and without your support I wouldn't be at this stage of training. To my parents, your unwavering belief and emotional support has helped me more than you can ever know. Thank you for all your help with looking after Scarlett and efforts to make things more manageable for me.

Lastly, this thesis is dedicated to my daughter, Scarlett, who reminds each day the importance of having fun and remaining curious. Thank you, I'm incredibly proud of you.

Chapter 1: Introduction to Thesis

Chapter Overview

This chapter provides a general overview of the thesis portfolio and introduces the rationale behind it.

Word count: 3479

1.1. Overview of portfolio chapters

The thesis portfolio consists of two main papers: a systematic review and empirical paper, both exploring the contribution and interaction of executive functioning (EF) and forms of adaptive and maladaptive coping strategies on emotional difficulties and outcomes. There is a bridging chapter and critical evaluation chapter which aims to synthesise findings from both studies.

The central thread of the portfolio is understanding how specific EF domains interact with cognitive and behavioural strategies in predicting emotional regulation (ER) difficulties and outcomes. Thus, exploring mechanisms rather than correlations was a key objective for both main papers. This is important as it will give a clearer insight into what works for who and why, furthering enhancing pre-existing models which integrate cognitive and emotional factors that guide clinical practice. This is pertinent particularly in the context of people with a cognitive impairment and the struggle to adapt emotionally following an Acquired Brain Injury (ABI) or progressive neurological conditions such as Multiple Sclerosis (MS).

Given the constructs discussed in this paper are broad and somewhat overlap, it is important to discuss the theoretical basis from which both main papers will be informed by when considering the evidence and drawing conclusions.

1.2. Conceptualising Executive Functioning

A common problem within existing research is how EF is defined and measured accurately. Luria's (1995) conception of the role of frontal lobes was based on a hierarchical model, in which frontal lobes served an overarching function above all other domains of cognition for the programming and verification of behaviour. Other conceptions of EF described it as a central control process within short-term memory involved with the regulation of information. The idea of cognitive processes being controlled by a central construct known as the 'central executive' was expanded upon with the working memory model (Baddeley, 1986). Wilson & Baddeley (1988)

introduced the term ‘dysexecutive syndrome’ to account for wide ranging impairments in regulating behaviour, a finding regularly observed in patients with frontal lobe damage. The supervisory attentional system (SAS) model of EF attempts to account for failures in goal-directed behaviour in novel and complex tasks in everyday life for people with frontal damage. The model is built on the premise that much of our behaviour is relatively automatic, not requiring control by the ‘supervisory system’. This system however is required in situations when novel circumstances present themselves which involve the management of potentially multiple competing sub-goals (Shallice & Burgess, 1991). It is generally agreed EF reflects the activity of brain circuits (namely frontal lobes) that prioritise and integrate cognitive capacities (Lezak, 1995).

Contemporary accounts have moved away from viewing EFs as an unitary construct synonymous with frontal functions. Stuss (2011) postulate no unitary executive control mechanism and that EF processes expand beyond frontal functions comprising of cognitive, meta-cognitive and social-emotional across domains acting together to establish control. Other models argue along similar lines in terms of fractioning EF into specific but overlapping domains, such as the unity/diversity model (Miyake et al., 2000) which focuses on three core aspects of EF :1) updating working memory, 2) inhibiting, 3) shifting. Research has found the three factors to be somewhat separable, even though they moderately correlate with another (Friedman, Miyake, Robinson, & Hewitt, 2011). Other models have made further distinctions between EF processes. According to (Diamond, 2013) EFs can be divided into ‘core’ EFs (inhibitory control, working memory and cognitive flexibility) and ‘higher-level’ EFs (reasoning, planning and problem-solving) all involved in maintaining goal based behaviour requiring supervisory attentional skills. Diamond (2013) states core working memory EFs and inhibitory control are interdependent processes which scaffold other EF processes. Inhibitory control refers to being able to control one’s attention, behaviour, thoughts and or emotions to override a strong internal predisposition to external distractions, and instead do what’s more appropriate or needed in the situation. Working memory refers to holding information in mind and mentally working with it (e.g. relating one thing to another, using information to solve a problem). The third core EF, cognitive flexibility, is thought

to build on the other two and comes in much later development (Davidson, Amso, Anderson, & Diamond, 2006). Cognitive flexibility can be viewed as synonymous with aspects of 'shifting' in terms of being flexible to adjust to changing demands, forming a new approach or different perspective. According to Diamond core EFs then provide further scaffolding for higher EFs such as planning, problem-solving, decision making and multitasking (Collins & Koechlin, 2012; Lunt et al., 2012). We are particularly interested in specific EFs and in both main papers, we refer to EFs as core and higher EFs in line with Diamond throughout the portfolio.

1.3. Models of coping

One proposed mechanism in explaining the relationship between EF and emotional outcomes is the role coping styles play as a mediator and moderating factor. A prominent model postulates coping involves a range of thoughts and behaviours a person uses to manage both internal and external stressors and is initiated when the person feels important goals have been threatened, harmed or lost, in an attempt to restore balance (Folkman & Moskowitz, 2004; Lazarus & Folkman, 1987). Lazarus and Folkman developed the stress, coping and appraisal model as a conceptual framework, and it remains a prominent theory. According to Lazarus and Folkman, coping begins with a cognitive process of primary and secondary stress appraisal. Primary appraisal is concerned with evaluating threat, challenge, harm or potential benefit, whereas secondary appraisal involves evaluation of solutions available and perceived resources to improve the stressful situation. They refer to two main forms of coping. Firstly, problem-focused coping, which is a practical behavioural response to finding solutions to a stressful situation when a person has more control over the outcome. Secondly, emotion-focused coping, which involves regulating the emotions associated with the stressor, and are more often used when a person perceives themselves unable to change the situation. The model views coping as a mediator of emotions (Folkman & Lazarus, 1988) and behavioural coping is often either defined as adaptive or maladaptive.

Other cognitive models of adjustment following major life events (Park, 2010) focus on life events that challenge closely held beliefs about personal safety or the

goodness of the world, which may provoke prolonged attempts to explore the meaning of one's experience or fit the stressful event into one's life narrative. Other models refer to avoidant coping, whereby a person engages in activities and cognitive processes (e.g. distraction, avoidance) with the sole aim of avoiding the situation of stress (Endler & Parker, 1990). Other adaptive coping strategies refer to efforts to adapt to the stressor itself, via acceptance or positive reappraisal (Compas, Jaser, Dunn, & Rodriguez, 2012). Acceptance and positive reappraisal have led to a focus on aspects of meaning in relation to efforts to cope with unwanted life events or aversive life conditions (Park & Folkman, 1997).

1.4. Evidence of Emotional Distress and EF

Studies have shown impairments in EF are associated with many forms of emotional distress. At a process level, EF has been found to correlate with rumination in clinical populations (Demeyer, De Lissnyder, Koster, & De Raedt, 2012), worry (Snyder et al., 2014) and poor use of adaptive emotional regulation (ER) strategies in non-clinical populations (McRae, Jacobs, Ray, John, & Gross, 2012). Research also indicates poor EF might influence attentional bias toward threat in anxious individuals, which in turn is involved in the maintenance of anxiety (Heeren, De Raedt, Koster, & Philippot, 2013). This indicates EF is an important process to consider given its overarching influence on behaviour (Hofmann, Schmeichel, & Baddeley, 2012) and how it might influence the relationship between adaptive coping strategies (including mindfulness) and emotional outcomes.

1.5. Coping in Acquired Brain Injury and Multiple Sclerosis

Given people with ABI and MS are known to have challenges adjusting to a major life event (e.g. stressor), stress coping appraisal models proposed by Lazarus & Folkman (1987) have been applied as a general model for post injury adaptation in ABI and MS. Despite variability in findings, the current literature reflects stronger support for coping styles that reflect a task or problem-orientated approach as more adaptive, whereas emotion-focused approaches such as avoidance, wishful thinking and worry are less adaptive (Anson & Ponsford, 2006; Brands, Bol, Stapert, Köhler, & van Heugten,

2018) for both groups. People with ABI or MS also have acquired impairments in cognition which has been found to impact their ability to cope with and manage those stressors in the emotional adjustment required post injury. It has been hypothesised there may be interactions between type and severity of EF difficulties, coping styles and emotional outcomes following ABI (Gracey, Evans, & Malley, 2009) and MS (Grech et al., 2016).

1.6. Process models of Emotional Regulation

Like cognitive processes such as EF and coping, ER is thought to involve both self-monitoring and executive components (Larsen & Prizmic, 2004). Therefore, conceptually EFs and successful ER overlap, as both can be construed as forms of goal-directed regulatory activity in changing environments (Ochsner, Silvers, & Buhle, 2012), therefore, adaptive ER requires high levels of cognitive processes (McRae et al., 2012). Similar brain regions in both cognitive and emotional control are implicated (Ochsner & Gross, 2008). Research has found increased activity in either the anterior cingulate cortex (ACC) or dorsolateral prefrontal cortex (DLPFC), or both during situations in which emotions are regulated through top-down control (Goldin, McRae, Ramel, & Gross, 2008).

In understanding how EF and coping potentially interact for neurological conditions we have to draw on our best understanding of EF processes and how they might be implicated in regulation of emotion, or at the number of different stages of appraisal for people who have the stressor to deal with and the adjustment. A number of models have been proposed, including Ochsner's (Ochsner & Gross, 2008; Ochsner & Gross, 2005) cognitive neuroscience model of ER which suggests cognitive strategies vary in their reliance on prefrontal and cingulate systems. Their model posits a sequence of regulatory processes including initial emotional reactivity, attention orientation to the emotional stimulus, management of emotional material into working memory and the use of supervisory attentional processes for higher skills such as problem-solving. Ochsner and colleagues indicate cognitive strategies such as verbal labelling and reappraisal

appear to reduce activity in the amygdala and insula emotional response areas. Goldin et al. (2008) found that ER strategies via suppression result in increased insula activity.

Pruessner, Barnow, Holt, Joormann, & Schulze (2020) propose a different account of ER via understanding three key components of EF which is analogous to Miyake et al (2000) unity/diversity model. Firstly, strategy stopping or switching which relies on 'shifting' EF processes to either initiate a new ER strategy or discontinue and switch to another action (Hofmann et al., 2012). Secondly, maintenance ER strategies which entails sustained attention to the task as well as shifting goal directed behaviour from internal and external distractions (Miyake et al., 2000). Maintenance requires working memory EF processes to continually update the ongoing strategy and shielding from distraction which is consistent with Diamond's (2013) stance of working memory and inhibition being interdependent processes. Lastly, monitoring involves updating working memory processes when discrepancies are detected between ongoing regulatory processes and changing contextual demands (Ochsner & Gross, 2005), which requires higher order EF processes such as decision making and problem-solving (Diamond, 2013).

Both models postulate a sequence of self-regulatory processes which are reliant on core EFs (inhibition, working memory) supporting further core (cognitive flexibility) and higher order EFs (monitoring, problem-solving) down the line with successful reappraisal adaptive coping strategies. It stands to reason that cognitive difficulties in those implicated areas will impact on selection of adaptive strategies (McRae et al., 2012) and emotional outcomes.

These hypothesised models have been explored in clinical populations with emotional difficulties, as well as the general population. Andreotti et al. (2013) found stronger working memory supported use of cognitive reappraisal and secondary coping which in turn were influential in regulating both positive and negative emotion. Schmeichel, Volokhov, & Demaree, (2008) also found working memory capacity was important for cognitive reappraisal, but also expressive suppression which involves

regulating emotion after an emotion has been triggered. Another study with non-clinical participants found those who performed better on a Stroop task displayed a greater tendency to use task-orientated coping and had lower stress responses (Compton et al., 2011). Other dimensions of EF such as cognitive flexibility have been shown to be negatively related to both anxiety and depression (Kashdan & Rottenberg, 2010). Gyurak et al. (2009) found 'higher' EF in the form of verbal fluency was associated with reduced signs (i.e. able to inhibit) of emotional behaviour (instructed and spontaneous) in response to an aversive stimulus in their experiment when comparing a sample of frontotemporal lobar degeneration patients, Alzheimer's disease and healthy controls.

This suggests the effects of interaction between EF and coping on emotional outcomes may vary across healthy and clinical groups where cognitive impairments are present. It also suggests verbal down-regulation of affect relies on core EFs. This implies adaptive coping strategies are highly reliant on people's cognitive abilities (including EFs).

Salas, Gross, & Turnbull (2014) proposed a two-stage reappraisal model based on their work in understanding ER post brain injury. In the first stage, inhibition is required to disengage from the automatic negative meaning. If inhibition is successful, alternative interpretations can be generated and this is moderated by verbal fluency. The second stage is concerned with reappraisal maintenance. Working memory ability has a role in keeping in mind the recently generated new interpretation, thus shielding it from the initial meaning that is still the focus of attention (Gross, 2013). Thus Salas et al. (2014) view inhibition and verbal fluency as critical initial internal reappraisal strategies, where working memory is important in later stages of the reappraisal process. This is also consistent with the implementation maintenance model of reappraisal (Kalisch, 2009) where choice and implementation (inhibition) work interdependently with components of maintaining and monitoring (core working memory) a reappraisal strategies success.

It stands to reason if an individual has difficulties with core EFs such as inhibition and working memory, subsequent efforts to reappraise cannot be accessed as a result.

Salas, Vaughan, Shanker, & Turnbull (2013) found inhibition difficulties resulted in concrete thinking (cognitive inflexibility) making it difficult to spontaneously generate reappraisals. Salas et al. (2014) suggest people with brain injury can use reappraisal strategies with adaptations considered in the context of time (e.g. longer to generate alternatives) and use of prompts from systems around the individual (Bowen, Yeates, & Palmer, 2018) which facilitate disengagement from negative stimuli and capacity to generate possible reinterpretations.

Given the difficulties neurological populations have with acquired EF difficulties and making use of reappraisal ER strategies, this has seen an interest in mindfulness-based interventions (MBIs) being integrated into neurorehabilitation contexts for brain injury (Ownsworth et al., 2015) and MS (Pakenham & Fleming, 2011) with good effect.

1.7. Mindfulness-based interventions

There is emerging evidence for MBIs being effective in improving core inhibition and working memory EF processes in the general population (Chiesa, Calati, & Serretti, 2011; Gallant, 2016). Therefore, there is a growing interest in MBIs and applications in neurological populations. Emerging evidence suggests mindfulness-based cognitive therapy (MBCT) is efficacious in treating depression after TBI (Bédard et al., 2014) and acceptance and commitment therapy (ACT) beneficial to people with TBI with EF difficulties (Whiting, Deane, Simpson, McLeod, & Ciarrochi, 2017). A systematic review including those therapies and other 'third-wave' CBT approaches found promising findings in addressing transdiagnostic difficulties for neurological conditions, including MS and ABI (Robinson, Russell, & Dysch, 2019).

What is less clear is the mechanisms explaining how mindfulness works, but some models have been proposed to account for the effects of mindfulness on ER. For example, Chambers, Gullone, & Allen (2009) propose the importance of how a person relates to their thoughts, rather than how they appraise their thoughts as key for effective ER. Other models postulate mindfulness operates via a reappraisal strategy (acceptance) for emotion (Webb, Miles, & Sheeran, 2012) or as a positive reappraisal of contexts

(Garland, Gaylord, & Fredrickson, 2011). These differing models provide some explanations for mechanisms involved between mindfulness and ER, however, pay little attention to cognitive processes, namely EF and how individual differences in this domain might impact one's ability to be mindful and/or regulate emotion.

The introduction of MBIs is somewhat antithetical to antecedent reappraisal ER strategies (Ochsner & Gross, 2008), in that mindfulness emphasises increased awareness and acceptance of all cognitive and emotional experience regardless of its apparent valence and intensity (Chambers et al., 2009). This highlights the different theoretical underpinnings taken by cognitive interventions such as CBT which seek to alter cognitive and emotional content (e.g. antecedent), which are more aligned to the Lazarus and Folkman model of coping, and mindfulness/acceptance based approaches often referred to as 'third-wave' CBT which are 'response-focused', stressing meta-competencies (relationship taken with one's experience is important, not the experience itself). Thus, 'antecedent processes' promote reflective action (problem solving, cognitive restructuring) and 'response processes' promote learning to accept rather than alter experience (Chambers et al., 2009).

While both reappraisal and mindful ER are likely to share common cognitive features as suggested by process models (Ochsner & Gross, 2008), it has been argued mindful ER is distinctive from reappraisal as it; (1) does not require interpretation into memory or cognitive elaboration; (2) experiences are not judged as good or bad, something to be solved or altered (Farb, Anderson, & Segal, 2012). This suggests core EFs such as cognitive flexibility and higher EFs such as verbal fluency and problem-solving are of less importance in mindful ER compared to reappraisal strategies. It could be MBIs are a more acceptable and efficacious treatment for individuals with such cognitive difficulties given less demand is placed on cognitive resources for ER. However, it has also been argued that mindfulness is still a reappraisal strategy for people new to mindfulness, requiring the use of active cognitive control to overcome habitual ways of responding (Hölzel et al., 2011).

Given the growing application of MBIs to neurological populations, we want to explore how mindfulness traits interact with cognitive processes. Is it a cognitive intervention with emotional benefits, or vice-versa? This poses questions around whether it can work for someone who is cognitively impaired. At present, these questions are largely unanswered, and we can't begin to answer them without understanding the possible causative mechanisms.

1.8. Rationale for systematic review and empirical paper

Given EF deficits have been related to a range of adaptive coping strategies (problem solving, cognitive restructuring and mindfulness) and maladaptive coping (emotion focused and avoidant) strategies, which in turn have been related to ER difficulties and emotional outcomes - this suggests possible interactional effects between cognition and coping strategies on mood. The current portfolio seeks to add to the developing evidence on the mechanisms by which interventions for cognitive and emotional difficulties might work. It is concerned with a more detailed account of the role specific EF processes play and how these relate to adaptive strategies in accounting for emotional outcomes. It is hoped that improved understanding of these mechanisms in cognitive neuropsychological terms could provide the basis for refining interventions, particularly for those who have acquired deficits in EF and related emotional difficulties.

The first chapter is a systematic review which aims to explore the mediating and moderating role of coping between EF impairments and emotional outcomes for adults following a diagnosis of ABI or MS. Emerging studies have started to explore the contribution of EF impairments as a 'predictor' and coping as a 'mediator' in predicting emotional outcomes following ABI. However, studies exploring associations between coping and EF have yielded mixed and inconclusive findings to date. In part, this appears to be related to how the existing literature defines and measures aspects of EF, but also the extent to which EF is involved in ER, and if so, what processes of EF are involved in certain processes of ER. A bridging chapter will connect the two main chapters.

The third chapter is an empirical paper which attempts to establish the specific facets of mindfulness, EF and ER that are related, and what the causal nature of these relationships could be. There is evidence in healthy populations that mindfulness could enhance core EFs involved in inhibition and working memory (including sustained and selective attention) (Chiesa et al., 2011). Evidence of associations between mindfulness and cognitive flexibility is less conclusive. Research has found higher shifting ability associated with less rumination and use of adaptive ER strategies of reappraisal (Hendricks & Buchanan, 2016). Others have found no relationship between the effective use of reappraisal and shifting (Malooly, Genet, & Siemer, 2013). If reappraisal relies on the flexible use of thinking (Ochsner & Gross, 2005) then it is likely people with cognitive flexibility difficulties may struggle to modulate how they feel (Salas et al, 2014). Thus, this paper was interested in the role cognitive flexibility plays in mediating the hypothesised relationship between specific mindfulness traits and ER.

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Chapter 2: Systematic Review

The contribution of coping styles and executive functioning in explaining emotional outcomes for people following acquired brain injury and multiple sclerosis: a systematic review

Systematic review prepared for submission to: Neuropsychological Rehabilitation

Word Count: 9,970

The contribution of coping styles and executive functioning in explaining emotional outcomes for people following acquired brain injury and multiple sclerosis: a systematic review

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Abstract

Objectives: The aim of this review was to critically evaluate the existing literature investigating the interplay of specific executive functioning (EF) domains and coping strategies on emotional outcomes following adjustment to Acquired Brain Injury (ABI) or Multiple Sclerosis (MS).

Methods: Five databases were searched using keywords for articles published up until September 2019. Cross-sectional and longitudinal studies assessing the interplay between EF and coping on emotional outcomes in people with ABI or MS were included. A narrative synthesis approach using PRISMA guidelines was taken due to heterogeneity across populations and study methodologies.

Results: Searches yielded seven studies in line with eligibility criteria. The strongest evidence related to adaptive coping strategies moderating the relationship between weaker core and higher EFs and depression in MS. Specific coping strategies of acceptance and growth were also found to moderate and mediate the relationship between core and higher EFs and emotional outcomes in MS, but more evidence is needed to replicate this finding. There was inconsistent evidence for interaction effects between core and higher EFs on mood outcomes for ABI.

Conclusions: Clinicians should consider the potential for EF difficulties being a barrier for people benefitting from coping interventions which vary in cognitive abilities required. For MS, it appears adaptive coping strategies can be selected in line with an individual's EF ability to improve emotional outcomes. The picture is less clear for ABI given the heterogeneity found in ABI, measures used and small number of studies, additionally, variability in findings which suggest both positive and negative effects of cognition on mood and coping. Formulation driven approaches are needed to understand what works for whom and why.

International Prospective Register of Systematic Reviews (PROSPERO) registration number: CRD42019138521

Keywords: acquired brain injury, multiple sclerosis, coping, executive functioning, rehabilitation

1. Introduction

Acquired Brain Injury (ABI) is a leading cause of death and disability in the UK with an estimated 1.3 million living with TBI related injuries in 2017, accounting for 10% of the National Health Services (NHS) annual budget (All-Party Parliamentary Group on Acquired Brain Injury, 2018). During 2016-17 there were 132,199 admissions for stroke, an increase of 10% since 2005-6 (Headway, 2017). Likewise, each year over 3 million individuals experience an ABI in the USA, also considered one of the leading causes of death and disability. ABI is caused by either traumatic brain injury (TBI) (e.g. head trauma from accidents) or causes related to conditions such as encephalitis, stroke, meningitis, hypoxia, anoxia, tumour or hemorrhage (Mozaffarian et al., 2016). Multiple Sclerosis (MS) is a chronic inflammatory disease which can also have a sudden onset and degenerative progression, characterised by central nervous system lesions often resulting in cognitive and physical difficulties (Kidd et al., 2017). Estimates suggest around 100,000 people are living with MS in the UK, and 5,000 people are newly diagnosed each year with the condition (MS Society, 2016). Global estimates increased from 2.1 million in 2008 to 2.3 million in 2013 (The Multiple Sclerosis International Federation, 2013).

People with an ABI often experience damage to prefrontal circuits in the brain, resulting in executive functioning (EF) impairments, which impacts an individual's ability to adapt behaviour to their changing circumstances (Stuss, 2011). EF refers to top-down cognitive processes associated with the prefrontal cortex and goal directed behaviour (Friedman & Miyake, 2017). There is a suggestion EF can be divided into 'core' EFs, such as inhibitory control, working memory and cognitive flexibility, and 'higher-level' EFs (including reasoning, planning and problem-solving) all involved in maintaining goal based behaviour requiring supervisory attentional skills (Diamond, 2013). Hofmann et al (2012) postulated core EFs are the underlying conceptual

mechanism in successful self-regulatory goal pursuits. In line with this model, well-preserved EFs allow successful implementation of 'active' adaptive coping.

Cognitive and especially frontal or executive problems are common and may contribute to the elevated levels of emotional problems in these clinical groups. EF impairments following an ABI are associated with a range of poorer outcomes in social (Hanks, Rapport, Millis, & Deshpande, 1999) and functional (Spitz, Ponsford, Rudzki, & Maller, 2012) domains of life. Individuals are typically at heightened risk of developing emotional disorders due to the emotional adjustment required and change to life circumstances caused by the injury (Williams & Evans, 2003). Similarly, people with MS often report cognitive and emotional difficulties. One study reported 91% of their sample had deficits of at least one domain of cognition with the majority exhibiting EF impairments (Drew, Tippett, Starkey, & Isler, 2008). An epidemiological study exploring mental health conditions in MS found a lifetime prevalence of depression as high as 24%, and anxiety disorders as high as 21.9% (Marrie et al., 2015).

1.1.The role of coping in adjustment to ABI and MS

The role specific styles of coping play in adapting to ABI has gained increasing attention during recent years because of the evidence certain coping styles can facilitate or impede emotional adjustment during times of stress **(**Gracey et al., 2015). The effectiveness of coping styles is context-specific, however following ABI an increased use of emotion and avoidant focused coping at the expense of problem-solving coping has been associated with higher levels of emotional distress (anxiety, depression, apathy and post-traumatic stress) and lower levels of self-esteem and psychosocial functioning (Anson & Ponsford, 2006; Bryant, Marosszeky, Crooks, Baguley, & Gurka, 2000; Finset & Andersson, 2000; Riley, Dennis, & Powell, 2010; Spitz, Schönberger, & Ponsford, 2013). Research shows increased use of problem-solving coping and decreased use of emotion-focused and avoidant coping (e.g. maladaptive coping) is considered adaptive for people adjusting to mild-severe brain injury, resulting in improvements in

psychosocial factors, such as employment and quality of life (Anson & Ponsford, 2006; Maestas et al., 2014; Tomberg, Toomela, Pulver, & Tikk, 2005).

Similarly, people with MS are found to use significantly more avoidant and emotional coping strategies compared to problem-focused coping (Goretti et al., 2009; McCabe & Di Battista, 2004). Use of maladaptive coping is related to higher levels of depression and psychological distress (Aikens, Fischer, Namey, & Rudick, 1997) and adaptive coping is related to improved quality of life longer-term (McCabe, 2006). Brands et al. (2018) found greater use of emotional focused coping being associated with poorer psychosocial and emotional adjustment for both populations.

1.2. EF impairments and emotional outcomes

Another proposed factor in explaining psychological distress following ABI or MS has been EFs as they are considered to underpin emotional self-regulatory mechanisms (Eisenberg & Zhou, 2015). Ochsner's process model of emotional regulation (ER) (Ochsner & Gross, 2008) attempts to integrate such findings to explain which specific cognitive processes are involved in various aspects of ER given coping styles vary in their reliance on prefrontal and cingulate systems. Their model posits a sequence of regulatory processes including initial emotional reactivity, attention orientation to the emotional stimulus, management of emotional material into working memory and the use of supervisory attentional processes for higher skills such as problem-solving for adaptive ER.

In non-neurological populations with mental health difficulties, research suggests impairments in EF such as inhibition, shifting and verbal fluency are important vulnerability factors for depression (Joormann & D'Avanzato, 2010; Synder, 2013). Adaptive ER strategies such as cognitive reappraisal, acceptance and problem solving reduce negative effect and exert protective effects of mental health difficulties (Aldao & Nolen-Hoeksema, 2010; Gross & John, 2003). Maladaptive ER strategies such as rumination, avoidance and suppression are considered less effective in reducing negative emotion in the long-term, and are linked to a range of mental health conditions (John &

Gross, 2004). Research in neurological conditions exploring process models to understand interactions between coping and cognitive difficulties is lacking, but (Salas et al (2013) found inhibition difficulties resulted in concrete thinking (cognitive inflexibility) making it difficult to spontaneously generate reappraisals.

This suggests that applied in neurological conditions such as ABI and MS, it could be specific impairments of both core and higher EFs might impact emotional outcomes, such as depression and anxiety by interfering with specific coping processes. Given executive impairments are commonly reported by people with ABI (Kennedy et al., 2008) and MS (Pepping, Brunings, & Goldberg, 2013), research has begun to explore the direct and indirect effects it has on emotional outcomes across both populations.

Given the number of studies that have examined EF, coping and emotional outcomes in both ABI/MS, and underlying executive deficits and coping styles are common across both conditions, a SR of the evidence would be helpful in guiding future research and clinical practice. This is important in contributing to theory and transdiagnostic models which integrate cognitive and emotional aspects of recovery following a diagnosis of ABI or MS.

1.3. Review aims

This review aimed to answer the following questions: Firstly, what is the evidence for direct relationships between EFs, coping and depression and/or anxiety. Secondly, the mediating and moderating effects of specific coping styles on the relationships between specific EFs and outcomes of depression and anxiety.

2. Methods

2.1. Protocol and registration

This SR was pre-registered on PROSPERO, the international prospective register of systematic reviews (PROSPERO 2019 CRD42019138521). The review was reported

according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement (Moher, Liberati & Tetzlaff , 2009).

2.2. Eligibility criteria

Eligibility criteria for inclusion are outlined using PICOS (participants, interventions, comparisons, outcomes, and study design), as recommended by The PRISMA Statement (Moher et al., 2009). As the studies in this SR are observational, 'interventions' and 'comparisons' are renamed 'interest' variables.

Studies were included if they fulfilled the following criteria:

- Population: Adult sample over the age of 18 that has experienced an ABI and/or MS.
- Interest: Eligible studies must include a valid measure of executive functioning (neuropsychological assessment or self-report) and coping.
- Comparison: Not applicable to this review.
- Emotional Outcomes: Initial searches were left open for screening stage. Eligible studies were checked at later stage when reviewing abstract and full-text articles where studies must include a valid measure of emotional outcomes.
- Eligible studies must be a peer reviewed journal article written in English
- Quantitative studies or studies with mixed methods design from which quantitative data can be obtained.

2.3. Information sources

A systematic search for studies was conducted in five electronic databases: MEDLINE, CINAHL, Psychinfo, Web of Science and Scopus. To identify additional studies, Google Scholar was searched. Reference lists from published reviews and obtained papers were checked.

2.4. Search strategy

An initial search was performed in October 2018 which was refreshed in September 2019. Please refer to Appendix A for detailed syntax search strategy for MEDLINE. Searches were performed using the following keywords and constructed around the PICO framework (Aslam & Emmanuel, 2010).

- For **population**: brain injury, brain damage, stroke, cerebrovascular accident, acquired brain injury, traumatic brain injury, encephalitis, multiple sclerosis, subarachnoid haemorrhage , and neurodisability.
- For **interest** variable coping: coping, coping skills, coping mechanisms, coping strategies and appraisals.
- For **interest** variable executive functioning: cognition, cognitive impairment, executive functioning, executive functions, executive processes, attention, inhibition, working memory, switching, problem-solving, decision-making and planning. For this review, we will use distinction made by (Diamond, 2013) in assigning EF tasks to either 'core EF' or 'higher EF' from included papers to explore specific effects.
- For **comparator**: Not applicable for this review.
- For **outcome**: The aim was to review studies of emotional outcomes including depression or anxiety. Studies were included which had at least one valid measure of either anxiety or depression.

2.5. Data extraction process

Data extraction was completed based on the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidance (Von Elm et al., 2007). STROBE outlines key information for reporting observational studies for completeness and accuracy. Key details included were the authors, origin of study, study aims and hypotheses, diagnoses (subtypes), measures, significant findings in relation to SR objectives and overall quality rating. Due to the lack of homogeneity in EF measures and population of interest, alongside a relatively small numbers of papers included for the review, a meta-analysis was not deemed appropriate. Instead, the results of the 7 included studies were interpreted in reference to guidelines on narrative synthesis (Popay et al.,

2006). Key findings were summarised in the context of methodological quality and strength of the evidence to answer the review's question.

2.6. Assessment of Methodological Quality

All articles included in the review were critically appraised in accordance with their methodological strengths and weaknesses using the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies (QATOCCS; National Heart, Lung and Blood Institute, NHLBI, 2014). See Appendix B. This was done after data extraction to minimise biases of selection for the review. This critical appraisal tool was selected based on its application to quantitative study designs, such as observational studies. The study's quality is based on the following domains; research question, study design, selection bias, blinding, confounders, methods of data collection, statistical analysis, drop-outs and withdrawals. The quality of each study is rated against 14 questions, for which the rater responds with yes, 'no', 'CD' (cannot determine), 'NA' (not applicable) or 'NR' (not reported) for each question. Items 6 and 7 relate to cohort study designs as they look at time effects, therefore they will be automatically answered 'no' for cross-sectional designs included in the review. The QATOCCS contains guidance when assessing quality against each item and allows the rater to summarise and critically appraise the studies, arriving at an overall rating of either 'good', 'fair' or 'poor'. The guidance indicates quality ratings should not be informed by a tally of responses rather the magnitude of potential biases needs to be considered when appraising quality. Therefore, ratings and issues of quality are discussed in relation to the interpretation of data. To improve rigour in the process, a random selection of included papers were independently assessed by a second reviewer (Trainee Clinical Psychologist with knowledge of the tool and topic area). Any disagreements were then discussed and resolved.

3. Results

3.1. Study selection

Figure 1 presents the PRISMA chart displaying the process by which the final selection of articles was identified. Initial electronic searches yielded 1786 articles with limits of peer-reviewed and English language applied. After removing duplicates, this left 1491 articles, in which one author (PG) initially screened titles and abstracts for initial eligibility and excluded those that clearly did not meet the inclusion criteria. One author (PG) reviewed all remaining 25 full-text articles for eligibility against the inclusion and exclusion criteria. The selection process was reviewed with a random selection of 12 papers by one of the team (WT) for eligibility. Differences were discussed and resolved, and final 7 papers thus confirmed for inclusion in the full review. 4 articles were second quality rated by one member of the team (WT), disagreements discussed and resolved consensually.

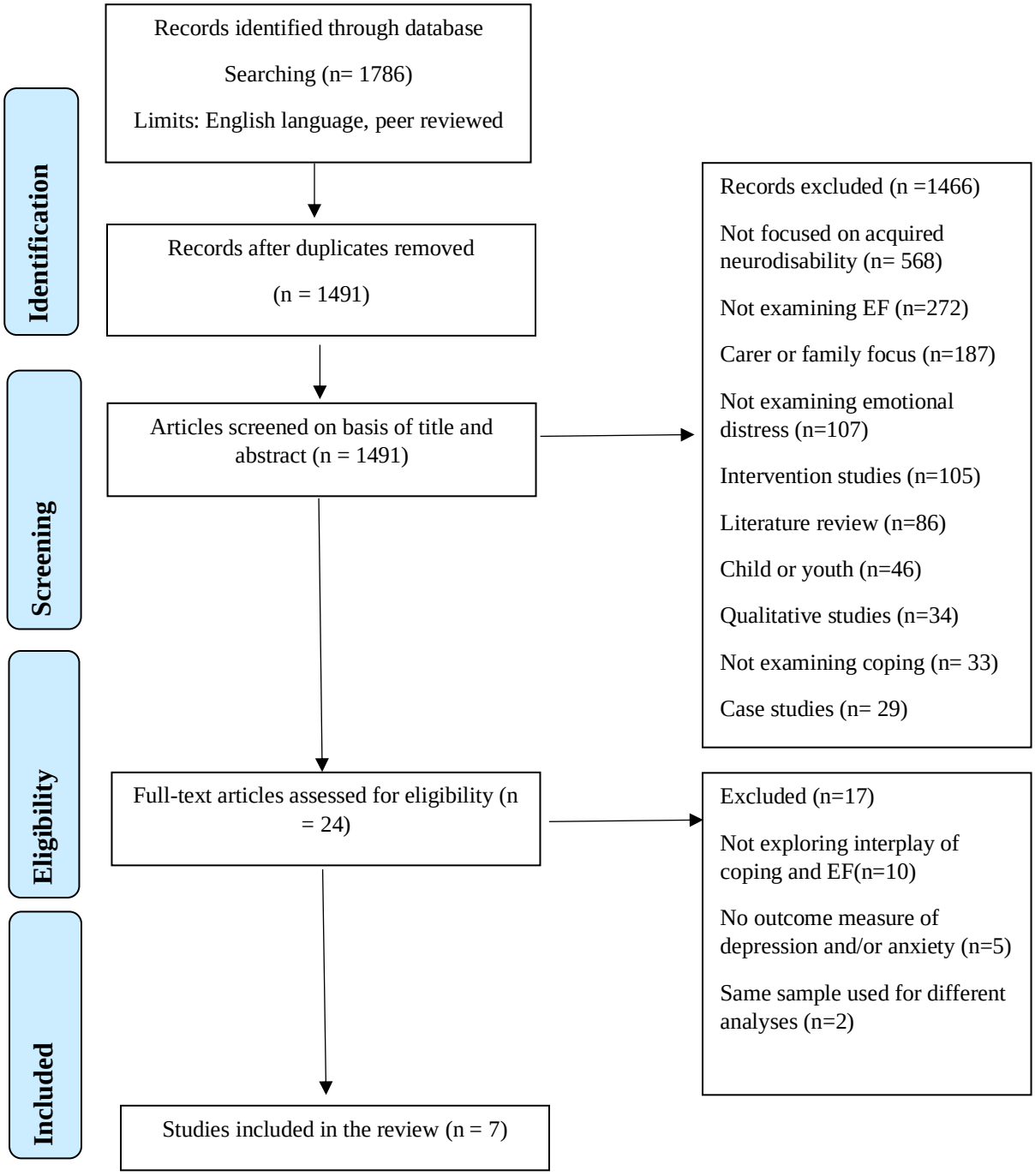

Figure 1. PRISMA flow diagram detailing processes of papers selected for review

3.2. Study characteristics

Study characteristics are explored to examine the study heterogeneity and how this might influence outcomes.

3.2.1. Participants

A total of 605 participants with ABI or MS were included with a mean age of 42.1(SD=11.7) years. 284 participants were diagnosed with MS with a mean age of 47.4(SD=9.3) years and 321 were diagnosed under the umbrella of ABI with a mean age of 37.4 (SD=13.8) years old. Relapsing-remitting MS, the most common subtype of MS, accounted for 66.2% of participants included in this review. The severity of TBI was classified with the post-traumatic amnesia (PTA) as defined by (Carroll, Cassidy, Holm, Kraus, & Coronado, 2004), indicating a total of 228 participants with the following injuries; severe TBI (n=154, 67.5%); moderate TBI (n=44, 19.3%); mild TBI (n=25,11%), not recorded (n=5,2.2%). For ABI (n=93, 29%) the most common causes of brain injury were traumatic (n=42,45%) and vascular (n=28,30%), but injury severity was not recorded (Wolters Gregõrio et al., 2015).

A strength identified across included studies was a clear description of the medical condition of participants, broken down by subtypes and cause of injury in the case of brain injury. However, little is known about their premorbid and current intelligence which potentially confounds associations observed.

3.2.2. Study Design

Five studies used cross-sectional single designs (Arnett, Higginson, Voss, Randolph, & Grandey, 2002; Grech et al., 2016; Spitz et al., 2013; Wolters Gregõrio et al., 2015; Wood & Rutterford, 2006), one a cross-sectional retrospective cohort design (Van Heugten, Köhler, Francke, & Bol, 2019) and one longitudinal single group design (Rabinowitz & Arnett, 2009).

One study collected data at more than one time point (Rabinowitz & Arnett, 2009) in a timeframe of 3 years. Despite strengths in utilising a longitudinal design, the sample size was not justified and was small (n=53). Therefore, hypotheses and analyses are likely underpowered meaning findings must be interpreted with caution given the increased probability of findings occurring by chance. Five studies (one of which was Rabinowitz & Arnett, 2009) explored coping as both a mediator and moderator of the relationship between EF and emotional outcomes, which added to the methodological strength when rating the quality of these studies. That is, if EF difficulties are a vulnerability factor this will affect the deployment of adaptive coping strategies which has a role in maintaining and causing, as well as moderating emotional distress.

The approach to understanding the interplay of EF and coping was broad in some studies. Three studies (Arnett et al., 2002; Rabinowitz & Arnett, 2009; van Heugten et al., 2019) combined cognitive tasks to form a single cognitive index. Although not flawed in design, this prevented extraction of data relating to the secondary review questions concerning which specific EF domains might interact with coping.

3.2.3. Interest variables of executive functioning and coping

Table 1 details measures of EF and coping utilised by each study. All included studies used more than one measure related to EF. Included studies used a comprehensive battery of various neuropsychological assessments which measure a variety of core and higher-level EFs as defined by Diamond (2013). This is a strength of all studies included. The most commonly administered measures pertaining to measure EF were Symbol Digits Modalities Test (SDMT) (4 studies), Trail Making Test (TMT) (4 studies), Paced Auditory Serial Addition Test (PASAT) (3 studies). Self-report measures of EF, including the Dysexecutive Questionnaire (DEX-P, DEX-I) and Frontal Systems Behavioural Scale (FrSBe) were used alongside cognitive tasks for two different studies. Other measures were used which capture general intellectual functioning in the main, such as subtests from the Wechsler Adult Intelligence Scale 4th edition (WAS-IV, 1981) - digit span, matrix reasoning, vocabulary, similarities, digit symbol and block design for two studies. These measures are not considered measures of EF primarily, but aspects of

the digit span (e.g. digits backward, sequencing) require core EF components, such as working memory. One study also used subtests from the Behavioural Assessment of the Dysexecutive Syndrome (BADS) (Wilson et al., 1996), a measure which is sensitive to 'higher' EFs, such as problem solving. This included zoo map, action programming and modified six elements.

In MS studies, van Heugten et al. (2019) used a range of core EF measures and one measure considered higher EF (as suggested by Shao, Janse, Visser, & Meyer, 2014), verbal fluency. Arnett studies included fewer measures, namely core EFs, but did include assessment of higher EF (planning). A strength of the ABI studies was exploring the effects of individual cognitive tasks on coping and mood. Unlike some of the MS studies, they did not compute scores into a single factor or variable of EF. This is advantageous, as it allows a closer inspection into which tests might produce specific effects in coping and mood. However, none included a sensitive measure of 'higher' EF. All studies had a good range of validated measures for core EFs, but others explored cognition more widely looking at other factors such as processing speed and memory. There was some commonality with TMT being used by all ABI studies, a measure considered to be sensitive to EF.

A key strength of the Grech et al. (2016) paper was a clear theoretical underpinning for the measures chosen and distinguishing measurement methods (e.g. cognitive/behavioural tasks versus self-report). This was further evidenced in the analysis plan, where separate cognitive indices were created, including distinguishing core and higher EFs. This allowed a more detailed examination of specific postulated EFs in terms of their interactions with specific coping strategies, and how this influences emotional distress. Thus, more in keeping with our SR questions.

Included studies used exclusion criteria around a diagnosis of learning disabilities (e.g. MS studies) and specific visual and motor difficulties which might confound performance on cognitive tasks. However only two studies explored the effects of premorbid (Arnett et al., 2002) and /or current levels of intellectual functioning (Wood &

Rutterford, 2006). Arnett and colleagues did this in their analysis whereas Wood & Rutterford computed different cognitive indices with performance on the WAIS, a measure of general intelligence. This means we do not know if any effects are EF specific or simply related to general intellectual functioning.

All studies used a self-report measure of coping styles. Four studies used Coping Orientation for Problem Experiences (COPE) (e.g. all MS studies), one (Wood & Rutterford, 2006) of which used the Brief-COPE version as recommended for moderate to severe TBI (Gregório, Brands, Stapert, Verhey, & Van Heugten, 2014). The COPE is routinely used for MS populations with some studies reporting good reliability (Aarstad, Lode, Larsen, Bru, & Aarstad, 2011). The Coping Inventory for Stressful Situations (CISS) and Utrecht Coping List (UCL) were used for ABI studies (van Heugten et al., 2019; Wolters Gregõrio et al., 2015), respectively. The psychometric properties of the CISS and UCL are considered valid for ABI populations (Brands, Köhler, Stapert, Wade, & van Heugten, 2014; Wolters et al., 2014). Spitz et al. (2013) used the Coping Scale for Adults (CSA) which is considered a valid measure in non-clinical populations (Frydenberg & Lewis, 2000), but no such data exist for ABI, but the shortened version is recommended for brain injury (Wolters et al., 2014).

3.2.4. Outcomes of interest

All studies measured depression with only three measuring anxiety. This suggests too few studies to draw firm conclusions in relation to anxiety outcomes. The most commonly used measure of depression was Beck's Depression Inventory (BDI-II), used in three studies. The BDI-II is shown to have psychometric properties in MS (Sacco et al., 2016) and TBI (Green, Felmingham, Baguley, Slewa-Younan, & Simpson, 2001). However single use of the BDI-II has been criticised for MS populations because of concerns around confounding somatic and physical symptoms (Brown et al., 2009). Two studies used the Chicago Multiscale Depression Inventory (CMDI) (Nyenhuis et al., 1995) alongside the BDI. The CMDI measure includes three subscales representing

different depression symptoms (vegetative, mood and evaluative), considered more sensitive for MS (Nyenhuis et al., 1998) with good psychometric properties (Chang et al., 2003). Three studies used the self-report Hospital Anxiety and Depression Scale (HADS) (Zigmond & Snaith, 1983), which contains both depression and anxiety subscales and is considered a valid screening tool for assessing depression in MS patients (Honarmand & Feinstein, 2009) and TBI populations (Dahm, Wong, & Ponsford, 2013).

Table 1. Summary of studies included in systematic review looking at interaction of coping and executive functioning on emotional outcomes

Authors Origin of study	Study aims and hypotheses (in relation to SR)	Sample Condition, type (%)	Executive functioning measure(s) Core and Higher EFs	Coping measure	Emotional distress measure(s)	Significant findings (in relation to SR)	QR
Arnett, Higginson, Voss, Randolph & Grandey (2002) USA	What is the relationship between coping, cognitive dysfunction and depression in multiple sclerosis? Hypothesis: Coping strategies would moderate relationship between cognitive dysfunction and depression in MS.	Multiple Sclerosis (MS), n = 55. Relapse-remitting n = 55, primary progressive n = 13, secondary progressive n = 29, progressive relapsing n =4.	**Core EFs** Reading span test (RST), Paced Auditory Serial Addition Test (PASAT), Symbol Digits Modalities Test (SDMT), Visual Elevator subtest from the Test of Everyday Attention (TEA) **Higher EFs** Planning - Tower of London (TOL)	Coping Orientation for problem experiences (COPE)	Beck's Depression Inventory (BDI), Chicago Multiscale Depression Inventory (CMDI)	**Study found support for moderating effects;** 1. Interaction of cognitive task index score and avoidant coping significantly accounted for 8% of variance in depression. 2. Interaction of cognitive task index and active coping accounted for 18 % of variance in depression. 3. Model including main effects and interaction terms for coping and cognition explained 67% of variance in depression. Individuals with below average cognitive functioning reported more depression when using higher avoidance coping and lower active coping indicating active coping possible buffering depression effects for lower cognition.	Poor

Grech, Kiropoulos, Kirby, Butler, Paine, Hester (2016) Australia	To investigate the moderating and mediating relationship of different coping strategies between EF, stress, depression and anxiety in MS. Hypothesis: Coping will play a mediating and moderating role in the relationship between executive function and emotional outcomes of depression, anxiety and stress. Adaptive coping will play a protective role in this relationship, whilst maladaptive coping will play individuals at greater risk of emotional distress.	Multiple Sclerosis (MS), n = 107. Relapse-remitting n = 78, secondary progressive n = 22.	**Core EFs** Visual elevator (VE), elevator counting with distraction, Reading span test (RST), Symbol digit modalities test (SDMT), trail making test (TMT), Hayling sentence completion test (HSCT) **Higher EFs** Problem solving - Action programming (AP); Multi-tasking - Modified six elements (MSET); Planning - Zoo map (ZM); Decision-making - Iowa	Coping Orientation for problem experiences (COPE)	Beck Depression Inventory (BDI), State Trait Anxiety Inventory (STAI)	**Support for mediating hypothesis**; 1. Poorer performance on the core, higher and total EF found to significantly indirectly predict higher depression and trait anxiety through greater use of the following coping; behavioral disengagement, acceptance, growth, adaptive coping and total coping. 2. Total coping showed a significant indirect relationship between each of the core, higher-level and total EF indices and depression. **Support for moderation hypotheses**; 3. Growth and acceptance coping styles significantly moderated the relationship between aspects of EF and depression. 4. Active coping moderated core EF and depression. 5. For adaptive coping, there was a significant relationship between higher subjective EF and higher depression.	Fair

			gambling task (IGT), Word list generation (WLG) **Self-reported EFs** Self and informant dysexecutive questionnaire (DEX-P, DEX-I).				

Rabinowitz & Arnett (2009) USA	Does coping style moderate and/or mediate the relationship between cognitive dysfunction and depression? Hypotheses: Coping will moderate the relationship between cognitive dysfunction and depression; coping will mediate the relationship between cognitive dysfunction and depression.	Multiple Sclerosis (MS), n = 53 Relapse-remitting n = 59, secondary progressive n = 30, primary progressive n = 11	**Core EFs** Reading span test (RST), Paced auditory serial addition task (PASAT), Symbol digit modalities test (SDMT), Visual elevator subtest (VEA), **Higher EFs** Planning - Tower of London (TOL)	Coping Orientation for problem experiences (COPE)	Chicago Multiscale Depression Inventory (CMDI), Beck Depression Inventory (BDI)	**Support not found for mediation**; 1. Neither active nor avoidant coping acted as a mediator but partial support for the composite score. **Predicted moderation effect was supported**; 2. Interactions of cognitive task and styles coping (active, avoidant and composite) significantly accounted for the variance in depression at time 2.	Fair
Sptiz, Schonberger & Ponsford (2013)	What are the direct, mediated and moderated associations between coping, cognition and emotional adjustment	Traumatic Brain injury (TBI), n = 97.	**Core EFs** Trail Making Test (TMT) A & B, Digit Span subtest (DST), Symbol Digit	Coping Scale for Adults (CSA)	Hospital Anxiety and Depression Scale (HADS)	**Support not found for mediation**; 1. Only verbal fluency was associated with adaptive coping, but with neither anxiety nor	Fair

Australia	following Traumatic brain injury (TBI)? Hypothesis: cognitive impairment would have a direct effect on psychosocial outcome as well as an indirect effect—by restricting the utilization of coping strategies and accurate appraisal of stressful situations.	Severity of injury, severe TBI n = 67, moderate TBI n = 16, mild n = 6, not recorded n = 11.	Modalities Test (SDMT), The Hayling Sentence Completion test (HSCT), **Higher EF** Controlled Oral Word Association Test (COWAT)			depression, indicating the absence of a mediated relation. **Support not found for moderation hypotheses;** 1. Active coping was found to moderate the relation between performance on the Hayling A (measure of processing speed) and depression.	
Van Heugten, Kohler, Francke & Bol (2019) Netherlands	To investigate the direct, mediated and moderated relationships between executive functioning, coping and depressive symptoms in patients with multiple sclerosis (MS). No hypotheses made.	Multiple Sclerosis (MS), n = 68. Relapse-remitting n = 73, primary progressive n = 15, secondary progressive n = 12	**Core EFs** Concept shifting test subtask (CST-C), Wisconsin card sorting test (WCST), Letter digit substitution test (LDST), Paced auditory serial addition test (PASAT),	Coping Inventory for Stressful Situations (CISS)	The Hospital Anxiety and Depression Scale (HADS)	**Partial support found for mediation effects;** 1. EF not found to mediate task orientated coping and emotion-orientated coping on depression. 2. Avoidance coping found to have mediating effect, in that better EF related to more depressive symptoms through less reliance on avoidance coping (seeking social support and distraction. 3. EF itself had a no significant direct effect on	Poor

			Higher EF Controlled oral word association test (COWAT)**,** Semantic fluency task from the Groninger intelligence test (GIT).			depressive symptoms, but it had a positive indirect effect. **No support for moderation effect of coping of any coping style on the association between cognition and depressive symptoms**	
Wolters, Ponds, Smeets, Jonker, Pouwels, Verhey & van Heugten (2015) Netherlands	What is the relationship between executive functioning, coping and depressive symptoms, in individuals with neuropsychiatric symptoms after acquired brain injury (ABI)?	Acquired brain injury (ABI), n= 93 Traumatic brain injury n = 45, cerebrovascular accident n = 30, tumor n = 8, intoxication n n = 4, multiple n	**Core EFs** Trail making test (TMT), Stroop colour word test (SCWT). **Higher EFs** No subtests	Utrecht Coping List (UCL)	Patient Health Questionnaire (PHQ-9)	**Partial support for mediation effect of coping;** 1. No main effects between EF tasks and coping, but effect present for self-reported EF. 2. Partial support for mediation effect – higher scores on the FrSBe predicted higher scores on UCLpas (passive reactions) with UCLpas in turn predicting higher scores on the depression. **No support for moderation effects of coping;**	Fair

	Hypotheses: Coping would mediate the influence of EF on depressive symptoms; patients with cognitive impairment would use less problem-focused coping and more often use emotion focused coping; Coping would moderate the relationship between EF and depressive symptoms.	= 5, other n = 8. Controls = 58.	**Self-reported EFs** Frontal systems behavioural scale (FrSBe).			3. The interaction between problem-focused coping and self-reported EF was not significant.	
Wood & Rutterford (2006). United Kingdom	What influence do cognitive and demographic variables have on outcomes for later stages of recovery following a TBI? Hypotheses: Cognitive impairment would indirectly influence multidimensional	Traumatic brain injury (TBI), n = 131. Severe TBI n = 65, moderate TBI n = 20, mild TBI n = 15.	**Core EFs** Vocabulary, Similarities, Digit Symbol, Block design, Matrix reasoning and digit span subtests of the WAIS-III. Hayling and Brixton tests (HBT), Trail making tests	Brief Coping Orientation for problem experiences (B-COPE)	The Hospital Anxiety and Depression Scale (HADS)	**No support for mediation via B-COPE;** 1. Main effect of working memory on depression, but not anxiety. Depression was significantly predicted by working memory ($b = -.460$, $p < .01$) but not for anxiety. 2. Significant mediation of working memory on depression and QoL via self-efficacy. 3. No effects of mediation via coping subscales between	Fair

	long-term outcome by means of mediation of coping and appraisal variables.		(TMT), Brixton Spatial Anticipation test (BSAT). **Higher EFs** No specific subtests			cognitive impairment and depression or anxiety.	

3.3. Quality Assessment of included studies

Table 2 in the appendix C summarises the risk of bias across the 7 studies using the QATOCCS. Five were considered as 'fair' (Grech et al., 2016; Rabinowitz & Arnett, 2009; Spitz et al., 2013; Wolters Gregõrio et al., 2015; Wood & Rutterford, 2006) and two as 'poor' (Arnett et al., 2002; van Heugten et al., 2019). All studies had a clear research question, a clearly specified population considering type or cause of injury, and exposure and outcome variables were clearly defined and measured with valid and reliable measurement tools. The five studies which were rated as 'fair' had strengths in certain aspects of methodological quality and in relation to the systematic review question. These strengths included clear inclusion and exclusion criteria, hypotheses and aims measurement of confounding variables (demographics, injury type and severity), longitudinal design and larger sample sizes to detect genuine effects. Only some studies drew on specific theoretical basis for selecting specific EF measures (Grech et al., 2016; Spitz et al., 2013; Wolters Gregõrio et al., 2015; Wood & Rutterford, 2006). Arnett et al. (2002) and van Heugten et al (2019) were rated as poor overall as they had a great number of weaknesses including: low sample size, not measuring over multiple time points and a broad approach to conceptualising and measuring EF, which limited the extent to which they could answer our SR questions.

A further consideration in assessing the quality of evidence to help us explore dissociable processes in accordance with our hypothesis was approach to statistical analysis. Some studies (Arnett et al., 2002; Rabinowitz & Arnett; van Heugten et al., 2019) calculated a single cognitive functioning index for their analysis plan. Although this approach is defensible on statistical grounds in terms of limiting possibilities of inflated type I errors from multiple analyses, it raises issues in terms of testing of specific hypotheses about dissociable processes. Grech et al (2016) did explore specific processes but acknowledged the potential for type I errors based on their sample size and multiple testing of interactional effects.

3.3.1. Depression and anxiety outcomes

All studies provided means and SDs for their outcomes. MS participants overall mean indicated people on average met 'caseness' for mild depression as determined by standardised cut-offs for the BDI. The CDMI provides no cut-offs, and subscales were used for two studies (Arnett et al., 2002; Rabinowitz & Arnett., 2009).

For ABI, studies (Spitz et al., 2013; Wood & Rutterford, 2006) found a range of depression and anxiety scores with means falling below cut-offs for caseness with the HADS, however mean scores and SDs likely indicating proportion of those with higher levels of depression or anxiety. This finding was consistent with one study which used the HADS-D subscale (van Heugten et al., 2019) for MS.

3.3.2. Mediation findings

In total, six studies explored indirect effects of cognitive impairment on depression via mediating role of coping, including three studies each for ABI and MS populations. Four studies reported some significant indirect effects (Grech et al., 2016; Rabinowitz & Arnett, 2009; van Heugten et al., 2019; Wolters Gregõrio et al., 2015). Two remaining TBI studies (Spitz et al., 2013; Wood & Rutterford, 2006) did not find mediation of coping style. Only one study reported some significant indirect effects of specific coping strategies (Grech et al., 2016). Tests of mediation were not possible for one study as coping was not found to be associated with anxiety (Wood & Rutterford, 2006). Spitz et al (2013) found direct effects of cognitive impairment on anxiety, but no indirect effects via coping.

3.3.2.1. Mediation findings for MS

Two studies exploring mediation effects were considered 'fair' and one 'poor' by the QATOCCS tool based on having methodological strengths in different areas. Rabinowitz & Arnett (2009) examined the indirect effects of cognitive impairment on depression via the mediating role of coping in a relatively small MS sample of 53 participants and was rated as 'fair'. No support was found for avoidant and active coping when analysed alone, but partial support was found for the composite coping scale when using bootstrapping statistical

techniques. Their findings suggest lower EF predicts greater use of avoidant coping (behavioural and mental disengagement, denial) which in turn is responsible for higher levels of depression. The authors concluded this supported their theory of viewing cognitive functioning as a coping resource because of its ability to affect depression through coping, thus coping is the mediator of this relationship. Grech et al (2016) used a comprehensive battery of cognitive tasks sensitive to core and higher EFs and specific coping strategies rather than using index scores as utilised by other studies which added to strength of quality rating. This enabled a detailed analysis plan in terms of exploring indirect effect of various EFs on both anxiety and depression via specific coping strategies. The study had clear hypotheses and the largest sample (n=113) in MS population studies included in this review, although the sample was not justified in terms of the analysis plan which tested multiple effects, thereby increasing effects occurring by chance. Furthermore, regressions did not control for premorbid and current level of intellectual functioning which means we do not know for sure if any effects are EF specific or related to intellectual functioning. That said, in support and extension of Rabinowitz & Arnett (2009) findings, the authors found specific core EFs and higher (problem-solving, planning, multitasking, decision-making) EFs had different patterns of interaction with coping styles and depression or anxiety. This relationship was also found to be significant for anxiety, an outcome not previously studied. Poorer performance on core and higher EFs indirectly predicted higher depression and trait anxiety via greater use of behavioural disengagement, but acceptance coping was protective and significantly associated with less depression. Poorer performance of core EFs indirectly predicted lower depression (not anxiety) through greater use of growth coping. Lower verbal fluency was not found to be indirectly related to depression or anxiety via specific coping strategies or appraisals. The authors concluded relationships appear to be specific to either core or higher level EFs. Furthermore, specific coping strategies appear to be more prominent across both anxiety and depression.

The authors concluded the findings support the model of coping acting as a mediator between cognitive function and depression, as well as expanding the findings to anxiety. The authors also pinpoint the findings of acceptance and growth coping indicate people with weaker EFs could benefit from utilising said strategies compared to more cognitively demanding strategies such as problem-solving to improve emotional outcomes.

van Heugten et al. (2019) also explored direct and indirect relationships between EFs (inhibition, working memory, shifting and verbal fluency), coping and depression in a relatively small sample of 68 people with MS. The study did not replicate the findings of Rabinowitz & Arnett (2009) or Grech et al. (2016) as neither task-focused nor emotion-focused coping (as measured by CISS) were significantly related to EF although they were for the depression outcome (as was avoidance coping). The authors did find a mediating effect in higher EF was significantly related to more depressive symptoms via less reliance on avoidance coping. This suggests better EF is related to less reliance on seeking social support and use of distraction, which in turn was related to higher levels of depression. These findings indicate possible negative effects of better EF on mood and coping. It could be better EF might be associated with heightened self-awareness of one's difficulties which is consistent with findings in brain injury (Shields, Ownsworth, O'Donovan, & Fleming, 2016). That said the better quality of evidence was found in the Grech et al (2016) and Rabinowitz & Arnett (2009) studies which did not report this effect.

3.3.2.2. Mediation findings for ABI

Studies which explored mediation effects of coping in ABI were considered 'fair' based on having methodological strengths in different areas. The variability in findings appears to be owing to the lack of homogeneity and breadth in EF measures as well as the large differences in terms of time post-injury for included studies. Wood & Rutterford (2006) explored later stages of recovery post-TBI (10> years post-injury) using a range of psychosocial outcomes (quality of life, employment, community integration, life satisfaction) with a large sample of 131 participants (around two-thirds were classified with severe TBI). The study had various strengths in terms of using a clearly defined population, valid measures, as well as a detailed analysis plan and measurement of potential confounding variables. They hypothesised cognitive impairment would indirectly influence multidimensional long-term outcome by means of mediation of coping and appraisal variables. They found a direct effect of working memory significantly predicting depression (but not anxiety), however this was mediated by self-efficacy and not coping, or appraisal variables as predicted. No other cognitive domain, including the EF index significantly predicted their range of outcomes, including measures of mood. This suggests deficit in core EFs of working memory might have direct effects on psychosocial outcomes, and with time this affects an individual's sense of self-efficacy negatively, further impacting on

emotional outcomes such as depression. Despite its methodological strengths this study had a broad focus in terms of predictors and outcomes which limited its analysis plan in exploring specific interactions between coping and EF variables on emotional outcomes. The authors also used a limited set of measures sensitive to core EF (inhibition, cognitive flexibility) for their EF variable, not exploring other EF processes. .

Wolters-Gregório, Ponds, Smeets, Jonker, Pouwels, Verhey, & Heugten (2015) investigated whether EF mediates the relationships between coping style and depression and quality of life in healthy controls and 93 people with ABI (11 years post injury on average) with at least one neuropsychiatric symptom. They used a smaller battery of measures including two core EF measures in the form of the Stroop and TMT and self-reported EF measure (FrsBe). They found differential effects between task and self-reported EF difficulties. Scores on the TMT and Stroop were not related to coping therefore not supporting the study's mediation hypothesis. However, subjective EF as captured by the FrsBE did find support for their predictions of lower levels of subjective EF being associated with higher passive coping, and in turn higher levels of depression.

Spitz et al (2013) also tested both direct and indirect effects of cognitive impairment on anxiety and depression with coping operating as the mediating variable in an ABI sample of 97 participants, 6 to 53 months post-injury. Their findings indicated greater impairments in cognition (memory, processing, and attention) predicted higher levels of anxiety and depression. They found poorer performance on verbal fluency was associated with less use of adaptive coping. However, they did not find mediation of the effect of cognition on either depression or anxiety by coping style. Like the other studies which explored mediation of coping in ABI, no executive measures were used which tap into 'higher' EFs which limits conclusions to specific core EFs only. This study also notes its own limitations in terms of lacking statistical power for utilised analysis as well lacking a control group. Given all designs were cross-sectional capturing recovery at different stages this makes it difficult to establish an understanding of the adjustment process over time.

3.3.3. Moderation findings

In total, six studies explored the role of coping as a moderator of the relationship between cognitive impairments and depression. Four out of the six studies reported some significant moderating effects of specific coping strategies (Arnett et al., 2002; Grech et al., 2016; Rabinowitz & Arnett, 2009; Spitz et al., 2013) and the remaining two studies found no support (van Huegten et al., 2019; Wolters et al., 2015). Only two studies explored the role of coping as a moderating variable between cognitive impairments and anxiety. One study (Grech et al., 2016) found that coping strategies moderate the relationship between EFs and anxiety, whereas others found no support (Spitz et al., 2013).

3.3.3.1. Findings for MS

Rabinowitz and Arnett (2009) found support of moderation, such that for individuals who reported low levels of adaptive coping or high levels of avoidance coping, cognitive dysfunction put them at increased risk of depression. Whereas individuals who reported high levels of active coping or low levels of avoidance coping, cognitive dysfunction had a weak relation with depression. The authors concluded adaptive coping may buffer the association between cognitive dysfunction and depression. As previously discussed, this longitudinal design replicated findings from a cross-sectional design carried out by the same authors (Arnett et al., 2002) which strengthens this finding.

Grech et al (2016) found support for hypothesized moderation effects, although strengths of effects were lower compared to mediation effects. Key findings were when growth coping is low, poorer core EF was related to higher depression, which was not present when growth coping was high. They also found small effects of acceptance and active coping moderating the relationship between total EF scores and depression. Growth coping was also a strong moderating factor for anxiety, in that when growth coping was high, higher performance on higher EF tasks and total EF was associated with lower state anxiety. They replicated findings from the Arnett studies of adaptive coping moderating the relationship between cognitive impairments and mood outcomes. They concluded the theory of impaired cognition interfering with the ability to use adaptive coping strategies should be expanded to incorporate their

findings, which suggest less cognitively demanding adaptive strategies such as growth and acceptance may be used to facilitate adjustment.

van Heugten et al (2019) found no moderating effect on any coping style on the association between their indexes which included core EFs and higher EFs (verbal fluency) and depression. They did not incorporate measures sensitive to higher EFs such as planning which have been found to produce effects in adaptive coping such as problem-solving in the other MS studies. This might explain variability in findings.

3.3.3.2. Findings for ABI

Two studies explored the moderating effects of coping with mixed findings. Spitz et al. (2013) found impaired information processing was related to depression in participants who did not utilise productive coping styles. That is low use of adaptive coping resulted in higher depression from weaker performance on the Hayling A task. No effects were found between coping and EF. They concluded utilisation of productive coping styles play a protective role for individuals who struggle with information processing, thereby minimising emotional distress. They found no other moderating effects for nonproductive coping, optimism, and sharing as measured by the CSA. Wolters Gregõrio et al. (2015) tests for moderation effects showed adaptive problem-focused coping (as measured by the UCL) moderated the relationship between self-reported EF difficulties and quality of life. The use of problem-focused coping was found to be more adaptive for individuals who report less EF difficulties than for people who reported higher levels of EF. No other moderation effects of coping were found between cognitive tasks of EF and mood, effects which are the main scope of this review.

3.4. Synthesis of results

3.4.1. MS

The pattern of findings indicates some support for decreased adaptive (planning, suppression, cognitive restructuring) and increased maladaptive (denial, behavioural disengagement and mental disengagement) coping mediating the relationship between weaker core EFs (namely inhibition, working memory) and higher EFs (planning) and higher depression.

There is also some preliminary evidence of interactional effects between a broader range of specific domains of core EFs (also including cognitive flexibility) and higher EFs (decision making, multitasking, problem-solving) with other specific coping strategies (acceptance and growth) on mood. Poorer performance on core and higher EFs indirectly predicted higher depression and trait anxiety via greater use of behavioural disengagement. Greater use of acceptance and growth coping were found to moderate the relationship between weaker core and higher EFs and lower anxiety and depression. Greater use of specific adaptive coping strategies (acceptance and growth) were found to mediate relationship between broad range of weaker core and higher EFs and lower depression and anxiety. Although the evidence is weak owing to small number of studies and methodological weaknesses, the studies suggest that a range of adaptive coping strategies may buffer against the effects of weaker EFs and mood outcomes.

3.4.2. ABI

There is limited evidence to suggest coping styles mediate or moderate the relationship between core EFs and mood following ABI. There is some evidence suggesting problem-focused strategies may be more adaptive for individuals who have strong executive abilities and less useful for individuals who have weaker executive abilities. There is also an indication of increased adaptive coping (e.g. problem solving) moderating the relationship between self-reported EF and quality of life. There is not enough evidence to comment on other adaptive strategies such as acceptance and growth being effective strategies post-injury. Thus, the available evidence to verify hypothesised specific relationships between coping and EF on mood is limited and inconclusive.

4. Discussion

4.1. Summary of the systematic review main findings

This SR reviewed the literature on the interaction between specific domains of EF and coping strategies in predicting emotional outcomes. In total, 6 cross-sectional and 1 longitudinal design were included which met the criteria for exploring mediation and moderation effects. A

narrative synthesis approach was used alongside quality ratings of studies in which two were considered ‘poor’ and five ‘fair’. There was a large amount of heterogeneity in study populations samples and measures used. Given the smaller number of studies included and methodologies applied, conclusions are made cautiously. A pattern of results emerged of impaired EFs being associated with less adaptive coping strategies (e.g. problem-focused) and more maladaptive coping strategies (emotion focused, avoidant). There is also some evidence that the relationship between coping style and emotional outcomes is stronger for those with less well preserved EFs, possibly because they are less able to implement adaptive coping strategies. This appears to be a stronger finding in MS compared to ABI populations where adaptive coping strategies (namely problem focused) have been found to buffer the effects of core (inhibition, working memory) and higher EFs (planning) impairments and depression. Acceptance and growth coping were found to have the same buffering effects, but also mediational effects for both anxiety and depression. Further replication is needed for those findings. The evidence for ABI populations remains unclear, possibly owing to the heterogeneity found in ABI, measures used and small number of studies which either had a broad focus on cognition or specific focus on EF.

4.2. Key findings in relation to the existing literature

4.2.1. ABI

There are mixed findings for coping as a mediator and moderator in ABI, although partial support for adaptive coping in facilitating better emotional outcomes. The findings of (Wolters Gregõrio et al., 2015) offer partial support to the existing literature in terms of increased problem-solving coping and decreased use of emotion-focused and avoidant coping resulting in improvements in quality of life (Tomberg, Toomela, Pulver, & Tikk, 2005; Wolters, Stapert, Brands, & Van Heugten, 2010) and productivity status (Dawson, Schwartz, Winocur, & Stuss, 2007).

All ABI studies used measures sensitive to core EFs only, none of which looked at higher EFs (e.g. planning, problem-solving) which it has been argued are implicated in the relationship between adaptive problem-orientated coping and mood (Krpan et al., 2007). Krpan, Stuss, & Anderson (2011) also found those with TBI compared to control participants were more likely to

engage in avoidant compared to planful behaviour, further supporting these core deficits in higher EF predicting maladaptive coping. Other findings pertinent to EF were found on self-report EF tasks. This discrepancy regarding strong associations between self-report EF difficulties and coping, opposed to limited evidence for relations between EF performance-based tests and coping, is consistent with recent findings by (Rakers et al (2018). They suggest performances on EF tasks reflect people's problem solving skills, whereas it could be self-reported EF difficulties in daily life reflect not only problems in executive activities but the experienced burden and psychological distress as well (Simblett & Bateman, 2011).

Another issue with detecting effects and variability in findings could relate to a mix of positive and negative effects of cognition on mood and coping, as well as mix of effects of mood on EF found in the existing literature. Stronger working memory has been associated with more ruminative self-focus and depression (Ownsworth, Gooding, & Beadle, 2019) and heightened self-awareness of difficulties can contribute to maladaptive coping and difficulties with ER (Shields et al., 2016). Individuals with weaker EF and self-awareness have been found to be less likely to ruminate and reflect on post injury selves after TBI resulting in decreased mood symptoms (Beadle, Ownsworth, Fleming, & Shum, 2018). Interestingly, one of the included MS studies found possible negative effects of stronger core EFs being related to higher depression via less reliance of seeking social support. It could be higher levels of self-awareness make individuals less likely to seek social support as increased awareness has been negatively associated with self-esteem and positively associated with depression (Carroll & Coetzer, 2011).

4.2.2. MS

A consistent finding was active coping moderating the relationship between weaker core (inhibition, working memory) and higher (planning) EFs and higher depression in three of the four included studies (Arnett et al., 2002; Grech et al., 2016; Rabinowitz & Arnett, 2009). This supports the existing wider literature which suggests impairments in EF such as inhibition and shifting are important vulnerability factors for depression (Joormann & D'Avanzato, 2010). As well as adaptive ER strategies such as cognitive reappraisal, acceptance and problem solving which have been found to reduce negative effect and exert protective effects mental health

difficulties (Aldao & Nolen-Hoeksema, 2010; Gross & John, 2003). This suggests CBT interventions which promote adaptive coping strategies may enhance cognitive strategies such as EF with problem-solving techniques. This supports the existing literature of adaptive coping strategies being related to improved quality of life (McCabe, 2006) and emotion and avoidant coping strategies being related to depression in MS (Aikens et al., 1997).

The evidence of moderation supports Hofmann et al. (2012) theoretical standpoint of EF and self-regulation as well as Ochsner's process model (Ochsner & Gross, 2005), in that well preserved EFs are required to enact effortful action required for goal protection, while a reduction in core EFs results in more automatic coping behaviour. Thus problem-focused strategies appear to play a key role in adjustment to MS in the context of EF impairments, although strategies are likely to be those less cognitively demanding. Growth coping was a prominent moderating variable for EF indices and outcomes of both anxiety and depression (Grech et al., 2016) and supports other coping models (Park, 2010) which emphasise meaning and value exploration in response to traumatic events. Of interest was the general effects of core and higher EFs on either depression or anxiety via growth and acceptance coping. When growth and acceptance coping was low, there was a relationship between higher depression symptoms and lower executive performance. It could be adaptive coping in the form of problem-solving strategies maybe be more adaptive for individuals with greater EF abilities, and less useful for individuals with weaker EF abilities. Thus, other adaptive strategies such as acceptance and growth coping might be more adaptive for those individuals with weaker EF abilities. This supports the theory of fewer reappraisal processes required for individuals with weaker EF to engage effectively with mindfulness-based therapies (Farb, Anderson, & Segal, 2012) although other findings have argued such approaches still require additional 'cognitive control' to break out of habitual patterns of responding (Hölzel et al., 2011) when learning such techniques to begin with.

4.3. Study limitations and methodological issues

All studies were seeking to test complex interactions between multiple variables but with little theoretical grounding in what might specifically be predicted. Hence assumptions were made about what the mediating or moderating variables are, in the context of cross-sectional

designs, which together limits a full understanding of whether there is support for any specific model-based hypothesis. It could be argued levels of depression exacerbate EF difficulties via coping styles utilised. Studies have also shown greater levels of anxiety and depression following TBI lead to impairment in cognition via psychological and neurophysiological factors (Keiski, Shore, & Hamilton, 2007). Research into cognitive processes in emotional disorders show specific emotional processes (e.g., rumination or worry) selectively impair attention or EF (Harvey, Watkins, Mansell, & Shafran, 2004; Nolen-Hoeksema & Watkins, 2011).

It must be acknowledged that our search terms around the construct of coping did not include alternative similar constructs, such as self-regulation or emotional regulation. Thus, some papers may have been missed which arguably capture a related construct.

A limitation of the current review methodology is most of the process was undertaken and managed by one individual. The recommendation is studies should be rated by at least two reviewers (Thomas, Ciliska, Dobbins, & Micucci, 2004), whereas, only a selection of four papers were independently assessed for quality by a second reviewer. It's reasonable to suggest there was an increased chance of possible biases as a result. Ideally a more robust approach would have included a second rater in all stages of the paper selection and quality rating. Therefore, it must be acknowledged the findings and conclusions draw from this review are from the perspective of one individual.

A further limitation is even though MS and ABI share common symptoms in terms of EF difficulties, different findings could reflect the different trajectory EF difficulties typically have (e.g. ABI is sudden and MS progressive) and adjustments required around the conditions. In ABI, injuries often result in multiple and very heterogeneous domains of cognitive deficits given the multiple mechanisms which cause injury. Thus, different brain bases for deficits in both populations, with likely different neuropsychology profiles impacting upon detectability of specific effects. It should be noted cognitive impairments extend beyond EF difficulties for both groups. Contemporary models of cognitive functioning suggest attention, arousal and information processing are necessary prerequisites of successful higher-order functions such as EF (Dams-O'Connor & Gordon, 2013) which suggests a number of potentially confounding factors on observed relationships postulated in this review. Furthermore, premorbid intelligence

and current intelligence was not accounted for in most studies, as well as other aspects of cognition such as verbal and visual abilities, language and visuospatial skills.

4.4. Future implications for research and clinical practice

Future studies should explore structural equation modelling techniques with larger samples in general populations to identify different types of causal relationships indicating those processes or interactions that are adaptive and those that are maladaptive. Future studies in neurological conditions would benefit from exploring specific processes under the umbrella of core and higher EFs and how this aligns with processes indicated in the process model of ER (Ochsner & Gross, 2008) and models of EF (Diamond, 2013; Miyake et al., 2000). One case study in ABI which took such approach found inhibition difficulties resulted in concrete thinking (cognitive inflexibility) making it difficult to spontaneously generate reappraisals (Salas et al., 2013).

For clinical practice, in the main, both groups will benefit from using less maladaptive strategies, such as emotion focused and avoidant coping strategies. In MS, the role adaptive coping strategies in the form of problem-solving and cognitive restructuring play in helping adjustment post diagnosis appear efficacious. In ABI, Goal Management Training (GMT) takes this approach by enhancing cognitive strategies such as EF with a problem-solving framework to good effect (Stamenova & Levine, 2018). This approach has also been applied with MS populations to good effect (Richard, 2018).

The nature of training, compensatory or CBT approaches is the requirement to engage processes which are reliant on core and higher EFs (e.g. holding thoughts in mind, seeking alternative thoughts and solutions). Perhaps some people with EF problems might need an alternative to training or compensatory approaches due to the nature of severity of EF. The findings suggest a possible role for acceptance or growth-based interventions for MS populations. Contemporary approaches referred to as ‘third wave’ CBT such as Acceptance and Commitment Therapy (Hayes, Strosahl, & Wilson, 1999) have emerged which target such processes, and have been shown to be efficacious for TBI (Whiting, Deane, Simpson, McLeod, & Ciarrochi, 2017) and MS (Nordin & Rorsman, 2012). Ultimately, therapeutic approaches

should be informed by formulation, targeting processes evidenced as central to poorer emotional outcomes following neurological conditions, such as ABI (Gracey et al., 2015). This review suggests identifying specific EF difficulties and how they interact with adaptive coping strategies is a good starting point to guide clinical interventions for enhancing mood outcomes.

4.5. Conclusions

The presence of bi-directional associations between domains of EF and coping strategies, and emotional outcomes appears multifaceted. It is likely there are several confounding factors not identified in the reviewed studies. However, it does appear adaptive strategies based on traditional and contemporary CBT approaches appear efficacious for MS when accounting for an individual's EF difficulties. Since research exploring this area is limited in number and not always based on theoretical models of EF and ER, recommendations for clinical practice are made tentatively. This is particularly apparent in relation to ABI given the lack of homogeneity in samples, measures and theoretical focus of the studies included. Thus, no specific recommendations are made for clinical interventions for ABI, but careful assessment of both EFs and coping should be made given the literature indicates both positive and negative effects of weaker cognition on coping and mood. Further research should continue to explore the specific interactional processes between core and higher EFs with specific coping strategies, and how this influence emotional outcomes in the light of evidence suggesting both positive and negative effects following adjustment to ABI or MS.

5. Funding

This systematic review was conducted as part of the first authors' doctoral training in clinical psychology.

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7. Appendices

Appendix A: Search terms for MEDLINE

Appendix B: Quality Assessment Tool for Observational and Cross-Sectional Studies

Appendix C: Quality appraisal ratings using the QATOCCS

Appendix A: Search terms for MEDLINE

Database: Ovid MEDLINE(R) <1946 to September Week 3 2019>

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1 exp Brain Injuries/ (64437)

2 exp Multiple Sclerosis/ (55109)

3 exp Stroke/ (121873)

4 exp Hypoxia, Brain/ (12269)

5 neurodisability.ab,ti. (156)

6 anoxia.ab,ti. (8565)

7 (encephaliti* or mening*).ab,ti. (125537)

8 ((brain or head or intracran* or cerebr* or cerebellar or brainstem or vertebrobasilar) adj3 (injur* or infarc* or isch?em* or thrombo* or apoplexy or emboli* or h?emorrhag* or h?ematoma* or aneurysm* or anoxi* or hypoxi*)).ab,ti. (178476)

9 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 (483173)

10 (coping adj1 (mechanism* or skill* or strateg* or resources)).ab,ti. (14962)

11 (appraisal* or attribution*).ab,ti. (37460)

12 10 or 11 (51705)

13 exp Cognition/ (148514)

14 exp Executive Function/ (12449)

15 working memory.ab,ti. (23755)

16 executive dysfunction.ab,ti. (2183)

17 ((executive function* or cognit* or attention or memory) adj3 (disorder* or dysfunction or impaired or impairment or difficult* or problem* or disability)).ab,ti. (110513)

18 inhibition.ab,ti. (752685)

19 ((organis* or organiz* or plan* or manag* or switch* or set shifting or self regulation or problem solving or decision making) adj3 (disorder* or dysfunction or impaired or impairment or difficult* or problem* or disability)).ab,ti. (54891)

20 (executive adj1 (function* or process* or control*)).ab,ti. (20783)

21 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 (1063245)

22 9 and 12 (1086)

23 9 and 12 and 21 (168)

Appendix B: Quality Assessment Tool for Observational and Cross-Sectional Studies

National Heart, Lung, and Blood Institute

Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies

Criteria	Yes	No	Other (CD, NR, NA)*
1. Was the research question or objective in this paper clearly stated?			
2. Was the study population clearly specified and defined?			
3. Was the participation rate of eligible persons at least 50%?			
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?			
5. Was a sample size justification, power description, or variance and effect estimates provided?			
6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?			
7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?			
8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?			
9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?			
10. Was the exposure(s) assessed more than once over time?			
11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?			
12. Were the outcome assessors blinded to the exposure status of participants?			
13. Was loss to follow-up after baseline 20% or less?			
14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?			

Quality Rating (Good, Fair, or Poor) (see guidance)
Rater #1 initials:
Rater #2 initials:
Additional Comments (If POOR, please state why):

Appendix C: Quality appraisal table using the QATOCCS tool

Table
2.
Summary of QATOCCS Rating

Criteria	Arnett et al.	Grech et al.	Rabinowitz et al.	Spitz et al.	Van Heugten et al.	Wolters et al.	Wood et al.
Clear research question?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Study population defined?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Participation rate above 50%?	NR	NR	NR	NR	NR	NR	Yes
Inclusion and exclusion criteria prespecified?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample size justification?	No	No	No	No	No	No	No
Exposure of interest measured prior to outcome?	No	No	Yes	No	Yes	No	Yes
Timeframe between measures sufficient?	NA	NA	Yes	NA	Yes	NA	NR
Different categories of exposure?	NA	NA	No	NA	No	NA	NA
Exposure measures clearly defined?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Exposure assessed more than once?	No	No	Yes	No	Yes	No	Yes
Outcome measures clearly defined?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Outcome assessors blinded?	NA	CD	CD	NR	CD	CD	NA
Follow-up loss under 20%?	NA	NA	NR	NA	Yes	NA	NR
Measurement of confounding variables?	Yes	No	Yes	Yes	Yes	Yes	Yes
Overall quality rating	Poor	Fair	Fair	Fair	Poor	Fair	Fair

CHAPTER 3: Bridging the systematic review and empirical paper

Chapter overview

This chapter provides a summary of the systematic review and leads into the rationale for the empirical paper

Word count: 445

The systematic review considered the relationship between specific domains of executive functioning and mood via the mediating and moderating role of coping styles in individuals' adjustment to ABI or MS. This indicated broad support in MS for increased use of adaptive styles (cognitive reappraisal, problem-solving, acceptance and growth) in buffering the effects of the relationship between a number of weaker core (inhibition, working memory and cognitive flexibility) and higher (planning, multi-tasking, problem-solving and decision-making) EFs and mood outcomes (anxiety and depression). The picture is less clear and inconclusive in ABI with only partial support for this hypothesised relationship, and studies reporting no relationship between core EFs and mood outcomes via coping styles.

Most processes thought to be involved in reappraisal are compromised in people with executive difficulties such as ABI and MS, resulting in difficulties to manipulate thoughts and ideas (Fuster, 2008). If reappraisal relies on the flexible use of thinking (Ochsner & Gross, 2004) then it is likely people with severe EF difficulties may struggle to modulate how they feel (Salas, 2014). The findings in relation to acceptance and growth coping styles potentially have important clinical implications in neurological populations where difficulties in core EFs may impact upon on an individual utilising reappraisals strategies which are underpinned by such executive processes for adaptive ER (Gross & Ochsner, 2005; Pruessner et al., 2020; Salas et al., 2014).

There are a small but growing number of studies which show that 'third wave' CBT approaches such as Acceptance and Commitment Therapy (ACT) based on such principles are effective in reducing psychological distress for TBI (Whiting et al., 2019), stroke (Graham et al., 2015) and MS (Pakenham et al., 2018). Likewise, Compassion Focused Therapy (CFT) has been found to be have utility following TBI (Ashworth, Gracey & Gilbert, 2011) and Mindfulness-based stress reduction found to improve emotional wellbeing in MS in a randomised trial (Senders et al., 2017). What is less well understood is the interplay between specific aspects of mindfulness and domains of EF in understanding ER difficulties. This relates to whether such interventions which utilise mindfulness skills improve emotional outcomes via cognitive changes (or vice-versa) or can be explained by other processes.

The empirical paper used a general population to test those key hypotheses before testing them out with clinical populations as we are not clear enough about how in the mainstream literature, mindfulness operates. There are models such as Teper et al., (2013) which postulate

specific cognitive processes which are essential for effective ER, but this is relatively untested. The use of a healthy control group to contribute to theory will inform clinical interventions for people with cognitive impairments. If we can understand and validate models we have around EF and coping this gives us another perspective of understanding the processes which are important when working with people who have ABI/MS.

CHAPTER 4: Empirical Paper

The role of executive functioning and its relationship to mindfulness and emotional regulation

Prepared for Consciousness and Cognition Journal

Word Count: 6479 (excluding references and appendices)

The role of executive functioning and its relationship to mindfulness and emotional regulation

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Word Count: 6479 (excluding references and appendices)

1. Abstract

Background. Mindfulness based interventions have been found to improve both executive functioning and emotional regulation for a wide range of health conditions. What is less well established are which specific facets of mindfulness, executive functioning and emotional regulation are related, and what the causal nature of these relationships could be. *Objective*. To identify associations and mediating relationship of executive functioning indices between specific facets of mindfulness and emotional regulation**.** *Methods.* Cross-sectional design with 125 participants from a non-clinical population who completed a task of executive functioning and self-report measures of mindfulness and emotional regulation on an online survey. *Results.* We observed significant pairwise associations between facets of mindfulness, EF indices and ER. Specifically, only perseverative errors (reflective of cognitive flexibility) was associated with three specific facets of mindfulness (describe, non-judge, observe) and emotional regulation, giving us a basis for exploratory mediational analysis. Testing of the mediating path showed as describe and non-judge facets of mindfulness increase, perseverative errors decrease, and this was statistically significant. A trend was found in terms of lower perseverative errors and higher emotion regulation difficulties, but this was not statistically significant. Therefore, no mediational effects were found. *Conclusion.* There is evidence to suggest some specific core EF abilities in relation to cognitive flexibility may play a role in emotional regulation, but further evaluation in this area would be advantageous to underpin effective intervention strategies.

Keywords**:** mindfulness, executive functioning, emotional regulation, cognitive flexibility

2. Introduction

Mindfulness is increasingly being used to support people in managing psychological aspects of physical health problems, as well as being a key component of both preventative and therapeutic psychological approaches. Research on mindfulness-based interventions (MBIs) has increased exponentially in the past decade (Hofmann & Gómez, 2017). Definitions of mindfulness or types of mindfulness intervention appear to vary depending on the context (Crane, 2017). Mindfulness is also commonly referred to as a psychological construct, in the form of dispositional traits or skills. This highlights the widespread use of mindfulness, but also the undifferentiated use of terms mindfulness and meditation (Davidson & Kaszniak, 2015). Operationalised in scientific terms, it is commonly described as containing two elements, awareness of the present moment and the quality this awareness entails (accepting, non-judgemental, curious) (Bishop et al., 2004).

Research shows a link between MBIs and emotional outcomes, including relapsing depression (Piet & Hougaard, 2011), anxiety and depression (Hofmann, Sawyer, Witt, & Oh, 2010), social anxiety (Goldin & Gross, 2010) and reducing suicidality in personality disorder (Linehan et al., 2006). Equally promising findings have been reported in meta-analytic and systematic reviews for reducing distress in people suffering from health conditions, including cancer (Cramer, Lauche, Paul, & Dobos, 2012), chronic pain (Cramer, Haller, Lauche, & Dobos, 2012; Veehof, Oskam, Schreurs, & Bohlmeijer, 2011) and fibromyalgia (Kozasa et al., 2012).

Research is now exploring possible mechanisms via which mindfulness operates in general wellbeing. Chambers et al. (2009) propose the importance of how a person relates to their thoughts, rather than how they appraise their thoughts as key for effective ER. Other models postulate mindfulness operates via a reappraisal strategy (acceptance) for emotion (Webb, Miles, & Sheeran, 2012) or as a positive reappraisal of contexts (Garland, Gaylord, & Fredrickson, 2011). Previous findings examining the five facets mindfulness questionnaire (FFMQ) have found that acting with awareness, non-judging and non-reactivity to inner experience independently contribute to well-being outcomes in non-clinical populations (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006; Short & Mazmanian, 2013).

However, research findings for neurological conditions where executive functioning (EF) difficulties are common are inconclusive with improvements in psychological and psychosocial outcomes found for traumatic brain injury (TBI) (Bédard et al., 2012; Lawrence, Booth, Mercer, & Crawford, 2013), whereas other studies have reported no improvements for emotional distress or cognitive functioning (McMillan, Robertson, Brock, & Chorlton, 2002).

There is evidence in healthy populations that mindfulness could enhance core EFs involved in inhibition and working memory (including sustained and selective attention) (Chiesa, Calati, & Serretti, 2011). A recent systematic review (Gallant, 2016) based on Miyake et al. (2000) unity/diversity model of EF also found stronger support for MBIs improving 'inhibitory' core EF process (attentional processes) but weaker support for the 'updating ' and 'shifting' core EFs. Both reviews focused on the relationship between mindfulness and cognitive processes (including EFs), however they did not explore how this relationship influences emotional outcomes and/or regulation.

Consistent with the above systematic reviews, studies which have used tasks more reflective of 'shifting' EFs have found mixed findings on cognitive improvements. Some studies have found improved performance on the Trail Making Parts (TMT) A and B task after receiving mindfulness training (Moynihan et al., 2013; Short et al., 2016) and an association between specific subscales (non-reactivity) of FFMQ (Baer et al., 2006) and improved performance on the colour-word Stroop task (Anicha, Ode, Moeller, & Robinson, 2012). A further study found meditators performed better than non-meditators on the Stroop task, which the authors concluded as mindfulness improving attentional and cognitive flexibility processes (Moore & Malinowski, 2009). However others found no support using the same tasks (Heeren, Van Broeck, & Philippot, 2009; Semple, 2010) or with other shifting tasks such as Dual Attention to Response Task (DART) (Jensen, Vangkilde, Frokjaer, & Hasselbalch, 2012). The variability in findings could reflect EF task selection or how mindfulness was conceptualised and delivered (e.g. type of practice, length). There is emerging evidence which shows differential effects on cognition associated with specific meditation practices (Britton et al., 2018).

It is possible that acquired deficits in EFs interfere with mechanisms by which mindfulness might operate (McRae, Jacobs, Ray, John, & Gross, 2012). Indeed, what is less well

established is how the association between mindfulness and EF impacts on ER, which makes it difficult to refine and develop MBIs further, especially in conditions where cognition is impaired.

Studies which have explored associations between mindfulness, EF and ER have found dispositional mindfulness was associated with performance on the TMT, but they found no mediational effects via EF on emotional outcomes (Short el al., 2016). In clinical populations where people commonly report EF impairments, studies have found people with comorbid Traumatic Brain Injury (TBI) and depression had greater impairments in cognitive flexibility as measured by the TMT and WCST compared to those without depression (Jorge et al., 2004). Similar findings were present for people with comorbid TBI and anxiety disorders (Gould, Ponsford, & Spitz, 2014). Another study exploring cognitive flexibility (using the Stroop) in people with Generalised Anxiety Disorder (GAD) found GAD may be characterised by inflexible style of responding, and mindfulness and relaxation techniques resulted in partial improvements in cognitive flexibility (Lee & Orsillo, 2014). Those studies indicate the complex interplay of cognitive and emotional processes, and how EF impairments in the form of shifting appear to play a role in emotional outcomes and how mindfulness may be an adaptive coping strategy.

Some argue for mechanism of operation via EFs, but within such a proposal, the clarity regarding what aspects of EF is lacking. A recent model has attempted to integrate 'executive control' more specifically within explaining the relationship between mindfulness and ER (Teper, Segal, & Inzlicht, 2013). They propose mindfulness improves executive control through its two facets of awareness (refined attention to subtle changes in affective states) and acceptance (non-judgemental openness towards sensations and experiences) which work iteratively and interdependently to facilitate executive control, thereby aiding ER. One study (Short et al., 2016) found self-regulation independently mediated the relationship between mindfulness and positive affect, however, both EF and self-regulation independently mediated the relationship between mindfulness and negative affect. They found specific facets of mindfulness with the FFMQ 'acting with awareness' and 'non-judgment' of inner experience were most strongly related to EF which supports the Teper model. Another study found trait mindfulness is negatively related to self-reported EF and positively related to emotional self-regulation (Lyvers, Makin, Toms,

Thorberg, & Samios, 2014). However, both studies effects of EF were only observed with self-report measures rather than task performance measures, which the authors themselves acknowledge when drawing conclusions of EF effects. A further problem with those studies is the clarity regarding how EF is conceptualised and how this relates to specific ER processes.

One cognitive model of ER (Ochsner & Gross, 2005) attempts this by distinguishing between antecedent and response focused strategies. The former involves thinking and feeling about something else or thinking differently about what you are seeing (e.g. reappraisal) which all rely on a sequence of regulatory processes such as initial emotional reactivity, attention orientation to the emotional stimulus, management of emotional material into working memory and the use of supervisory attentional processes for higher skills such as problem-solving. Response strategies involve the capacity to influence emotion-response tendencies once they have already been elicited (Gross & Thompson, 2007). Indeed, these processes underpin traditional Cognitive Behavioural Therapy (CBT) for the treatment of disorders of ER (Beck & Haigh, 2014). Thus, given mindfulness is not considered to involve reappraisal processes (Farb, Anderson, & Segal, 2012), rather present awareness and acceptance, it could be less demands placed on cognitive processes might be an equally or more effective route of reappraisal for people with EF difficulties.

Given mindfulness has been shown to improve both emotional outcomes and cognitive functions, this does suggest cognitive processes may underlie, or at the very least be associated with the link between mindfulness and ER. Grounded in a conceptual model of mindfulness and emotional regulation via EF (Teper et al., 2013), the current study seeks to add to the developing evidence on how higher levels of mindfulness are supporting ER, and which cognitive processes are involved. As a first step, it would be helpful to explore which components of mindfulness and EF are associated with better ER. It is hoped improved understanding of these mechanisms could provide the basis for refining interventions, particularly for those who have acquired deficits in EF and related emotional difficulties.

2.1. Hypotheses

The principal objective of this study is to further understand the role EF plays between a person's dispositional mindfulness and ability to regulate emotions using a cross-sectional design.

1. Higher levels of overall trait mindfulness will be associated with better ER.
2. In accordance with past research findings (Baer et al., 2006; Short & Mazmanian, 2013) facets of mindfulness 'acting with awareness' and 'non-judging' will contribute more significantly than other facets to overall ER.
3. Higher levels of the EF process cognitive flexibility will significantly contribute to better ER.
4. In accordance with past research findings (Anicha et al., 2012; Lyvers et al., 2014) we predict aspects of trait mindfulness will be negatively associated with cognitive flexibility.
5. Exploratory question: The potential mediating role of specific EF indices will be investigated if significant correlations exist between specific subscales of mindfulness, EF and ER. It is hypothesised that EF will mediate the relationships between mindfulness and ER.

3. Materials and Methods

3.1. Design

This study used a correlational design, collecting data collected at one time point. The key independent variables (IVs) were the five facets of mindfulness (observing, describing, acting with awareness, non-judging and non-reacting) and three specific indices of EF as measured by WCST (trials to complete first category, perseverative and non-perseverative errors). Five demographic variables, including, age, gender, education, neurological or developmental conditions and practice with mindfulness also served as IVs to control for confounding effects on our variables of interest.

3.2. Participants

125 participants completed the survey. All participants were aged 18 and older, recruited through non-random sampling (e.g. self-selecting, snowballing) via social media sites (Facebook, LinkedIn, Twitter). The only pre-determined eligibility criteria were all participants were aged 18 or above.

3.3. Measures

3.3.1. Five Facet Mindfulness Questionnaire

The Five Facet Mindfulness Questionnaire (FFMQ) (Baer et al., 2006) is a self-report questionnaire which includes 39-items that measure 5 subscales of mindfulness (observing, describing, acting with awareness, non-judging and non-reacting). Items are rated on a five-point scale ranging from 1 (never or very rarely true) to 5 (very often or always true). Total scores range from 39-195, with subscale scores calculated separately. Baer and colleagues reported good internal consistency (a= .75-.91) and test-retest reliability (r = .65-.83).

3.3.2. Executive Functions

According to (Diamond, 2013) EFs can be divided into 'core' EFs (inhibitory control, working memory and cognitive flexibility) and 'higher-level' EFs (reasoning, planning and problem-solving) all involved in maintaining goal based behaviour requiring supervisory attentional skills (SAS). The task is consistent with SAS model (Norman & Shallice, 1986) of EF in that it relies on concept formation (understanding and applying the task rules), establishing a pattern of response which inhibits the old response based on feedback and generating a new response to solve the problem. In accordance with Diamond (2013) the choice of the WCST would be more befitting of core EF processes involved in 'cognitive flexibility' which is underpinned by core EFs of 'updating working memory' and 'inhibiting', therefore a suitable task for tapping into core EF processes alongside higher EFs such as problem solving. The concept of cognitive flexibility can be seen as synonymous with Miyake et al'.(2000) 'shifting' core EF description (Snyder, Miyake, & Hankin, 2015).

We used an adapted computerised version of the Wisconsin Card Sorting Test (WCST) (Heaton et al., 1993). The WCST is a standardised test of EF which requires a person to execute

their plan, monitor actions and feedback, and change their plan. It is one of the most frequently used measures of EF (Lezak, 2004). The WCST involves matching stimulus cards with one of four category cards, in which the stimuli are multidimensional according to colour, shape and number – each dimension defining a sorting rule. Participants must figure out the rule based on feedback (right or wrong) through a process of trial and error. There are up to 6 attempts to derive a rule and each rule attainment is met with feedback of completing a category. Participants are unaware sorting principles shift during the test. The task measures two types of errors, firstly, perseverative errors in which participants make a response in which they persist with a wrong sorting rule, and non-perseverative errors. The task also gives data regarding how many trials it takes for a participant to establish the correct rule and if the participant was able to maintain the correct set. This study utilised a 60-card version based on making the experimental task less burdensome on the participant to ensure full participation. In the current study, trials to complete first category was considered a measure of concept formation and perseverative errors a measure of shifting.

3.3.3. Dependent variable - Difficulties in Emotion Regulation Scale

The Difficulties in Emotion Regulation Scale (DERS; (Gratz & Roemer, 2004) is a self-report questionnaire consisting of 36-items measuring emotion regulation difficulties. This consists of 6 subscales (non-acceptance, goals, impulse, awareness, strategies and clarity). Items are rated on a five-point scale ranging from 1 (almost never) to 5 (almost always). Total scores range from 36-180. Higher scores suggest greater problems with ER. Scores can also be calculated for different subscales but for the purposes of this study we will calculate the total score. Gratz and Roemer have demonstrated the DERS to be a valid and reliable measure with good internal consistency (a = .93), consistency between subscales (a = .80) and test-retest reliability (p = .88).

3.4. Procedure

Ethical approval was gained by the Faculty of Medicine and Health Sciences at University of East Anglia (Appendix A). The Lead Investigator and research team posted the advert onto social media with a link attached to the online survey. Once clicked, this led participants to the information sheet and option to consent and proceed to undertake the study. Demographic information, WCST, measures of mindfulness and emotional regulation were

completed at one time point on the platform Psytoolkit (Stoet, 2010; 2017), lasting approximately 20 minutes.

3.5. Data Preparation

Descriptive and frequency analyses of the scores on the questionnaires and WCST were performed. Frequency analysis was used to identify missing data. There was no missing data for the mindfulness, EF and ER measures. All variables were standardised to z-scores in order to help compare the coefficients as different units of measurement had been used (Field, 2013).

General guidance on required sample sizes for SEM (Kline 2016; Tabachnick & Fidell, 2013) indicated we were underpowered for this method of analysis, therefore we could not explore our final objective in exploring facets between all the measures. In order not to increase the chance of Type I errors we therefore used multiple regression analyses. This plan helped us to consider the pairwise associations between our three variables of interest in considering the basis for further exploratory mediational analyses of specific components of mindfulness and EF (IVs), and their effects on ER (DV). Our decision to explore ER as a unitary construct for the purposes of this study was because our hypotheses are concerned with identifying specific FFMQ and WCST components. Additionally, we elected this approach to minimise the possibility of a type II errors.

In preparation for building regression models, distributions of all variables were explored to see they met the assumption of normality distribution for parametric testing. The FFMQ was normally distributed. Potential outliers were examined visually through histograms and P-P plots to ensure assumptions of linearity and homoscedasticity had been met. Sensitivity analyses were run to explore the presence of outliers on the planned regression models. Independence of errors assumption was checked with the Durbin-Watson statistic.

In preparation for exploratory mediation analysis, significant FFMQ subscales would serve as predictors and the logarithm transformed total DERS was our outcome. WCST indices associated with both FFMQ subscales and ER would be explored as mediating variables.

3.6. Data Analysis

Our first regression model will also examine our first and second hypothesis. Our third hypothesis will be examined in our third regression model. Our fourth hypotheses will be explored in our second regression model. Regressions were undertaken to control for the influence of demographic variables on mindfulness, EF and ER. Demographic variables were entered in the first block using the enter method, followed by facets of mindfulness and EF our measures in the second block for our respective models. These analyses will yield models in which each component IV (the 5 FFMQ subscales, the 2-3 EF subtest scores) can be compared by looking at the coefficients to see which ones seem to have the largest contribution to the DV (DERS). Inspections of the models for effect sizes to identify level and significance of contribution of each variable will determine variables for later exploratory mediational analyses to examine our fifth hypothesis. We planned to use mediation analysis using the PROCESS code (Hayes, 2013) if each regression model was significant using the re-sampling bootstrapping technique.

The highest number of IVs was 10 (regression model 1 and 3). Based on this model G*Power sample size estimation to achieve a power of 0.80 to observe a medium effect size of 0.15 requires a minimum of 118 participants (Erdfelder, Faul, & Buchner, 1996). Our sample of 125 completed surveys means this study was sufficiently powered to perform our analysis plan.

4. Results

Data was analysed using Statistical Package for the Social Sciences version 25. Alpha level was set at .05 for regression and mediation analyses. Assumptions for multiple linear regressions were mostly satisfied, however there was presence of skewness in total DERS and EF indices. Table 1 shows participant characteristics for those included in the study.

Table 1. Participant characteristics (n = 125)

Gender, % Male/Female/Other	32/67/1
Mean age in years (*SD*)	37.1 (*14.0*)
Age range	20-84
Education[a], % minimum/further	2/98
Employment status,%	
Unemployed	14
Self-employed part-time	3
Self-employed full-time	3
Part-time employment	18
Full-time employment	55
Retired	7
Mindful practice[b], % Yes	48
Conditions[c], % Yes	7
Country of origin[d], %	
United Kingdom	59
Europe	10
Asia	20
North America	8
Middle East	2
Other	1

Note. [a] Minimum education refers to 11 years and further is beyond that.

[b] Mindful practice refers to carrying out mindful (meditation, yoga, pilates) practice in some way on a regular basis (e.g. 1 or more times per week).

[c] Neurological and developmental conditions refer to the following; acquired brain injury, learning disabilities, multiple sclerosis, Autism, Asperger's Syndrome.

[d] Country of origin refers to country person was originally from. Data has been grouped to continents except for the UK due to the large number of participants for that group.

Table 2 presents the descriptive data of outcome measures. The FFMQ showed a normal distribution, however both total DERS and WCST indices were negatively skewed, meaning logarithm transformations were performed for total DERS and for the individual WCST indices, resulting in normal distributions. There was no collinearity between predictor variables. The correlation between total FFMQ and DERS was strong, however, this study was interested in the FFMQ subscales as predictors of DERS (correlations were small to moderate). Observed correlations did not influence the predictor demographic variables entered into our regression models. Indeed, univariate screening to select predictor variables has been criticised for increasing the likelihood of inflating models (Babyak, 2004), therefore demographic selections were a priori based on previous research.

Table 2. Descriptive correlations for key study variables.

Measures	*n*	Mean (*SD*)	Range	Response Time (ms)	FFMQ	WCST	DERS
FFMQ							
Observe	125	27.0 (*5.7*)	14-39			.06	-.23
Describe	125	27.7 (*5.5*)	8-40			.21	-.47
Awareness	125	25.1 (*6.3*)	8-39			.01	-.43
Non-judge	125	27.1 (*6.8*)	11-40			-.13	-.57
Non-react	125	21.6 (*4.9*)	10-33			.00	-.56
Total FFMQ	125	128.4 (*18.1*)	72-173				.71
WCST				1913.4			
Perseverative errors *z*-score	125	0.3 (*0.2)*	-0.9-0.8		-.20		.21
Non-perseverative errors *z*-score	125	0.3 (*0.2)*	-0.9-0.9		-.06		.02
Categories achieved *z*-score	125	0.5 (*0.1*)	0.2-0.9		-.10		.12
Composite score *z*-score	125	0.3 (*0.2*)	-0.9-0.7		-.10		.14

DERS	125	80.5 (*21.7*)	39-150	.71	.14

Note. FFMQ = Five Facet Mindfulness Questionnaire; WCST = Wisconsin Card Sorting Test; DERS = Difficulties in Emotion Regulation Scale

4.1. Regression model one: Influence of mindfulness on emotional regulation

Support was found for hypothesis one. With mindfulness IVs in the model a significant proportion of variance in ER was accounted for, $R^2 = 68.1$, adjusted $R^2 = 65.3$, $F_{(10,114)} = 24.3$, $p = .001$. Partial support was found for our second hypothesis in that both predicted facets were significantly related to ER, however 'non-react' had the biggest effect, which was not predicted. In the final model after controlling for demographic variables, higher scores on FFMQ describe ($\beta = -.30$, $t(114) = -4.93$, $p<.001$), FFMQ act with awareness ($\beta = -.15$, $t(114) = -2.44$, $p<.01$), FFMQ non-judge ($\beta = -.34$, $t(114) = -5.86$, $p<.001$) and FFMQ non-react ($\beta = -.42$, $t(114) = -6.90$, $p<.001$) subscales were associated with lower levels in self-reported difficulties in ER. See Table 3.

Table 3. Summary of multiple regression analyses testing the contribution of mindfulness subscales in accounting for emotional regulation.

	Standardised		
Predictor	*B*	*t*	*p*
Gender	-.16	-2.86	.01**
Age	-.15	-2.61	0.1**
Education	-.04	-.66	.51
Mindful	-.25	-4.09	.02**
Condition	.13	2.28	.00**
FFMQ subscales			
Observe	-.07	-1.15	.25
Describe	-.30	-4.93	.00**
Awareness	-.15	-2.44	.02**
Non-judge	-.34	-5.86	.00**
Non-react	-.42	-6.90	.00**

Note. FFMQ = Five Facet Mindfulness Questionnaire.

*$p < .05$, **$p <.01$.

4.2. Regression model two: Influence of mindfulness on executive functioning

Contrary to our fourth hypothesis, the model regressing FFMQ on concept formation (trails to first set) was not significant, $R^2 = 9.2$, adjusted $R^2 = 1.3$, $F_{(10,114)} = 1.16$, $p = .33$. Increases in FFMQ 'describe' was associated with fewer trials needed to complete first category ($\beta = -.26$, t (114) = -2.54, $p < .05$). However, a significant proportion of variance in perseverative errors ($R^2 = 22.6$, adjusted $R^2 = 15.8$, $F_{(10,114)} = 3.33$, $p = <.001$) and non-perseverative errors was accounted for ($R^2 = 14.4$, adjusted $R^2 = 6.9$, $F_{(10,114)} = 1.92$, $p = . <05$). Higher FFMQ 'describe' ($\beta = -.28$, t (114) = -2.99, $p < .01$) and FFMQ 'non-judge' ($\beta = -.35$, t (114) = -3.87, $p < .001$) were associated with fewer perseverative errors, however increases in FFMQ 'observe' ($\beta = .20$, t (114) = 2.14, $p < .05$) was associated with increased perseverative errors. Increases in FFMQ 'describe' were also associated with non-perseverative errors ($\beta = -.25$, t (114) = -2.53, $p < .05$). See Table 4.

Table 4. Summary of multiple regression analyses testing the contribution of mindfulness subscales in accounting for executive functioning subscales

Dependent variable	Trials		Perseverative		Non-Perseverative	
Independent variables	*B*	*p*	*B*	*p*	*B*	*p*
Gender	-.10	.28	-.18	.05*	-.06	.52
Age	.08	.40	.09	.33	.12	.21
Education	.09	.32	-.11	.22	-.12	.18
Mindful	.11	.28	.14	.13	.06	.56
Condition	.04	.65	-.10	.25	.24	.01*
FFMQ subscales						
Observe	.09	.39	.20	.03*	.14	.16
Describe	-.26	.01*	-.28	.01**	-.25	.01*
Awareness	.13	.21	.10	.29	.14	.16
Non-judge	-.10	.31	-.35	.01**	-.09	.34
Non-react	-.04	.73	.03	.78	.06	.54

Note. FFMQ = Five Facet Mindfulness Questionnaire.

*$p < .05$, **$p < .01$.

4.3. Regression model three: Influence of executive functioning on emotional regulation

With EF indices in the model, a significant proportion of variance in DERS was accounted for, $R^2 = 14.5$, adjusted $R^2 = 8.6$, $F_{(8,116)} = 2.46$, $p = .<02$. In the final model, only increased perseverative errors ($\beta = .23$, t (116) = 2.14, $p < .05$) predicted higher levels of difficulties in ER therefore supporting our third hypothesis regarding shifting aspect of EF only (Table 5).

Table 5. Summary of multiple regression analyses testing the contribution of EF indices in accounting for emotional regulation.

	Standardised		
Predictor	*B*	*t*	*p*
Gender	.00	.02	.99
Age	-.29	- 3.26	.01**
Education	-.04	-.44	.66
Mindful	-.08	-.95	.34
Condition	-.05	-.42	.63
WCST factors			
Categories achieved	.09	.69	.49
Perseverative errors	.23	2.14	.04 *
Non-Perseverative errors	-.10	-.83	.41

Note. WCST = Wisconsin Card Sorting Test.

*$p < .05$, **$p <.01$.

4.4. Mediation analysis

Given we observed significant associations between facets of mindfulness, perseverative errors and ER, we had the basis for exploring our fifth hypothesis of mediating effects via EF. Specifically, we observed FFMQ ‘non-judge’ was strongly associated with perseverative errors and FFMQ ‘describe’ was associated with all EF indices. However, only perseverative errors were associated with ER, therefore trials to complete first category and non-perseverative errors were not examined as potential mediators. Exploratory mediation analysis was therefore performed using the PROCESS code (Hayes, 2013) to explore perseverative errors as the mediating variable between identified FFMQ facets (describe, non-judge) and ER. FFMQ ‘describe’ was related to all EF indices so therefore investigated first. Perseverative errors were

significantly predicted by FFMQ 'describe' scores (b = -.05, SE = 0.01, p = <.001) but did not significantly predict ER (b = .08, SE = 0.04, p = .11). When perseverative errors are not in the model, describe significantly predicts ER (b = -.04, SE = 0.02, p = .01). Since a mediator must be associated with both predictor (describe) and outcome (DERS), this suggests perseverative errors is not a mediator between the describe facet and total DERS. Figure 1 contains the path model of mediation.

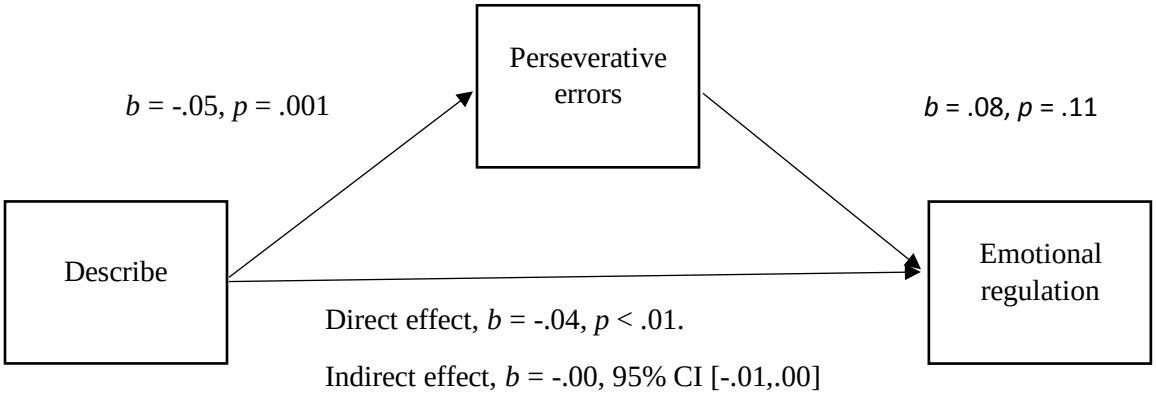

Figure 1. Path analysis for mediation by perseverative errors of the association between describe facet of mindfulness and emotional regulation.

FFMQ 'non-judge' did significantly predict DERS (b = -.06, SE = 0.02, p =.001). The R^2 value tells us that non-judge explains 9% of the variance in DERS. FFMQ 'non-judge' significantly predicts perseverative errors (b = -.06, SE = 0.01, p = <.001); however, perseverative errors did not significantly predict ER (b = .04, SE = 0.05, p = .39). As perseverative errors did not predict DERS this indicates no mediation effect. See Figure 2.

In summary, both models demonstrate that as FFMQ 'describe' and 'non-judge' facets increase, perseverative errors decrease, and as perseverative errors increase so do ER difficulties, but not significantly. Therefore, mediation of FFMQ 'non-judge' and 'describe' facets effect on ER by perseverative errors was not supported, in the context of clear effects.

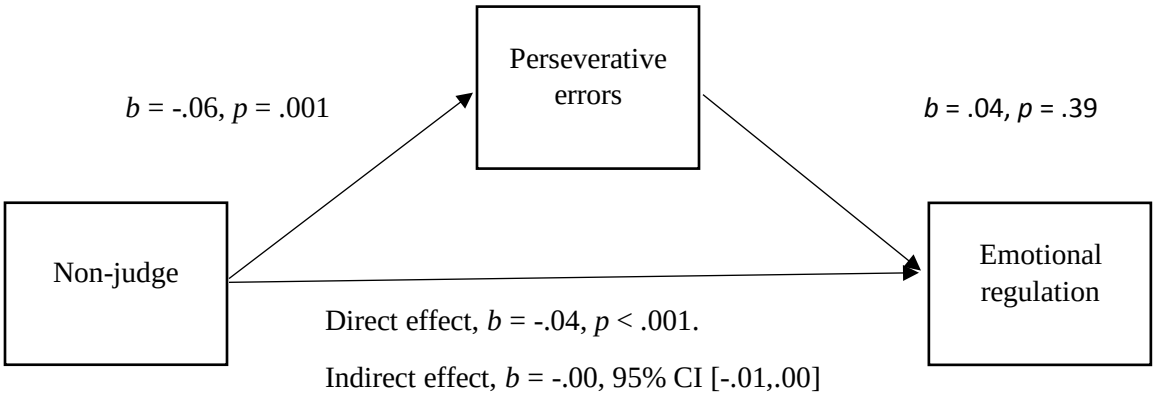

Figure 2. Path analysis for mediation by perseverative errors of the association between non-judge facet of mindfulness and emotional regulation.

5. Discussion

This study has extended previous research demonstrating relationships between mindfulness and ER. In addition to replicating this association, we found FFMQ 'non-judge' and 'describe' aspects of mindfulness to be associated with 'shifting' aspect of EF and with ER, however, further analysis did not support mediation.

In relation to our first hypothesis of which predicted FFMQ facets would significantly predict total score variance in DERS, our findings provide strong support. The addition of mindfulness facets accounted for 60% variance in ER, illustrating a strong association. These results are consistent with the extensive literature exploring the beneficial psychological effects of mindfulness and models which postulate mindfulness operates via reappraisal strategies, such as acceptance (Webb et al., 2012). There was also partial support for our second hypothesis, in that both FFMQ 'acting with awareness' and 'non-judging' mindfulness facets would be most strongly associated with ER in line with previous findings (Baer et al 2006; Short & Mazmanian, 2013; Teper et al, 2013). Although both were associated, the most significant predictor was FFMQ 'non-react' which is contrary to previous findings. We also found support for Baer et al. (2006) in that only the observe facet is a non-significant IV. They observed a positive correlation suggesting negative effects for ER, however, this effect was moderated by

increases of experience with mindful practice. Our findings only explored practice as a possible confounding variable, so we are unable to comment on practice effects influencing this relationship. However, it makes intuitive sense that 'observe' alone would not be adaptive as it implies no appraisal strategy or course of action to improve one's situation. A recent meta-analysis exploring ER strategies found that 'attentional deployment' (e.g. initial orientation, concentration) (Ochsner & Gross, 2008) produced no overall effect in modifying emotional outcomes (Webb et al, 2012). It could be, the FFMQ 'observe' facet scaffolds the other facets which we have found to facilitate adaptive ER. This fits with the process model of ER postulated by Gross & Ochsner (2008) whereby initial orientation is followed by a sequence of other processes in adaptive ER strategies.

There was partial support for our third hypothesis in that WCST indices would predict total variance in DERS. We found an association between perseverative and non-perseverative errors and ER, but no significant association between concept formation and ER. Only FFMQ 'describe' was related to concept formation and all other EF indices. This indicates higher FFMQ 'describe' is the only mindfulness aspect which has any bearing on how quickly a person establishes the rules of a task, alongside being involved when required to switch or making errors at random. Higher FFMQ 'non-judge' also contributes to higher cognitive flexibility.

The contribution of perseverative errors as an IV in accounting for variance in ER lends support to other studies which have found correlations between core EFs impairments in cognitive flexibility and poor use of adaptive ER strategies (Joormann & D'Avanzato, 2010; Lyvers et al., 2014; McRae et al 2012), including processes such as worry (Synder et al., 2014) and rumination (Derneyer et al., 2012). This is in line with other findings such as higher shifting ability associated with less rumination and use of adaptive ER strategies of reappraisal (Hendricks & Buchanan, 2016). It could be difficulties with shifting exacerbate these processes, causing further distress. This is consistent with the Self-Regulatory Executive Functions (S-REF) model (Wells & Matthews, 1994) whereby perseverative emotional cycles like rumination and worry are thought to reduce specific EF processes, thereby decreasing ability of the person to self-monitor and shift attention away when ruminating or worrying which can then exacerbate emotional distress. Of course, the reverse may be true where emotional distress disrupts EF processes leading to rumination and worry tendencies.

Consistent with previous findings (Gallant, 2016; Moynihan et al., 2013), the current findings provide only partial support for our fourth hypothesis of a direct relation between mindfulness facets and perseverative errors, but not concept formation as predicted. Somewhat surprisingly, the FFMQ 'describe' facet was negatively related to all WCST indices, with FFMQ 'non-judge' and observe facets being negatively and positively related to only perseverative errors, respectively. Three out of the five FFMQ facets was associated with perseverative errors, with higher FFMQ 'non-judge' and 'describe' facets associated with less perseverative errors (e.g. higher cognitive flexibility). This supports findings from other studies which have found cognitive flexibility to be positively correlated to meditation practice and levels of mindfulness (Moore & Malinowski, 2009). Interestingly FFMQ 'observe' association was in the opposite direction, which again highlights observing alone doesn't appear to have beneficial effects, and in this case possibly detrimental effects. It must be noted all our observed significant associations demonstrated small to moderate effects, and there was no relation between FFMQ 'acting with awareness' and 'non-reactivity' which is not in keeping with previous research (Anicha et al., 2012).

Our final hypothesis of EF indices mediating the relationship between mindfulness and ER in accordance with the Teper model was not supported. Testing of the mediating path showed that as FFMQ 'describe' and 'non-judge' increase, perseverative errors decrease, and this was statistically significant. A trend was found in terms of better ability to shift (lower perseverative errors) was associated with greater ER difficulties, but this was not statistically significant. Therefore, no mediational effects were found. As found in the regression models, FFMQ facets significantly predicted ER even with EF in the model. Taken together, this suggests that EF difficulties in the form of cognitive flexibility need consideration but are not a key factor when considering the relationship between mindfulness disposition and ER difficulties.

5.1. Limitations

A limitation of our study is the lack of breadth of tasks we used to measure a multidimensional construct such as EF. A more rigorous approach would have used an array of measures tapping into different EF processes in accordance with contemporary theoretical accounts of EF (Diamond, 2013; Miyake et al., 2000; Stuss, 2011). Research findings have shown the WCST does tap into other non-executive processes. For instance, perseverative errors

may reflect specific deficits in processing feedback accurately, a lack of cognitive flexibility resulting in a failure to understand task rules have changed, or a too narrow attentional focus on one specific dimension while failing to monitor others (Gläscher, Adolphs, & Tranel, 2019). There are also concerns about the poor ecological validity of these type of measures (Burgess et al., 2006).

It must also be noted the DERS (emotional regulation) and FFMQ (mindfulness) data were highly correlated, which indicates the measures deployed could actually reflect the same construct. Coffey et al (2010) performed a series of exploratory and confirmatory factor analyses of the subscales which revealed a four-factor model of awareness, clarity, acceptance and negative ER. Each factor included subscales from both the mindfulness and ER measures. Our study was limited in its scope in examining mindfulness and ER as distinct or overlapping constructs so we cannot comment further on this. The sample size was too low for Structural Equation Modelling (SEM), therefore preventing us from looking at a wider range of relationships within the constructs.

Our regressions show some promise in terms of relationships in line with our hypothesis, however these are all for confounds controlled for, and looking at facets of mindfulness alongside one another. We must also acknowledge just under half of our sample reported regular mindful practice once per week which indicates a likely self-selection bias in motivation to participate in the study, thereby inflating the benefits of mindful based practices.

The mediation analyses were limited to individual variables in isolation, so risking reduced ability to detect relationships. Another issue is the WCST might not be sensitive enough to get a good range of scores in a general population sample. We had a small number of people who reported clinical conditions (n=9), but it's doubtful this would contribute to a good wide range of abilities across the WCST and the sample. This might account for the trend, but lack of significance we observed.

5.2. Implications for future research and clinical practice

Future studies should carefully consider EF measurement. Based on our findings, shifting/cognitive flexibility EF measures should be included in future studies, but the need for more sensitive shifting measures, such as the Verbal Fluency Test and Trails Making Test part B (subtests from the D-KEFS: (Delis, Kaplan, & Kramer, 2001) is warranted. The use of experimental designs with clinical populations with EF impairments and matched healthy control groups will add further rigor to reported associations detected in cross-sectional designs. Longitudinal designs will help unpack the debate around cognitive improvements sustaining, and whether practice effects are correlational or causal (Vago, Gupta, & Lazar, 2019). Within that, research should look at more specific effects of mindfulness on EFs and how this relates to ER difficulties and emotional outcomes. This will guide clinical practice in the context of adapting psychological therapies when considering individual differences in EFs or specific EF profiles associated with progressive and acquired neurological conditions.

Given the limited findings which have explored these relationships in both clinical and non-clinical populations, it is too early to formulate more specific links within those relationships and how this might inform clinical practice. However, there does appear to be a role of core EF processes such as cognitive flexibility, given we found it was related to specific aspects of mindfulness and ER difficulties. This appears to align to therapeutic approaches such as ACT, where mindfulness skills are a key process in promoting psychological flexibility, which has some conceptual overlap with cognitive flexibility (Whiting, Deane, Simpson, McLeod, & Ciarrochi, 2017). As suggested by Whiting and colleagues further research is needed to explore whether such approaches to compensate for impairments in cognitive flexibility can promote acceptance.

5.3. Conclusions

Our findings contribute to the existing literature by providing a more detailed inspection of specific mindfulness and core EF processes such as cognitive flexibility. We found FFMQ ‘describe’ aspect was associated with both concept formation and cognitive flexibility, and FFMQ ‘non-judge’ aspect also contributes to higher cognitive flexibility. However higher FFMQ ‘observe’ was positively correlated to perseveration errors, indicating negative effects. Despite associations between these specific aspects of mindfulness, cognitive flexibility and ER, we did not observe mediation via perseveration errors. Our findings therefore do not support the

conceptual model of 'executive control' acting as a mediator between mindfulness and ER as postulated by Teper, Segal & Inzlicht (2013). The finding of FFMQ 'describe' aspect being related to all indices of EF and ER, fits with the existing literature that verbal labelling of emotion alone appears sufficient to reduce activity in amygdala and insula emotional response areas (Ochsner & Gross, 2008). Interestingly, the FFMQ aspect of higher 'non judge' abilities being associated with less perseveration errors and difficulties with ER also supports Farb et al. (2012) in that non-engagement of cognitive reappraisal (which relies on working memory, cognitive flexibility and verbal fluency) can also be an adaptive ER strategy. This is a promising finding for populations such as TBI where severe EF difficulties make it severely difficult to implement cognitive reappraisal techniques (Anson & Ponsford, 2006). In a case study of ABI where executive difficulties are prominent, Salas et al. (2013) found inhibition difficulties resulted in concrete thinking (cognitive inflexibility) making it difficult to spontaneously generate reappraisals, which supports the Ochsner & Gross model of sequences of self-regulatory processes such as working memory, inhibition and cognitive flexibility involvement for adaptive ER.

Our findings also must be considered in the context of the methodological weaknesses in relation to our analysis plan and not being able to unpack all the facets of the mindfulness, EF and ER to get a clearer picture of effects. That said there is some indication that some specific core EF abilities related to cognitive flexibility may have a role to play in ER, and therefore may be of clinical relevance. Further work is therefore needed to foster a deeper understanding of specific relationships between potentially helpful interventions such as mindfulness-based interventions and improved ER.

Funding

This empirical paper was conducted as part of the first authors' doctoral training in clinical psychology.

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CHAPTER 5: Additional Methodology

Chapter Overview

This chapter details additional methodology not included in the main empirical paper. This includes a more detailed discussion about the ethical considerations of the empirical study.

Word count: 1197

1. Additional method

This additional method chapter includes details of the method and procedure not covered in the main paper due to limited word count.

1.1. Procedure

Potential participants were approached via social media links. Social media platforms of Twitter, Facebook and Linkedin were used. The Lead investigator and research team posted the advert onto their timelines to share with followers and encouraged followers to share in turn. The social media links contained an advert about the study and a link to the survey. Potential participants were then encouraged to click on the link provided which took them to the participant information sheet (PIS) (see Appendix D) embedded in the online survey platform PsyToolkit (Stoet, 2017). After reading the PIS, contact details of the researchers involved and point of contact for any complaints were provided. Participants were then given information in relation to web browsers and the need to use a keyboard to successfully complete the survey. Health Research Authority (2017) (HRA) guidance for online surveys states that consent can be assumed granted once a person has clicked on the link provided on the PIS to proceed to the study. However, we added a tick box asking participants to click it if they wish to take part to explicitly request consent. The survey could not be accessed until this was clicked.

Participants were required to fill in demographic information concerning age, sex, educational attainment and experience of using mindfulness. No identifiable information was collected. Participants first completed the WCST whereby specific instructions around the rules of the test and how to navigate the keyboard and cursor were provided. Psytoolkit (Stoet, 2017) provided an example for practice before advancing to the test. Upon reading the instructions, participants were required to press ‘q’ using the spacebar to advance to the test. Upon completing the WCST, participants were then required to complete the FFMQ and DERS self-report questionnaires. This took the participants through all the measures of the test and was expected to last between 15-20 minutes. Upon completion, participants were met with a debrief page and given the opportunity to email the researchers if they wish to be considered for the prize draw of six Amazon vouchers worth 10 pounds each. Participants were thanked for participating and

informed that their role in the study was completed at this stage. Participants were offered the opportunity to contact the researcher if they would like to see the published findings in the future.

1.2. Ethics

1.2.1. Informed consent

All participants were invited to take part in the study via social media platforms, such as Facebook, Twitter and LinkedIn. A post was made by the researchers advertising the study which contained a link which directed people, once clicked, to the PIS. The PIS provided detail about the nature of the study, right to withdraw, potential harm and benefits, time to complete and how the data will be stored. Health Research Authority (HRA) (2017) guidance for online surveys states consent can be assumed granted once a person has clicked on the link provided on the participant information sheet to proceed to the study. However, we added an additional tick box asking participants to click it if they wished to take part in the study to gain consent explicitly. Participants could not proceed until they had ticked this box.

1.2.2. Confidentiality

The study did not require people to provide their names as it was an anonymous dataset. Only demographic details were required. The study did offer the chance to be included into a prize draw for Amazon vouchers. On completion of the study, participants were given the opportunity to send the lead researcher their contact details if they wish to be entered into the prize draw. Their contact details (first name and email) were handled separately from responses on the questionnaire to ensure anonymity and were transferred to an excel spreadsheet file which was password protected and only privy to the researcher. As such all data was kept electronically. All personal details were destroyed upon the prize draw being completed.

The online survey was programmed via PsyToolkit. PsyToolkit is a web-based data collection tool which allows both collection of online survey data and contains already coded psychological experiments. The survey was created with the psychological experiment embedded into the same survey. Data was stored on their webserver which is based in Strasbourg, France. This falls in line with the new General Data Protection Regulation (GDPR)

(Information Commissioner's Office, 2018) as the UK was part of the European Union at time of data collection. Additional guidance and advice were sought from Information Compliance and Data Protection Specialists at UEA who confirmed the study was GDPR compliant. GDPR states data should not be transferred outside the European Economic Union. Only the PsyToolkit developer, Professor Dr Gijsbert Stoet had access to the data, as he manages the server. To comply with the new UK Data Protection Act (UK Parliament, 2018), this was stated in the participant information sheet. From liaising with Dr Stoet, I was informed data is held on the server during the study. The webserver backs up data daily, so it was unlikely data would be lost during the study. Data was accessed by me (Philip Goldstone) at UEA and downloaded periodically to the UEA network drive. Once the survey was closed and all data downloaded from the Psytoolkit server, it was permanently deleted from the server. Data was routinely downloaded from the server whilst on a UEA networked computer. Data was stored in line with the UK Data Protection Act and UEA Data Management policy (2015), and my primary supervisor will be the data custodian and responsible for the management of data. At the end of the study the data will be archived for 10 years then destroyed.

1.2.3. Coercion

Given the study was an online survey, we did not anticipate any coercion issues, as there was not a direct interface with people which might promote power imbalances (British Psychological Society, 2014). Furthermore, the identity of participants was anonymous meaning participant autonomy to participate was not compromised.

1.2.4. Distress/Debriefing

This study did not place participants under undue distress. We anticipated some mild frustration completing the WCST, however, expectation of making errors was stated before the task in the instructions to normalise this eventuality. In the debrief section participants were given contact details of the main researcher if they had questions about the study. I did not receive correspondence regarding distress, only contact in relation to be included for the prize draw and curiosity around when the research would be published. Participants were encouraged to contact their GP/family doctor if they had health-related questions or concerns resulting from participation. To our knowledge no such concerns resulted from participating in the study.

1.2.5. Right to withdraw

Participants were free to withdraw during the completion of the survey at any stage. Due to the data being anonymous, participants were not able to request withdrawal of their data upon completion of the survey. This was because we had no way of knowing who provided which data set. This was clearly indicated in the PIS also to help people consider whether they wished to participate or not. We had no such requests, and everyone who was able to access the survey completed it in its entirety.

CHAPTER 6: Additional Results

Chapter Overview

This chapter relates to additional results from the empirical paper.

Word Count: 2363

1.1. Data preparation

Data was downloaded from Psytoolkit server to an Excel spreadsheet. Items of the FFMQ and DERS were reverse-coded to ensure accurate scoring. Participants were ascribed an automatic unique identifiable combination of letters and numbers alongside raw data given for the demographics, DERS, FFMQ, time to complete and response times to WCST. This data was exported to SPSS version 25. Psytoolkit could only produce individual participant text files of raw data (containing unique identifier) for WCST, which were not scored. Scores were then manually scored by one person (Philip Goldstone), noting the following; total number of errors, perseverative errors, non-perseverative errors, average response times and trials to complete categories. Scores were re-rated by the same individual to improve reliability and consistency. Upon scoring, the WCST data was matched to the correct participant identifiable combination on SPSS for data input.

1.2. Methods of analysis

Multiple regression analysis was selected to ascertain the relationships between mindfulness, EF and ER as basis for exploring indirect effects via EF in a path analysis. Stepwise methods are more exploratory, and variables are placed into the model all at one time (Clark-Carter, 2018). They are influenced by random variation in the data which effects replicability of findings. Given we had some pre-conceived ideas around theory and evidence, this exploratory method was deemed unsuitable. Strong effects have been reported between mindfulness and emotional outcomes, along with directional relationships with EF. There are conceptual models proposed which consider the direction of these relationships and Teper, Segal & Inzlict's (2013) conceptual model is one we have based some of our hypotheses on. Therefore, a hierarchical model was selected as we had some existing theory and research to build our models on to inform the order of influential IVs for our analysis. This involved entering our IVs in 2 blocks. The first block being demographics, and the second influential IVs from our measures. We used the 'enter' method of regression for both blocks. This way we could ascertain how much extra variance our measures accounted for.

We reported the adjusted R^2 statistics in the model summary for all 3 regressions. This statistic shows how much of the variance in the DV can be explained by the predictor variables

when entered in block one and two. The model also illustrated the unique contribution of each predictor to the model, and this is checked under the beta heading of the output box labelled coefficients (Field, 2013). For results we reported 'standardised coefficients' to aid ease of interpretation. This told us the number of SDs that the outcome will change as a result of one SD change in the predictor, thereby allowing direct comparison of predictors. The predictor that shows the largest beta value is considered to make the strongest individual contribution to explaining the DV, when all other variables are held constant (Field, 2013).

The mediation analysis was carried out using the PROCESS computerised tool for path analysis (Hayes, 2013), containing the syntax which was free to download via SPSS. In this model, variable X (predictor - FFMQ) is modelled to influence Y (outcome – DERS) directly as well as indirectly through a single intermediary or mediator variable causally located between X and Y. The conceptual mediational model is presented in Figure 1; Hayes, 2013).

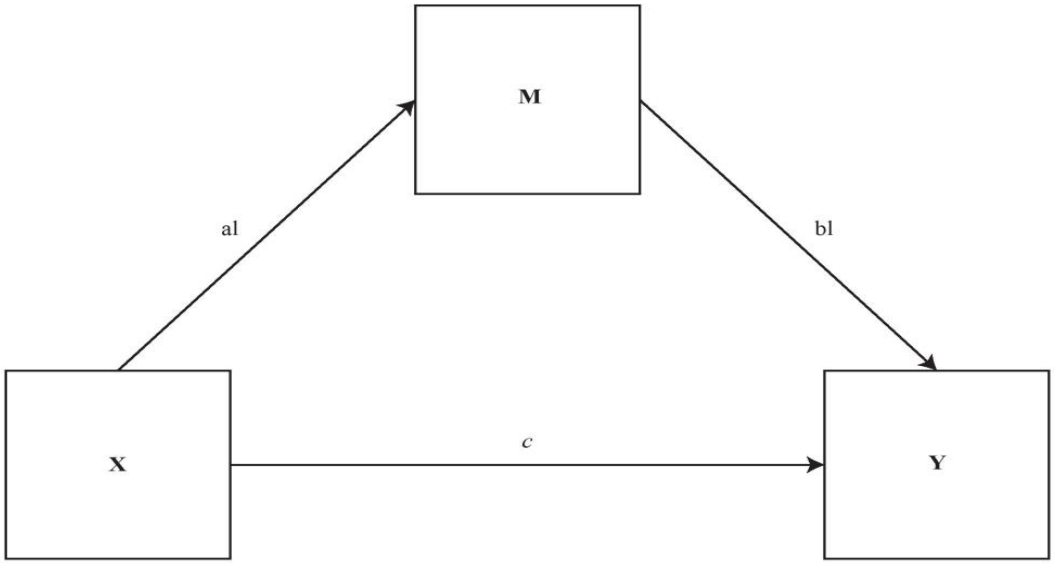

Figure 1. Conceptual mediation model

X = predictor variable

Y = criterion variable

M = mediating variable

a1 b1 = Indirect effects of X on Y, c = direct effect of X on Y.

There are other approaches such as the Baron & Kenny (1986) causal steps method and Sobel (1982) test for mediation effects. The former is criticised due to low power increasing chances of Type II errors and lack of quantification of the intervening effect resulting in probable Type I errors (Hayes, Slater, Snyder, Preacher, & Hayes, 2014). The latter makes more assumptions about the shape of the distribution of the indirect effect and is considered less powerful (Briggs, 2006). Therefore, mediation analysis using the re-sampling technique of bootstrapping was used to investigate our hypothesis of EF mediating the relationship between mindfulness and ER. Bootstrapping techniques create an empirical estimation of the distribution of the population based on the data in the sample (Hayes, 2013). Bootstrap methods use bias-corrected confidence intervals (BC CI) and we set this at 95%. A 95% CI is a range of values that you can be 95% certain contain the true effect of the population (Prince et al., 2003), thereby making allowances for the effect of sampling error. If the upper and lower bounds of the BC CI do not contain zero a significant mediation effect can be inferred. The benefit of bootstrapping methods compared to other methodologies is increased power in detecting mediation effects and reducing possibility of Type 1 errors (MacKinnon, Lockwood, & Williams, 2004). Preacher and Kelley (2011) suggest using at least one measure of effect size alongside BC CI. Accordingly, we interpreted the effect size with Kappa-squared (k^2) along with the explained variance (R^2) in ER.

1.3. Statistical analysis assumptions

Box-plots and histograms were examined to detect potential influential outliers which might bias the model. Linearity and homoscedasticity were examined using bivariate scatterplots for all variables of interest – plotting standardised predicted values against standardised residuals (Field, 2013). Linear relationships and homoscedasticity assumptions were met for all 3 regression models.

Normality of the distribution was assessed using skewness, kurtosis and visual inspections of histograms. Skewness is a measure of symmetry in distribution and kurtosis refers to the spread of scores (Clark-Carter, 2018). To establish whether the assumption of normality was violated, scores were converted to z-scores. Skewness and kurtosis are considered potentially problematic when above > 1. The DERS and EF indices scores were above this cut-

off, therefore logarithm transformations were completed to normalise negatively skewed distributions to enable parametric testing. Residual checks were completed. Field (2013) recommends that 95% of the sample should fall within one SD (-1.96 and 1.96) and 99% should fall within two SDs (-2.58 and 2.58). Residuals exceeding 3 SDs (-3.29 and 3.29) are problematic. We did not identify any residuals which exceeded 3.29. The remaining residuals identified by casewise diagnostics were subjected to sensitivity analysis and Cooks distance to see if their absence would greatly impact the model. Cooks distance is a measure of the overall influence an individual case can have on a model, and distances greater than 1 are potentially problematic (Ling, Cook, & Weisberg, 1984).

All 3 regression models were checked for presence of possible multicollinearity. Multicollinearity is present when strong associations exist between independent variables (IVs). Therefore, causing difficulties in interpretations as the influence of predictors cannot be differentiated (Clark-Carter, 2018). High correlations (>.80) are suggestive of multicollinearity. Correlations were inspected to assess collinearity of IVs. All correlations were less than .8 for all 3 regression models indicating no problem of collinearity. Further inspection of the variance inflation factor (VIF) (<10) and tolerance values (>.2) were in accordance of those cut-offs by Field (2013). This suggested multicollinearity was not problematic or biasing the results of further analyses. Data met the assumption of independent errors with the Durbin-Watson (1950) statistic indicating values close to the value of 2 and within the suggested 1-3 range. Below is a commentary of assumption testing for multiple regression analysis in relation to our 3 regression models.

1.3.1. Multiple Regression One: Influence of mindfulness on emotional regulation

A multiple regression was run to predict DERS with all five FFMQ subscales entered in the same step (model 2) and combined with the demographic variables (model 1).

Normal distribution and homoscedasticity

The histogram of the DV (Total DERS) residuals and P-P plot indicated skewness and kurtosis in the distribution. Closer inspection suggested the distribution was negatively skewed, therefore logarithm transformations were performed with the log10 function in SPSS to raise the minimum value above 0 to enable parametric testing.

Inspection of scatterplots of the standardised residuals (*ZRESID) against the standardised predicted values of the outcome variable (*ZPRED) displayed a random and evenly dispersed array of residuals, indicating linearity and homoscedasticity assumptions had been met. There was no curve formation indicating further again that data was linear. Inspection of the partial plots of the DV (DERS score) against predictor demographic and FFMQ subscales indicated in the main negative linear relationships.

Influential cases and outliers

Residuals were checked after initial regression was performed. Scatterplot matrices and box-plots indicated the presence of some outliers. In accordance with guidance (Field, 2013) in identifying problematic extreme outliers (-3.29 and 3.29), no cases exceed this range. Standardised residuals ranged from -1.934 to 3.285. Cook values did not exceed 1 (minimum =.000, maximum = .281), indicating no individual cases were biasing the model. However, a sensitivity analysis was performed on four cases identified by casewise diagnostics to examine the presence and absence of the outliers on the overall fit of the model, but no substantial differences were found. Therefore, the cases were retained to ensure analysis was suitably powered.

Independence

Independence of the model residuals was assessed using the Durbin Watson Test (1950). The assumption of independence errors was also met (1.73) statistic, indicating independence of errors.

Multicollinearity

Predictor variables were assessed by inspecting the correlation matrix, which found no strong associations (r >.8). To be expected, the subscales of the FFMQ correlated with small to medium effect sizes. The largest of which was FFMQ non-judge scores and FFMQ acting with awareness (r = .32), however this is to be expected as both are part of the same construct of mindfulness. All predictors were well below the VIF value of 10 and above 0.2 for tolerance, indicating no collinearity within the data. Taken together with the small to moderate correlations, the assumption of multicollinearity was met.

1.3.2. Multiple Regression Two: Influence of mindfulness on executive functioning

A multiple regression was run for mindfulness to predict EF (as measured by WCST). This study was interested in the contribution of specific mindfulness facets on the three WCST indexes (perseveration errors, non-perseveration errors and trials to complete first category). Thus, three regressions were run with the same demographics entered in model 1 and FFMQ subscales entered in model 2 for each WCST indices.

Normal distribution and homoscedasticity

The histogram of the DV (Total FFMQ) residuals and P-P plot indicated a normal distribution for each regression. As such the assumption of normality for this multiple regression was met.

Inspection of scatterplots of the standardised residuals (*ZRESID) against the standardised predicted values of the DV (*ZPRED) displayed a fairly random and evenly dispersed array of residuals, indicating linearity and homoscedasticity assumptions had been met. There was no curve formation indicated further again that data was linear. Inspection of the partial plots of the 3 DV's against predictor demographic and FFMQ subscales indicated a mix of minimal relationship (trails to complete first category) and negative linear relationships (both perseveration and non-perseveration errors).

Influential cases and outliers

Residuals were checked after initial regression was performed. Scatterplot matrices and box-plots indicated the presence of some outliers. In accordance with guidance (Field, 2013) in identifying problematic extreme outliers (-3.29 and 3.29), no cases exceed this range. Standardised residuals ranged from -2.91 to 2.14. Cook values did not exceed 1 (minimum =.000, maximum = .114), indicating no individual cases were biasing the model. However, a sensitivity analysis was performed on six cases identified by casewise diagnostics to examine their presence and absence on the overall fit of the model, but no substantial differences were found. Therefore, the cases were retained to ensure analysis was suitably powered.

Independence

Independence of the model residuals was assessed using the Durbin Watson Test (1950). The assumption of independence errors was met (2.42) statistic, indicating independence of errors.

Multicollinearity

Predictor variables were assessed by inspecting the correlation matrix, which found no strong associations (r >.8). To be expected, the indices of EF correlated with medium effect sizes. The largest of which was non perseveration errors and trails to complete first category (r = .67), however this is to be expected as both are part of the same construct of EF. All predictors were well below the VIF value of 10 and above 0.2 for tolerance, indicating no collinearity within the data. Taken together with the small to moderate correlations, the assumption of multicollinearity was met.

1.3.3. Multiple Regression Three: Influence of executive functioning on emotional regulation

A multiple regression was run for EF to predict ER. The same demographics were entered in model 1 and three EF indexes (perseveration errors, non-perseveration errors, trials to complete first category) entered in model 2.

Normal distribution and homoscedasticity

The histogram of the DV (Total DERS) used the logarithm transformed variable established from regression one.

Inspection of scatterplots of the standardised residuals (*ZRESID) against the standardised predicted values of the outcome variable (*ZPRED) displayed a random and evenly dispersed array of residuals, indicating linearity and homoscedasticity assumptions had been met. There was no curve formation indicating further again that data was linear. Inspection of the partial plots of the DV (DERS score) against predictor demographic and EF indexes indicated negative and positive linear relationships for perseveration errors and non-perseverations errors respectively.

Influential cases and outliers

Residuals were checked after initial regression was performed. Scatterplot matrices and box-plots indicated the presence of some outliers. In accordance with guidance (Field, 2013) in identifying problematic extreme outliers (-3.29 and 3.29), no cases exceed this range. Standardised residuals ranged from -3.07 to 2.13. Cook values did not exceed 1 (minimum =.000, maximum = .116), indicating no individual cases were biasing the model. However, a sensitivity analysis was performed on five cases identified by casewise diagnostics to examine the presence and absence of the outliers on the overall fit of the model, but no substantial differences were found. Therefore, the cases were retained to ensure analysis was suitably powered.

Independence

Independence of the model residuals was assessed using the Durbin Watson Test (1950). The assumption of independence errors was also met (2.09), indicating independence of errors.

Multicollinearity

Predictor variables were assessed by inspecting the correlation matrix, which found no strong associations (r >.8). Predictors were the same as regression 2. All predictors were well below the VIF value of 10 and above 0.2 for tolerance, indicating no collinearity within the data. Taken together with the small to moderate correlations, the assumption of multicollinearity was met.

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CHAPTER 7: General discussion and critical review

Chapter Overview

This chapter summarises the findings from both the systematic review and the empirical paper.

Word Count: 4960

1. Overview of results

1.1. Main Findings

This section focuses on bringing together the main findings of both the systematic review and empirical paper and discussing this in relation to the existing literature. Both papers link to models of executive functioning (EF) and emotional regulation (ER), exploring specific relationships between EF domains and coping strategies on mood.

It became clear from the systematic review there are a limited number of studies which have sought to test complex interactions between multiple variables, furthermore, that such interactions were based on little theoretical grounding in specific interactional effects between cognition, coping and mood. Research does highlight broad support for increased use of adaptive coping strategies moderating the relationship between weaker core EFs (inhibition, working memory) and higher EF (planning) and depression following MS. A broader range of weaker core EF (including cognitive flexibility) and higher EFs (including decision-making, problem-solving and multitasking) supported moderation findings and were also found to be indirectly related to higher depression and anxiety through greater use of behavioural disengagement. Poorer performance on core and higher EFs were found to be indirectly related to lower anxiety and depression via higher use of acceptance and growth coping strategies. Those findings provide partial support to the theoretical standpoint of EF and self-regulation being linked (Hofmann, Schmeichel, & Baddeley, 2012) as well as the process model (Ochsner & Gross, 2005), in that well preserved EFs are required to enact effortful action required for goal protection, while a reduction in core EFs results in more automatic coping behaviour likely resulting in poorer emotional outcomes following adjustment.

Studies included in this review provide minimal evidence of moderating and mediating between EFs and mood via coping strategies for ABI. The picture is further complicated for ABI given the variability in findings in the wider literature which suggest both positive and negative effects of stronger cognition on mood and coping (Ownsworth, Gooding, & Beadle, 2019; Shields et al., 2016; Wolters Gregõrio et al., 2015).

The research paper within this portfolio aimed to provide further insight into whether specific EF processes (namely cognitive flexibility) interact with specific coping styles in accounting for difficulties with ER. The main hypotheses were that higher self-reported aspects of mindfulness would be related to higher cognitive flexibility, and less difficulties with ER. It was also hypothesised higher cognitive flexibility would be related to less difficulties with ER. We also performed exploratory mediation analyses investigating the relationship between specific aspects of mindfulness and total ER via cognitive flexibility. Although the findings did show support for associations between aspects of mindfulness, cognitive flexibility and ER – mediation via cognitive flexibility was not supported. These patterns of results suggest specific core 'cognitive flexibility' may have a role to play in ER and mindfulness skills, and therefore may be of clinical relevance. These results are discussed in more detail in relation to the wider literature below. The strengths and limitations of the portfolio are discussed later in the chapter and need to be considered when interpreting the findings.

1.2. The relationships between EF, coping and ER

The process models of ER postulated by (Ochsner & Gross, 2005) and (Pruessner, Barnow, Holt, Joormann, & Schulze, 2020) have important clinical relevance for neuropsychological assessment and rehabilitation. Impairments in the self-regulatory processes highlighted in those models can compromise different ER strategies utilised by individuals as a result of specific EF difficulties. Both models align to models of EF (Diamond, 2013; Miyake et al., 2000) which mostly indicate the importance of core EFs (inhibition, working memory) working interdependently to scaffold other core EFs such as cognitive flexibility and higher order EFs involved in monitoring when discrepancies are detected between ongoing regulatory processes and changing contextual demands (Gross & John, 2003). This later process requires the supervisory attentional system (SAS) when novel circumstances present themselves which involve the management of potentially multiple competing sub-goals (Shallice & Burgess, 1991).

Findings from our systemic review for MS populations provide some support for those models and theoretical accounts of ER, in that individuals with weaker core (inhibition, working memory) and higher EFs (planning) reported higher levels of depression and anxiety as a result of utilising more maladaptive coping strategies such as behavioural and cognitive

disengagement, and denial. In accordance with process models, this would suggest individuals were getting 'stuck' in the initial stages of ER. That is difficulties in keeping the automatic appraisal of a negative solution to mind (working memory) and decreasing the salience of that appraisal (inhibition) before using other strategies such as cognitive reappraisal (working memory, verbal ability and set-shifting) and problem-solving with alternative courses of action (planning).

Importantly, those studies suggest adaptive methods such as cognitive reappraisal and problem-solving are effective in buffering against the effects of weaker EFs and emotional distress (Arnett, Higginson, Voss, Randolph, & Grandey, 2002; Grech et al., 2016; Rabinowitz & Arnett, 2009). Likewise, other adaptive coping strategies such as acceptance and growth were found to have the same effect (Grech et al., 2016). This fits with the wider literature which suggests poorer core EFs (inhibition, shifting) are vulnerability factors for depression and lead to greater use of maladaptive strategies such as rumination which interfere with the use of cognitive reappraisal (Joormann & D'Avanzato, 2010). Furthermore, use of adaptive ER strategies such as cognitive reappraisal, acceptance and problem solving reduce negative affect and exert protective effects on mental health difficulties (Aldao & Nolen-Hoeksema, 2010; Gross & John, 2003). Research has found individuals with depression show significant deficits in specific components of EF, such as inhibition, shifting and verbal fluency compared to healthy controls (Snyder, 2013). This possibly suggests EF problems in MS are in part a manifestation of general psychological distress following the immediate primary appraisal of threat to the condition, and then the secondary appraisals involving a perceived lack of control and belief in the ability to adjust. This conclusion is made with caution as the data regarding secondary appraisals was not available, however this might explain why reappraisal strategies which are highly reliant on people's cognitive abilities can still be accessed and effective.

There is a theoretical argument for possible relationships between coping style, EF and mood for ABI, but the findings are mixed and inconclusive, possibly owing to the severity and wider range of cognitive difficulties experienced, which make it harder for those individuals to make use of adaptive coping strategies (Wolters Gregõrio et al., 2015). There is possibly great heterogeneity in brain injury samples whose patterns of cognitive issues could for some be protective but for others be problematic for ER. Thus, the overall effect would be no significant

findings, but hidden in the sample might be subgroups with specific helpful and unhelpful profiles. Most participants included in our systematic review had a severe TBI and were at different stages of post injury, but mostly the later stages of recovery. Research indicates cognition may have a stronger association to coping and emotional adjustment closer to the time of injury, possibly owing to cognitive impairments being more salient at that stage (Christensen et al., 2008). Studies included in the review for brain injury covered core EFs, none of which looked at higher EFs (e.g. planning, problem-solving) which it has been argued are implicated in the relationship between adaptive problem-orientated coping and mood (Krpan, Levine, Stuss, & Dawson, 2007; Krpan, Stuss, & Anderson, 2011).

There is evidence to suggest that reappraisal generation is positively associated with higher inhibition and verbal fluency ability, whereas reappraisal maintenance relies more heavily on working memory capacity and supports further use of secondary appraisals (Andreotti et al., 2013; Kalisch, 2009; Salas, Gross, & Turnbull, 2014; Schmeichel, Volokhov, & Demaree, 2008). In ABI, a recent case study found inhibition difficulties resulted in concrete thinking making it difficult to spontaneously generate reappraisals as a result of a left frontal stroke (Salas, Vaughan, Shanker & Turnbull, 2013). Salas et al. (2014) view inhibition and verbal fluency as critical in initial reappraisal strategies, where working memory is important in later stages of the reappraisal process. This implies top-down strategies which align to CBT might be a struggle for individuals with these cognitive difficulties to make use of.

The findings from our empirical paper with a general population provide support for this with associations noted between the effects of higher perseverative errors and increased emotional difficulties. Research is scarce in neurological populations, but there is evidence to suggest that comorbid emotional difficulties with a TBI account for greater difficulties with cognitive flexibility compared to people with TBI and no mood difficulties (Gould, Ponsford, & Spitz, 2014; Jorge et al., 2004). This also fits with the wider literature of non-neurological populations which has found associations between lower cognitive flexibility with worry (Snyder et al., 2014) and rumination (Demeyer, De Lissnyder, Koster, & De Raedt, 2012), whereas higher cognitive flexibility has been associated with less rumination and use of adaptive ER strategies of reappraisal (Hendricks & Buchanan, 2016). It stands to reason that if reappraisal

relies on the flexible use of thinking (John & Gross, 2004) then it is likely people with cognitive flexibility difficulties may struggle to modulate how they feel (Salas et al, 2014).

Proponents of 'third wave' approaches which incorporate mindfulness processes argue an advantage over traditional CBT approaches is there is no expectation to challenge beliefs (Kangas & McDonald, 2011), thereby reducing the load of processes which require both core and higher EFs for utilising adaptive strategies such as cognitive restructuring (e.g. reappraisal).

Given the emergence of interventions for neurological populations which incorporate mindfulness strategies, we wanted to explore how mindfulness traits interact with cognitive processes and ER to investigate how and why they might work, and for whom they might benefit in the context of EF difficulties. Our exploration of the interplay between mindfulness and EFs was also informed by the findings of Grech et al. (2016) who pinpointed growth and acceptance coping strategies playing a mediating and moderating role between weaker core and higher EFs and emotional outcomes. The findings from Grech et al. (2016) support accounts that mindfulness may promote meaning-based coping with stressful life events by facilitating positive reappraisal (Garland, Gaylord, & Fredrickson, 2011). This is a promising finding for populations such as TBI where severe EF difficulties make it severely difficult to implement cognitive reappraisal techniques (Anson & Ponsford, 2006). This is in line with other research where cognitive difficulties and emotional adjustment are required, which show that sense making appraisals or existential questions affect how well people can cope with and find meaning adjusting to brain tumor (Strang, Strang, & Ternestedt, 2001). Sense of coherence (SOC) is a framework which explores people's orientation to the world, and extent to which they see the world as comprehensible, manageable and meaningful (Antonovsky, 1996). People higher in SOC are reported to be more likely to understand what is happening, believe they have resources to manage the demands and strive to find meaning (Eriksson & Lindström, 2005). There is some evidence that SOC can be enhanced through mindfulness based interventions (MBIs) (Ando, Natsume, Kukihara, Shibata, & Ito, 2011). A recent randomised trial which utilised mindfulness and value-based goals with cognitive rehabilitation to support people with brain tumour reported enhanced psychological wellbeing and quality of life (Ownsworth et al., 2015).

We found the FFMQ aspect of higher 'non judge' abilities being associated with less perseveration errors and difficulties with ER also supports (Farb, Anderson, & Segal, 2012), in that non-engagement of cognitive reappraisal (which reportedly relies less on working memory, cognitive flexibility and verbal fluency) can also be an adaptive ER strategy. We also found FFMQ 'describe' aspect was related to all indices of EF and ER which fits with the existing literature that verbal labelling of emotion is alone enough to reduce activity in amygdala and insula emotional response areas Ochsner & Gross (2008). The self-monitoring of emotion, and the subsequent labelling, might impact significantly on ER in the absence of frank reappraisal. This fits with the Interacting Subsystems framework (ICS) (Teasdale, 1993) a model which provided the framework for MBCT (Segal, Williams, & Teasdale, 2002). Gracey et al. (2015) discussed the distinction made within the ICS between concrete, semantic meaning and autobiographical meaning amassed through multisensory input, termed 'propositional meaning' and 'implicational meaning' respectively. The authors suggested implicational meanings could be explored through 'felt senses' in therapeutic settings since some clients with a brain injury may have difficulty expressing concrete cognitive ideas, as found by Salas et al. (2014). Thus, mindfulness which enables non-judgemental observation and labelling initial experiences as they come and go might be helpful for individuals who get caught in ruminative recycling of depressogenic meanings.

We did not find support for Teper, Segal, & Inzlicht (2013) model which suggests 'executive control' mediates the relationship between aspects of mindfulness and ER. Theoretical accounts have advocated mindfulness is a separate ER strategy involving awareness and acceptance (Chambers, Gullone, & Allen, 2009; Farb et al., 2012) which is different compared to processes outlined by (Ochsner & Gross, 2008). Those accounts have suggested 'mindful ER' strategies do not involve the same demand on cognitive processes, however others have argued increases in mindfulness correspond to all stages of the process model of ER outlined by Gross (Guendelman, Medeiros, & Rampes, 2017). This supports the claim that novel practitioners in MBIs use primarily top-down ER strategies highlighted by increased recruitment of prefrontal cortex areas but the opposite effect in experienced meditators (Chiesa, Calati, & Serretti, 2011). How this effect translates to populations with pre-existing cognitive difficulties is unclear as the evidence for MBIs improving cognition from healthy populations is inconclusive.

This begs the questions of whether MBI's are emotional interventions with cognitive benefits, or vice-versa, or even if our conceptual dissociations of cognition and emotion are helpful. Furthermore, it questions the premise of MBIs requiring less recruitment of EFs, thus being more accessible for populations with cognitive difficulties. We therefore need models that capture more fully the interconnectedness of affect and cognition.

1.3. Critical discussion of coping theory

Both studies in the portfolio primarily looked at styles of coping and how someone's EF influences this. However we did not explore psychological and contextual factors which are found to play a prominent role in adjustment to neurological conditions, such as ABI or MS. Studies included in the systematic review mainly focused on coping styles and not primary or secondary appraisals of ability to cope (e.g. self-efficacy). Interestingly, Wood & Rutterford, (2006) found working memory was related to depression via self-efficacy indicating an individual's sense of ability to exert some control over one's environment or situation interacts with choice of strategy as well as someone's EF profile. Prominent models within ABI and MS integrate coping styles alongside appraisals, as well as identity and specific experiences when formulating adjustment difficulties (Dennison, Moss-Morris, & Chalder, 2009; Gracey, Evans, & Malley, 2009; Ownsworth, 2014). Self-efficacy has been associated with psychosocial outcomes following ABI (Cicerone & Azulay, 2007) and MS (Motl & Snook, 2008) which indicates it's an important factor to consider in clinical formulation of adjustment difficulties. Brands, Köhler, Stapert, Wade, and van Heugten (2014) addressed the stress buffering effect of secondary appraisals such as self-efficacy and found higher self-efficacy was related to lower levels of passive coping and increased active coping in acquired brain injury patients. Other psychological concepts such as self-esteem have also been found to be related with poorer outcomes following ABI (Cooper-Evans et al., 2008; Longworth, Deakins, Rose, & Gracey, 2018) and use of adaptive problem-focused coping styles in MS, suggesting that an individual's own sense of self-worth is an important consideration underpinning coping styles (Mikula, Nagyova, Vitkova, & Szilasiova, 2018).

The body of evidence does indicate reappraisal is a generally efficacious and adaptive strategy, whereas expressive suppression is mostly maladaptive (Roberts, Levenson, & Gross, 2008). However, some have argued indexing emotional coping strategies, such as 'acceptance' and 'growth' as maladaptive through certain measures such as the COPE has meant the loss of important information regarding the advantageous relationship between these strategies and adjustment (Austenfeld & Stanton, 2004). This was demonstrated by Grech et al. (2016) findings and indicates the importance of comprehensive and individual coping strategy analysis for future research.

Coping is commonly operationalised from a dispositional perspective. It is widely recognised coping is not a 'static' response as conceptualised by our portfolio, instead it is now widely considered that flexibly adapting one's behaviour across different situations is equally if not more important than the ability to use any single strategy (Bonanno & Burton, 2013). In recent years, the literature around coping has expanded beyond operationalising from a dispositional individual perspective to include important other factors such as access to resources (Lazarus, 1993). One critique of the coping literature has been the strong emphasis placed on the individuals' appraisals of a situation without accounting for wider context factors (Hobfoll, 2001) and meaning in relation to people efforts to cope with unwanted life events or aversive life conditions (Park & Folkman, 1997). Hobfoll's theory suggests social and cultural contexts of coping involve the individuals' relationship to their families and wider social groups. Research in brain injury has shown a return to meaningful activity is a predictor of later emotional outcome (Turner, Fleming, Ownsworth, & Cornwell, 2011). Douglas (2013) suggest social support factors helped to create and maintain a sense of connection between self-identity and society post TBI. Another dimension to this is how the structure and supports around someone might help to mitigate against the effects of cognitive, social, emotional and functional aspects of neurological conditions. These principles are explicit in holistic neurorehabilitation approaches (Prigatano, 1999), which have been found to be cost-effective in the long-term for brain injury (Wilson, Evans, & Keohane, 2002).

1.4. Strengths and limitations of the thesis portfolio

A key strength of this portfolio was the attempt taken to ground our research in contemporary models of EF, coping and ER, attempting to integrate those accounts in understanding specific interactions and how this might guide clinical models and interventions for populations who have both cognitive and emotional difficulties. For our systematic review the delineation of core and higher EFs in accordance with Diamond (2013) provides a more detailed understanding about the specific role of EF as it relates to coping directly, and adjustment indirectly in ABI and MS. This extended to our empirical paper where the focus was on aspects of the WCST task rather than indexing a total score pertaining to EF. We focused on mediation and moderation aspects of hypothesised relationships, this provides a stronger basis for inferring conclusions compared to correlational analyses, however, designs were cross-sectional with small-moderate samples, so conclusions are made tentatively on hypothesised relationships and understanding of specific ER strategies.

The use of an adapted computerised WCST task had both advantages and disadvantages. In relation to the former, this made the survey more accessible, we were able to test a larger number of people and limited the potential for human error in correctly administering and applying the rules of the WCST paradigm in response to providing feedback and scoring responses correctly. That said a weakness of this approach pertains to the validity of the version we used, the argument around the wide range of executive and non-executive processes (Gläscher, Adolphs, & Tranel, 2019) it measures and the need for specific technological requirements to complete it. The later point was a potential source of selection bias for our empirical paper, however our non-response analysis indicated no significant differences between those who participated and those who could not. However, the number of people who could not access the survey meant we could not implement our preferred analysis plan of SEM, which limited the scope of our enquiry to a total score of ER difficulties rather than specific facets of ER.

Our decisions regarding choice of measures and platform (Psytoolkit, 2017) was ultimately dictated by time and budget limitations. An assessment of other EF processes sensitive to shifting and/or other core or higher EFs would have expanded the scope of interactional

effects between specific domains of EF, mindfulness facets and ER. This would have possibly identified a greater range of relationships for further exploration to inform research with neurological populations. We also did not factor in the potential effect of wider cognitive difficulties and the influence this has on EF. This relates to domains specific to EF (inhibition, working memory) which are theorised to support cognitive flexibility, and wider aspects of cognition (verbal and visual abilities, language, memory and visuospatial skills) which are the framework for higher order functions (Dams-O'Connor & Gordon, 2013).

We must also recognise the chance for bias in how core and higher EFs were categorised in line with Diamond (2013) for the systematic review. This was undertaken by the lead researcher (PG) and arguments could be made for certain tasks reflecting other core and higher EF processes.

1.5. Limitations of the line of enquiry as a whole

One likely confounding factor which has not been accounted for in both papers is fatigue, and it's interacting effects with cognition and coping in influencing emotional outcomes. The experience of fatigue has been found to be a prominent and disabling factor in both ABI and MS populations (Cantor, Gordon, & Gumber, 2013; Chiaravalloti & DeLuca, 2008). Fatigue has also been found to be associated with emotional outcomes following ABI (Johansson & Rnnbck, 2014). Clinical models for understanding responses to fatigue after ABI suggest considering the role fatigue plays in choice of helpful and unhelpful coping responses (Malley, Wheatcroft, & Gracey, 2014). Ukueberuwa & Arnett (2014) found people with MS who reported higher fatigue performed better on cognitive tasks (inhibition, working memory, planning) when less avoidant coping was reported. Mental fatigue has been reported to arise particularly in response to greater executive processing demands (Azouvi et al., 2004). Grech et al (2016) findings of less effortful coping strategies such as acceptance and growth being associated with better outcomes amongst those with poorer EF indicates an avenue for further exploration where fatigue is a prominent factor. Tang & Posner (2009) suggest when people are required to focus their attention and put forth sustained cognitive effort, there is a possibility of mental fatigue. Kaplan (2001) proposed attention restoration theory which highlights benefits of exposure to nature to restore directed attention. Mental restoration is suggested to work by encouraging a period of higher levels of

involuntary attention, while decreasing directed, voluntary attention to restore efficient mental effort. Studies suggested glucose is one mechanism for the restoration of attention after exposure to nature (Gailliot et al., 2007). Thus, it appears mindfulness skills engaged with nature could have beneficial effects for people who suffer with fatigue which impacts upon their cognition and mood.

Both papers have limitations in terms of scope and generalisabiltiy from our chosen sampling frames. The systematic review choose populations of ABI and MS as both are well researched in the coping literature and recognised under the umbrella of neurodisability given the similarities of adjustment to both cognitive and emotional difficulites. Within ABI there is considerable heterogeneity regarding mechanisms and nature of injuries which limits generalisability. Papers included for ABI were largely reflective of etiologies which reflected traumatic brain injury as opposed to different causes such as stroke. Therefore, our findings for ABI are more reflective of TBI populations as opposed to stroke populations.

The empirical paper used a general population to test hypotheses postulated around key cognitive processes being involved in emotional regulation. The rationale for using a general population was namely informed by the lack of clarity in the mainstream literature postulating how a strategy such as mindfulness operates. This was important in the context of cognitive impairments where such strategies are postulated to work via said mechansims. Thus it is unclear whether mindfulness is a strategy with cognitive or emotional benefits, a combination of the two or strategy with no benefit for this population. Therefore, the choice of a healthy control group was taken to contribute to theory in order to understand and inform how clinical interventions for people with cognitive impairments might work. To achieve this, we wanted to further understand and validate models of EF and coping to understand the complex interplay of cognitive and emotional processes which are important to consider when working with people who have ABI or MS. This approach allowed us to recruit a large sample and gain a wider distribution of data on our measures to inform a more rigorous statistical approach. However, a weakness of our study was we did not recruit a large enough sample to break down specific interactions further with structural equation modelling.

Given the limitations of our findings and the general literature which have explored these relationships in both clinical and non-clinical populations, it is too early to formulate more

specific links within those relationships and how this might inform clinical practice. Our findings show there does appear to be a role of core EF processes such as cognitive flexibility considering we found it to be related to specific aspects of mindfulness and ER difficulties. On reflection, future studies would benefit recruiting a larger non-clinical sample to perform SEM, with the addition of a higher EF task alongside a core EF task. Alternatively, a clinical sample focusing on specific mechanisms of injury such as stroke or TBI would partially address the issue of heterogeneity. This portfolio has taken an 'individualistic' lens when considering factors which influence adjustment to ABI and MS. There has been a shift from a medical approach to a more relational approach to rehabilitation. The consequences of brain injury can be understood to be more prominent when people are with others, rather than in isolation (Yeates, 2009). This relational approach does not focus just on survivors of brain injury; but the impact on survivors' relatives and communities. In other words, considering the 'brain-injured relationships and systems' (Bowen et al., 2018). It has been suggested when individual's family members are actively engaged in rehabilitation, they are more likely to have better outcomes than those who are not (Sherer et al., 2007). Salas et al. (2014) have stressed the importance of involving systems around the individual to facilitate reappraisal generation for adaptive ER. Chronister et al. (2015) found perceived burden and social support mediated the relationship between burden and quality of life in TBI. Alway, McKay, Ponsford, & Schnberger (2012) found family expressed emotion (criticism and emotional involvement) to be associated with mood outcomes, and use of coping styles is influenced by the amount of support from family and friends (Chronister & Chan, 2006). Pakenham (2001) reported caregiving factors such as cognitive appraisal, coping strategies and coping resources were predictors of adjustment in MS. This indicates an individual as well as their wider system needs consideration in the assessment and intervention stage to facilitate adaptive coping following ABI or MS.

Finally, the conceptualisation and measurement of mindfulness is challenging within the existing scientific literature. This ranges from mindfulness being conceptualised with reference to a disposition (e.g. trait) or state (e.g. practice), and the assumption of construct homogeneity. Firstly, the extent to which trait or dispositional mindfulness relates to state mindfulness or indeed mindfulness cultivated through mindful practices has to be acknowledged when interpreting the findings of our empirical study. It could be someone self-reports higher dispositional mindfulness irrespective of mindful practice. Secondly, when referring to

mindfulness as a disposition, this poses questions around how flexible and sustainable this is to change through mindful practice. Some researchers had assumed dispositional mindfulness to be a stable entity (Tang, Holzel & Posner, 2015). That said there is evidence that increased practice of mindfulness over a long period of time leads to both state and dispositional change (Kiken et al., 2015). This finding is important because it suggests dispositional mindfulness is amenable to change for some individuals as a result of receiving psychological intervention. This is consistent with neuroscientific literature which indicates meditation can change brain function and structure in ways that facilitate being more mindful (Holzel et al., 2011).

1.6.Current treatment strategies for ABI and MS

Many of the strategies proposed by process models lend themselves to CBT given their antecedent response focus. A recent Cochrane review which included only 4 eligible studies did not find evidence to support the efficacy of CBT for treating depression after TBI (Gertler, Tate, & Cameron, 2015) which could explain the inconclusive findings for ABI in our systematic review. A meta-analysis concluded CBT is a potentially effective treatment for depression in people with MS (Hind et al., 2014) which supports the findings of moderation effects of adaptive coping reported in our systematic review. Approaches focused on other adaptive coping strategies such as acceptance and growth have indicated promising findings for neurological conditions (Pakenham, Mawdsley, Brown, & Burton, 2018; Whiting, Deane, McLeod, Ciarrochi, & Simpson, 2019), but are lacking in well-designed randomised controlled trials and corresponding meta-analytic reviews which test their effectiveness. Integration of mindfulness exercises have been incorporated with Goal Management Training (GMT) to good effect for neurorehabilitation in brain injury (Levine et al., 2011) for people with executive difficulties. Practice guidelines (Tate et al., 2014) for ABI indicate any therapeutic intervention should be considering someone's cognitive, communication and sensory strengths and difficulties. In the context of EF difficulties, CBT informed interventions would benefit from clear structure, regular use of summaries and shortened sessions (Gracey, Longworth & Psaila, 2015). In the context of third-wave CBT therapies which use metaphors, there is guidance to use more 'concrete' as oppose to abstract concepts given difficulties individuals may have with cognitive flexibility (Hill, Anderson, Hynd, Wheeler, Evans & Price, 2017).

It has been suggested transdiagnostic CBT models can be utilised in a neurorehabilitation context for ABI (Gracey, Longworth & Psaila, 2015) which incorporate wider psychological, cognitive and contextual factors discussed earlier in this chapter in understanding distress. The model identifies a series of feedback loops starting with increased emotionally driven processing biases such as selective attention to threat, which serves to maintain underpinning threat to self, resulting in poorer psychosocial adjustment over time. The model is more closely aligned with cognitive process models, which could enable some mapping of emotional processes to neuropsychological deficits and strengths.

1.7. Future implications for research and clinical practice

Results from this thesis portfolio have both research and clinical implications. In attempting to integrate models of executive functioning and coping in understanding emotional difficulties following brain injury or MS, we have begun to form an understanding of what some of these specific relationships might entail and what treatments might facilitate improved emotional outcomes. This is clearer in the context of MS where a combination of adaptive strategies appears to buffer against the effects of weaker EFs and primarily depression, but also for anxiety. We are not able to make any recommendations specifically for brain injury, but careful consideration in the assessment of cognition (whether intact or not) and how this interacts with coping is important given the literature indicates both positive and negative effects on mood.

The results from our empirical paper need to be considered carefully due to methodological weaknesses regarding the design and revised analysis plan which did not allow us to explore interactional effects of dispositional mindfulness and EFs on specific ER strategies. It is also uncertain whether findings regarding WCST in neurologically healthy individuals apply to those in neurological populations, furthermore, how this relates to selection of ER strategies.

Due to the heterogeneous nature of cognitive deficits in neurological population such as ABI, it seems vital to gain a greater understanding of what aspect of MBIs work on which cognitive processes for whom. Therefore, more controlled studies are needed to understand fully and determine the effect of MBIs on cognition following ABI or MS.

The findings of higher use of growth and acceptance coping styles moderating the relationship between weaker core and higher EFs and higher depression and anxiety in MS lends support to the potential utility of third wave CBT approaches, such as ACT which target such processes to increase psychological flexibility. Future studies should explore this hypothesised relationship in the context of brain injury as this has not been done in a mediation and moderation study design to our knowledge. In the context of neurological conditions and increased use of ACT, studies exploring the possible relationships between the 6 processes of 'psychological flexibility' and specific difficulties with core or higher EFs could inform adaptations required to help individuals engage with the approach.

1.8. Overall conclusion

In our introduction chapter we set out to answer the questions around understanding mechanisms between specific domains of EF, coping strategies and ER. Our aim was to further enhance pre-existing models which integrate cognitive and emotional factors when formulating adjustment difficulties in ABI or MS. In conclusion, this portfolio did not fully answer those questions as there are currently a significant lack of high-quality research tied to theoretical accounts which investigates specific aspects of EF, coping and ER. Additionally, due to the heterogeneous nature of neurological conditions, theoretical accounts of EF and how this is measured - it is vital more research is undertaken with an attempt to synthesise those constructs. Further exploration of emotion focused strategies such as acceptance and growth are needed, given some of the existing literature has overlooked its potential utility in facilitating adjustment. The findings of this portfolio do indicate potential positive implications for such strategies alongside our findings of cognitive flexibility being associated with specific aspects of mindfulness and ER. However further research is needed to verify and replicate those findings with better quality study designs and clinical populations where EF difficulties are apparent. Only by addressing these areas of future research can clinical recommendations regarding specific coping strategies be made for EF difficulties.

What does remain clear, in a neurorehabilitation context, is people will benefit from holistic person-centered assessments which integrate cognitive, psychological, physical and social factors when devising treatment plans in line with individual treatment goals. Firstly,

hierarchical models of cognition are a good conceptual framework for understanding an individual's cognitive abilities and how EFs might be better identified or supported in order to utilise interventions within a CBT framework. Secondly, personal and social context factors are important in determining barriers and/or facilitators in the post adjustment phase. This involves formulating psychological constructs such as self-esteem and self-efficacy, and their influence over choice of coping and appraisal style. The role of wider systems such as loved one's and other professionals involved in an individual's care needs careful consideration. The former is of vital importance and this should be extended to understanding families experience of neurological conditions and offering support and involvement in the treatment process. Working clinically with this population, it has been a humbling experience to witness how people and their families adapt to the multiple changes which occur post brain injury. I was struck by their resilience and determination to make positive change in difficult circumstances.

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Appendices for Overall Thesis Portfolio

Appendix A: Submission guidelines for Neuropsychological Rehabilitation journal

Appendix B: Submission guidelines for Consciousness and Cognition journal

Appendix C: University of East Anglia FMH Ethics Approval

Appendix D: Study Information Sheet

Appendix A Submission guidelines for Neuropsychological Rehabilitation

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Appendix B: Submission guidelines for Consciousness and Cognition journal

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CONSCIOUSNESS AND COGNITION

AUTHOR INFORMATION PACK

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GUIDE FOR AUTHORS

Introduction

Consciousness and Cognition, An International Journal, provides a forum for a natural-science approach to the issues of consciousness, voluntary control, and self. The journal features empirical research (in the form of articles) and theoretical reviews. The journal aims to be both scientifically rigorous and open to novel contributions.

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Appendix C: University of East Anglia FMH Ethics Approval

Faculty of Medicine and Health Sciences Research Ethics Committee

Philip Goldstone
MED

Research & Innovation Services
Floor 1, The Registry
University of East Anglia
Norwich Research Park
Norwich, NR4 7TJ

Email: fmh.ethics@uea.ac.uk

Web: www.uea.ac.uk/researchandenterprise

06 December 2018

Dear Philip

Title: The role of executive functioning and its relationship to mindfulness and emotional regulation.

Reference: 201819 - 027

The submission of your research proposal was discussed at the Faculty Research Ethics Committee meeting on Thursday 29 November.

The Committee were happy to approve your application in principle but have the following concerns which they would like you to address and amend accordingly:

- Some simplification of the language used in the application and the protocol is suggested as they need to be easily readable by the lay-person.
- Your own CV on the PIS needs more detail, eg what is the study for?
- Is the survey platform GDPR compliant – the UEA requires you to use JISC Online Surveys?
- It is not clear who the actual participants are - only people who engage in mindful practices?
- It might be useful to state how much the vouchers are for and how many there are to win. Is a prize draw ethical in itself?
- Given that participants may link directly through to the questionnaire from Twitter or other social media, it would be worthwhile adding the PIS to the start of the questionnaire so as to ensure that everyone who participates has had the opportunity to access and read it.

Please write to me once you have resolved/clarified the above issues. I require documentation confirming that you have complied with the Committee's requirements. The Committee have requested that you detail the changes below the relevant point on the text in this letter and also include your amendments as a tracked change within your application/proposal. The revisions to your application can be considered by Chair's action rather than go to a committee meeting, which means that the above documentation can be resubmitted at any time. Please could you send your revisions to me as an attachment in an email as this will speed up the decision making process.

As your project does not have ethics approval until the above issues have been resolved, I want to remind you that you should not be undertaking your research project until you have ethical approval by the Faculty Research Ethics Committee. Planning on the project or literature based elements can still take place but not the research involving the above ethical issues. This is to ensure that you and your research are insured by the University and that your research is undertaken within the University's 'Guidelines on Good Practice in Research' approved by Senate in July 2015.

Yours sincerely

Professor M J Wilkinson
Chair
FMH Research Ethics Committee

Faculty of Medicine and Health Sciences Research Ethics Committee

Philip Goldstone
MED

Research & Innovation Services
Floor 1, The Registry
University of East Anglia
Norwich Research Park
Norwich, NR4 7TJ

Email: fmh.ethics@uea.ac.uk

Web: www.uea.ac.uk/researchandenterprise

18 February 2019

Dear Philip

Title: The role of executive functioning and its relationship to mindfulness and emotional regulation.

Reference: 201819 - 027

Thank you for your response to the recommendations from the FMH Ethics Committee to your proposal. I have considered your amendments and can now confirm that your proposal has been approved.

Please can you ensure that any further amendments to either the protocol or documents submitted are notified to us in advance, and also that any adverse events which occur during your project are reported to the Committee.

Approval by the FMH Research Committee should not be taken as evidence that your study is compliant with GDPR and the Data Protection Act 2018. If you need guidance on how to make your study GDPR compliant, please contact your institution's Data Protection Officer.

Please can you also arrange to send us a report once your project is completed.

Yours sincerely

Professor M J Wilkinson
Chair, FMH Research Ethics Committee

Appendix D : Study Information Sheet

Version 1.

University of East Anglia

Participant information sheet

My name is Philip Goldstone and I'm a Trainee Clinical Psychologist at the University of East Anglia. We would like to invite you to participate in this research project. Before deciding whether to take part, it is important for you to read the following information below carefully. If you would like more information, please feel free to contact the researchers (contact details below).

What is the research about?

The research aims are to improve our understanding of how mindfulness works to help emotional regulation.

Why should I participate?

Your participation would be greatly appreciated in helping us understand more about the mechanisms by which mindfulness works. In the future, we hope to do studies with people who have difficulties with certain thinking skills, so understanding these processes might one day help us improve the effectiveness of therapies with certain mental health and neurological conditions. The study will also give away Amazon vouchers following a prize draw for those who complete the study.

What do I have to do?

The online study should take up to 20 minutes to complete. You will be asked to rate your responses on two different questionnaires. You will then be asked to complete an online task which involves sorting cards. This study works best with access to a keyboard as one of tasks requires this so better if you can complete the study on a laptop or desktop computer.

How might taking part affect me?

Taking part in this research will mean you have to give up approximately 20 minutes of your time. One of the tasks is designed to present a challenge to thinking and reasoning skills, which some people might find frustrating. We will not be able to provide feedback on your scores but would welcome any concerns you might have from completing the study.

Will data be kept confidential?

Yes, all data will remain confidential. Only the researchers and person who owns the platform PsyToolkit used for the study can access the data. You will not be required to provide your name for the study, therefore data collected will be completely anonymous. If you are wishing to be considered for the prize draw of Amazon vouchers, we will ask for your email address, so you can be contacted if you win. This data will only be seen by the researcher and kept on an encrypted password protected memory USB stick. Upon completion of the draw, this information will be deleted.

Can I withdraw from the study?

You can withdraw at any stage of the study whilst completing the survey. You are free to do so without consequence up until the point you submit your survey responses. At this point the responses will be saved anonymously and we will no longer be able to identify your data.

What will happen at the end of the study?

We aim to share the results through academic journals and conference presentations. If you would be interested in the study's findings, then please let the researchers know so that you can be contacted later.

Please find the contact details of the lead researcher below:

Philip Goldstone – Trainee Clinical Psychologist

University of East Anglia Doctorate in Clinical Psychology

Norwich Medical School, Norwich, NR4 7TJ, Email: p.goldstone@uea.ac.uk

Primary Supervisor - Dr Fergus Gracey

Senior Research Fellow – University of East Anglia Doctorate in Clinical Psychology

Norwich Medical School, Norwich, NR4 7TJ, Email: f.gracey@uea.ac.uk

For any complaints in relation to the study, please find the contact details of the Head of Department below:

Professor Niall Broomfield – Programme Director ClinPsyD Doctoral Programme in Clinical Psychology, Head of Department, Department of Clinical Psychology, Norwich Medical School, University of East Anglia, Norwich, NR4 7TJ, Email: n.broomfield@uea.ac.uk