BRAIN ACTIVATION CHANGES DURING NEGATIVE EMOTION REGULATION TASK FOLLOWING BRIEF MINDFULNESS EXERCISE. AN fMRI STUDY

KAVISHASHREE VIJAYAKUMAR

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BRAIN ACTIVATION CHANGES DURING NEGATIVE EMOTION REGULATION TASK FOLLOWING BRIEF MINDFULNESS EXERCISE. AN fMRI STUDY

by

KAVISHASHREE VIJAYAKUMAR

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LIST OF ABBREVIATIONS

fMRI – Functional Magnetic Resonance Imaging

ER - Emotion Regulation

ANEW - Affective Norms for English Words

PANAS-X- Positive and negative affect schedule expanded version

MAAS- Mindfulness awareness attention scale

MBSR- Mindfulness-based stress reduction

MBCT- Mindfulness-based cognitive therapy

HC- Healthy Controls

GAD- Generalized Anxiety Disorder

fNIRS - Functional near-infrared spectroscopy

WM- Working memory

BOLD - Blood Oxygen Level Dependent CBF – Cerebral Blood Flow

HRF- Hemodynamic Response Function

ROI – Region of Interest

SPM – Statistical Parametric Mapping

GLM- General Linear Model

STC- Slice timing correction

SPSS- Statistical Packages for Social Sciences

RFT – Random Field Theory

FFX – Fixed Effect Analysis

RT – Reaction Time

Perubahan Pengaktifan Otak Semasa Tugas Pengawalan Emosi Negatif Selepas Latihan Keprihatinan Ringkas: Kajian fMRI

ABSTRAK

Pengenalan: Keprihatinan dapat meningkatkan kesihatan mental dengan memberi galakkan terhadap tindak balas kawalan emosi adaptif, Keprihatinan dikaitkan dengan kawalan emosi kerana ia memerlukan kesedaran tidak reaktif dan penerimaan terhadap keadaan semasa.

Objektif: Kajian ini bertujuan untuk mengukur perubahan dalam tugasan pengawalan emosi negatif dan pengaktifan otak yang berkaitan selepas latihan keprihatinan ringkas dan buku audio ringkas.

Kaedah: Enam orang peserta (2 lelaki dan 4 wanita) berumur antara 19 dan 34 tahun (min = 24, SD = 2.19) mengambil bahagian dalam kajian ini Neuroteknologi yang diggunakan adalah pengimejan resonans magnetik kefungsian, Intevensi pengawalan ringkas selama 15 minit telah dijalankan selepas pra tugasan pengawalan emosi di mana peserta bertindak balas terhadap perkataan bagi emosi negatif dan neutral. Pasca tugasan pengawalan emosi dijalankan untuk menilai keberkesanan intervensi keprihatinan ringkas. Rangsangan perkataan negatif dan neutral yang digunakan dalam kajian ini diektrak daripada Norma Afektif untuk Perkataan Inggeris (ANEW). Kami menggunakan soalan kaji selidik lapor diri seperti skala Positif dan Negatif - Diperluas (PANAS-X) dan Skala Keprihatinan Tumpuan dan Kesedaran (MAAS) dalam versi Bahasa Melayu untuk mengukur tahap emosi dan keprihatinan peserta.

Hasil: Ukuran berulang ANOVA telah dijalankan bagi mengukur perbezaan antara kumpulan (kesan rawatan), perbezaan antara kumpulan berdasarkan masa (kesan interaksi

masa-rawatan) dan perubahan dalam kumpulan (kesan masa) untuk skor PANAS-X dan masa tindak balas bagi rangsangan visual negatif dan neutral. Ujian-t sampel bebas telah dijalankan untuk menganalisis kawasan otak yang diaktifkan dalam analisis konjugsi. Nilai p yang digunakan dalam ujian statistik ini ialah < 0.05 bagi ketiga-tiga objektif tersebut. Kawasan serupa yang diaktifkan oleh kumpulan prihatinan dan kumpulan audio buku adalah girus precentral kiri, girus postcentral kiri, cuneus kiri, dan girus oksipital tengah kiri untuk rangsangan negatif. Seperti yang didedahkan daripada penemuan kajian, latihan keprihatinan meningkatkan pengawalan emosi dengan menunjukkan kurang sifat emosi negatif seperti yang ditunjukkan dalam skor PANAS-X. Peserta menunjukkan emosi yang lebih positif dalam pemarkahan pasca-PANAS-X. Walau bagaimanapun, hasil skor PANAS-X dan Waktu Reaksi tidak memberikan hasil yang signifikan secara statistik tetapi ukuran kesan sederhana dan besar dikenal pasti untuk kumpulan perhatian dan audiobook.

Kesimpulan: Seperti yang dinyatakan dari penemuan kajian, latihan kesadaran meningkatkan peraturan emosi dengan menunjukkan sifat emosi yang kurang negatif seperti yang dilihat dari hasil PANAS-X dan Waktu Reaksi. Peserta menunjukkan emosi yang lebih positif dalam skor PANAS-X berbanding dengan pra pengukuran dan peserta juga bertindak balas pada kadar yang lebih pantas berbanding dengan skor masa reaksi yang pos pengukuran. Kumpulan audio dan kesedaran menunjukkan kawasan umum yang bertanggungjawab untuk pergerakan motor sukarela, proprioception, penjanaan dan pengaturan emosi, maklumat visual dan perhatian. Walaupun intervensi kesedaran diberikan hanya selama 15 minit, pengaktifan otak dapat dikenal pasti.

Brain activation changes during negative emotion regulation task following brief mindfulness exercise: An fMRI study

ABSTRACT

Introduction: Mindfulness enhances mental health by promoting adaptive emotional control responses. Mindfulness is linked to emotion control since it needs a nonreactive awareness and acceptance of current circumstances.

Objective: This study aims to measure the changes in negative emotion regulation task and the associated brain activation following a brief audio mindfulness exercise and a brief audiobook exercise.

Methods: Six participants (2 male and 4 female) between the ages of 19 and 34 (mean = 24, SD = 2.19) participated in this study. The neurotechnology used is functional magnetic resonance imaging (fMRI). Brief mindfulness intervention for 15 minutes was carried out after the pre-emotion regulation task where participants responded to emotionally valent negative and neutral words, A post emotion regulation task was carried out to evaluate the effectiveness of the brief mindfulness intervention. The negative and neutral word stimuli used in this study were extracted from Affective Norms for English Words (ANEW). We used self-reporting questionnaires such as PANAS-X and MAAS Malay version to measure emotion and mindfulness.

Results: Repeated measure ANOVA was carried out for between-group differences (treatment effect), between-group differences based on time (time-treatment interaction effect) and within-group changes (time effect) for PANAS-X scores and reaction time of

the negative and neutral visual stimuli. Independent sample t-test was carried out to analyze the activated brain regions in the conjunction analysis. The p-value used in these statistical tests was uncorrected < 0.05 for all three objectives. The commonly activated regions between both the mindfulness and audiobook groups are the left precentral gyrus, left postcentral gyrus, left cuneus, and left middle occipital gyrus for negative stimuli. As revealed from the study's findings, mindfulness exercise enhances emotion regulation by showing less negative emotion trait as seen from PANAS-X score. Participants showed more positive emotion in the post-PANAS-X scoring. However, the results of the PANAS-X score and Reaction Time did not yield statistically significant results but a medium and large effect size prominently were identified for both the mindfulness and audiobook group.

Conclusion: As revealed from the study's findings, mindfulness exercise enhances emotion regulation by showing less negative emotion trait as seen from PANAS-X and Reaction Time results. Participants showed more positive emotion in the post PANAS-X scoring compared to the pretesting and participants also responded at a faster rate compared to the pretesting reaction time score. Audiobook and mindfulness groups showed common regions that are responsible for voluntary motor movements, proprioception, generation and regulation of emotions, visual information, and mindfulness. Although the mindfulness intervention was given for only 15 minutes, brain activation were able to be identified.

CHAPTER 1 INTRODUCTION

1.1 Emotion and Emotion Regulation

Emotion and emotion regulation are both interlinked. However, emotion and emotion regulation both present different meanings. Emotions are a part of our everyday life, especially in environments that provide a wide range of rewarding and stressful experiences. Regulating these emotions is usually a deliberate and intentional practice performed to maintain daily functioning and social compliance (Katana et al., 2019a).

Emotion has been researched for a long time, but there is no common definition. According to Kleinginna and Kleinginna (1981), based on a review of 92 possible definitions and nine key claims, there is a consensus on the emotion definition, which is still used today (Kim and Fesenmaier, 2015, Tyng et al., 2017). Emotions are the result of complex interactions between subjective and objective factors where affective responses of great emotional reactivity (high-low activation/calming-arousal) and emotional valence (pleasure-displeasure) are influenced by neurological and hormonal systems capable of (a) generating affective responses of emotionally salient (pleasure-displeasure) and high emotional arousal (high-low activation/calming-arousal); and (b) generating mental tasks such as emotionally relevant perceptual functions impact, evaluations, and classification procedures; and (c) encourage psychological and physiological changes that are common (Kim and Fesenmaier, 2015,Tyng et al., 2017). Emotions are a part of our everyday life, especially in situations that offer a diverse range of rewarding and stressful experiences. Regulating these emotions is a purposeful and conscious task performed to maintain daily functioning and compliance with social norms (Katana et al., 2019b).

Emotion regulation (ER) is the process of initiating, sustaining, controlling, or

changing the frequency, length, and strength of internal feelings and motivations, usually in order to achieve one's goal (Esmaeilinasab et al., 2016). Emotion regulation appears to be a system that allows for better coping with environmental demands, such that emotions are key signals informing concerning external conditions or internal states that can be better managed (Jarymowicz and Imbir, 2015). Emotion regulation also affects the dynamics, duration, and speed with which emotions occur, as well as the behavioral, experiential, and physiological implications of generated emotion (Aldao, 2013, Gross, 2015). Emotion regulation can be used to decrease, strengthen, or sustain the feeling of positive or negative emotions, based on an individual's current objectives or goals (Kobyliska and Kusev, 2019). These changes can occur on three levels: the types of emotions that people experience, when they experience them, and how they experience and express them (Katana et al., 2019). Our ability to control our emotions has significant ramifications for our health and social connections (Wilms et al., 2020)

1.2 Mindfulness

The term "mindfulness" is now routinely used to refer to a group of practices. It typically refers to actions such as paying close attention to both exterior and internal physiological sensations, as well as mental contents, while retaining specific characteristics and aims (Davidson and Kaszniak, 2015, Dorjee, 2017, Levit-Binnun et al., 2021). Mindfulness can be defined as a technique, a state of mind, or a personality quality. Mindfulness techniques were viewed as essential for the contemplative life and were frequently employed in conjunction with other practices that bolster virtues such as kindness and compassion, or as a warm-up to engage in meditations that would provide insight into one's character (Dahl and Davidson, 2019, Levit-Binnun et al., 2021). Other

types of meditation, such as those that integrate moral orientation and self-inquiry, combine, and expand on psychological processes like non-reactive attention and related metacognitive (introspective) skills learned through mindfulness (Dorjee, 2017, Dahl and Davidson, 2019, Levit-Binnun et al., 2021).

All other meditation techniques are founded on a simple coming to awareness of the present moment. Individuals who are aware of what is going on in the current moment can see what is emerging and what is receding. By doing so, we learn to be calm and still, allowing thoughts to come and go without attachment or attempt to grasp them. Over time, we can know how our minds work and become aware of thought patterns that arise frequently. Mindfulness of breathing, compassion-focused meditation, and the body scan are all useful techniques in various forms of mindfulness (being aware of each part of the body in turn as an anchor for the present moment and for where we hold tension and stress in our bodies). Walking meditation, which focuses exclusively on awareness of our feet in contact with the soil and grounding to the present moment, is another form of mindfulness. Over time, regular mindfulness practice allows people to react to their surroundings and anything that arises during their day with greater peace and serenity. (Behan, 2020a, Afonso et al., 2020).

1.3 Problem Statement

Mindfulness is a psychological well-being therapy that increases self-awareness and emotional regulation in response to both external and internal stimuli (Grecucci et al., 2015, Khusid and Vythilingam, 2016, Vitale, 2021). Mindfulness has been linked to a reduction in negative emotions and an increase in good emotions (Wu et al., 2019, Zhou et al., 2020), and past research has focused on the link between mindfulness and negative

emotions (Tong and Keng, 2017, Guendelman et al., 2017a, Wu et al., 2019, Zhou et al., 2020).

Mindfulness is linked to better psychological health, according to a growing body of research. The higher the trait, the better. For example, mindfulness has been associated with lower daily negative affect and higher levels of positivity (Weinstein et al., 2009, Keng et al., 2011, Tong and Keng, 2017). Meditation and other mindfulness techniques have been related to improved psychological health in a variety of populations, according to studies (Keng et al., 2011a, Guendelman et al., 2017,Goldberg et al., 2019,Westphal et al., 2021). In addition, it is also important to have some awareness of strategies to regulate emotions when an individual is healthily facing a negative emotion and is aware of the surroundings. A mindfulness exercise will be beneficial to young adults and people in their surroundings.

There is a paucity of studies on emotion regulation and mindfulness in healthy young adults. Previous studies on emotion regulation and mindfulness are based on clinical populations such as bereaved individuals (Huang et al., 2019), bipolar disorder and major depressive disorder (Musket et al., 2021), and social anxiety disorder (Singh et al., 2020).

Furthermore, no research has been done in exploring brain activation changes between individuals undergoing an emotion regulation task which is measured by a before and after brief audio mindfulness exercise and audiobook exercise. There is also limited study that is carried out to explore negative emotions in healthy individuals, the study was mainly carried out on eating disorder individuals (Sze et al., 2021 , Manchón et al., 2021). Therefore, extensive study is required to explore the changes in brain activation through an emotion regulation task using a brief mindfulness exercise or brief audiobook listening

where the results will be beneficial to know how mindfulness exercise will regulate a young adult's emotions especially in negative emotions. This study differs from other research studies because previous research has been conducted investigating mindfulness and emotion regulation using electroencephalogram (Lin et al., 2020) and functional near-infrared spectroscopy (Rosenbaum et al., 2020a). However, in this study, the researcher would use functional magnetic resonance imaging (fMRI) to assess changes in brain activity during the emotion regulation task before and after a brief audio mindfulness exercise and a brief audiobook.

1.4 Research Question

The research questions that were addressed in this study are stated below:

1. Are there any changes in reaction time in the Emotion Regulation task before and after the brief audio mindfulness exercise and brief audiobook?
2. Are there any changes in emotion level based on the Positive and Negative Affect Scale Expanded Form (PANAS-X) score before and after a brief audio mindfulness exercise and brief audiobook?
3. Are there any changes in the associated brain activation in the Emotion Regulation task before and after the brief audio mindfulness exercise and brief audiobook exercise?

1.5 Research Objectives

The general objectives are stated in 1.5.1 and specific objectives in 1.5.2:

1.5.1 GENERAL

To examine the changes in emotion regulation task and the associated neural activation following a brief audio mindfulness exercise and brief audiobook exercise.

1.5.2 SPECIFIC

1. To compare the changes in reaction time in the Emotion Regulation Task before and after a brief audio mindfulness exercise and brief audiobook.
2. To determine the changes in young adult's emotion level based on PANAS- X score before and after a brief audio mindfulness exercise and brief audiobook
3. To compare the brain activation in the Emotion Regulation Task before and after a brief

audio mindfulness exercise and brief audiobook exercise.

1.6 Research Hypothesis

The hypotheses that were addressed in this study are stated below:

1. Ha: There will be significant changes in reaction time in the Negative and Neutral Emotion Task before and after the brief audio mindfulness exercise and brief audiobook.

2. Ha: There will be significant changes in the emotion level based on PANAS - X score before and after the brief audio mindfulness exercise and brief audiobook.

3. Ha: There will be significant changes in the brain activation in the Negative and Neutral Emotion Task before and after the brief audio mindfulness exercise and brief audiobook exercise.

CHAPTER 2 LITERATURE REVIEW

2.1 Emotion and Emotion Regulation

2.1.1 Emotion

In psychological science, emotion has been thoroughly investigated and evaluated. It's a big idea in art, literature, and everyday life, and it's at the center of the human experience (An et al., 2017). Furthermore, it represents a person's current physical and mental state, affecting cognition, communication, and decision-making (Long et al., 2021). Arousal and valence are two emotional aspects, with arousal referring to the intensity of the emotion and valence referring to the emotional content, which is divided into positive, negative, and neutral feelings (Kim et al., 2013, Bailen et al., 2019, Long et al., 2021). Positive emotions can boost subjective well-being and enhance physical and mental health, whereas negative emotions can harm people's physical and mental health as well as their work prospects (Gupta, 2019). Different emotions arise in response to external environmental stimuli, and these emotions are accompanied by changes in personal representations and psychological reactions that may be quantified and characterized using scientific processes (Wolf, 2015, Long et al., 2021).

Emotions can also have opposing effects; a happy mood can lead to a poor consequence, while a negative emotion may lead to a happy outcome (An et al., 2017). Happiness, for example, is generally thought to be a pleasant and desired emotion, but research has proven that it has a darker side. Happiness is not necessarily a good thing, and the pursuit of happiness is not always a good thing. People who are adamant about achieving happiness are more likely to be depressed, and unhappy (An et al., 2017).

Negative emotions are thought to be adverse to goal setting, effort investment,

cognitive functions (including attention and memory), motivation, self-regulation, and self-efficacy (Rowe and Fitness, 2018). Neutral emotions are defined as indifferent, nothing in particular, and a lack of choice in one direction or the other are all examples of neutral affect. It's also worth noting that neutral affect can coexist with both positive and negative affect. (Gasper et al., 2019).

2.1.2 Emotion Regulation

Emotion regulation has traditionally been thought of as an individual difference trait that is largely consistent over time and conditions but varies by age group. Emotion regulation techniques have been identified in several ways (Naragon-Gainey et al., 2017). Cognitive reappraisal and suppression are two common approaches. Reappraisal is a cognitive approach for modifying the influence of emotion by altering the way a situation is built or analyzing an emotional stimulus (Troy et al., 2018). Suppression is a response-focused method aimed at limiting or reducing actions such as facial expressions, verbal expressions, and gestures that relate to emotional responses (Katana et al., 2019a).

Cognitive reappraisal is an antecedent-focused emotion management method that occurs early in the emotion's experience. This method successfully alters emotional experiences by altering cognitive processes and re-interpreting emotional occurrences. It enables people to alter the underlying evaluations that lead to bad feelings. The practice of cognitive reappraisal on a regular basis has been linked to improved interpersonal functioning, positive affect, and a variety of mental health markers. The act of updating and modifying one's understanding of emotional experiences, thoughts, and events is known as cognitive reappraisal (Gross, 2002, Wang et al., 2017, Troy et al., 2018, Kelley et al., 2019, Ferschmann et al., 2021). When a person is upset, for example, he or she may

pause to consider the event that elicited these unpleasant emotions to better comprehend what went wrong. This method might help him/her feel less angry (St-Louis et al., 2021)

Expressive suppression is a type of response modulation in which an emotional experience is inhibited or suppressed after it has been engaged or consolidated (Wang et al., 2017). When a person tries to stop themselves from expressing their emotions, this is known as expressive suppression. In comparison to a passive viewing condition, expressive suppression may diminish recollection of emotional events. However, these processes are not mutually exclusive; declines in cognitive control do not always coincide with worsening emotion regulation later in life. As a result, successful emotion regulation is also reliant on other mental processes (Gross, 2002, Wang et al., 2017, Kelley et al., 2019, Ciuluvica et al., 2019). When a person is upset, for example, he or she may suppress his or her wrath by not expressing these unpleasant emotions. This strategy almost always backfires and makes one's rage worse (St-Louis et al., 2021).

2.1.3 Emotion Stroop Task

The emotional Stroop effect is a phenomenon in which participants' reactions are delayed when they are asked to respond to non-emotional information in a task because of emotional information in stimuli. The emotional Stroop effect has been examined using a range of task stimuli, including emotion - eliciting sentences, emotional imagery, facial expressions, and even sensitive stimuli for clinical populations, since its discovery. The emotional Stroop task is commonly employed in fMRI research to investigate the brain underpinnings of emotion-cognition interaction (Song et al., 2017)

In neuroimaging investigations, three different forms of the emotional Stroop task were used. The typical emotional "color-word" Stroop test asks participants to name the

ink colour of words or count the number of emotionally salient or neutral words (Straub et al., 2022, Yusoff et al., 2022) . The emotive word stimuli, on the other hand, is semantically irrelevant to the task instruction in this classic variation of the test (e.g., naming the ink colour of words, or counting the number of words) (Mathews and MacLeod, 1985, Wingenfeld et al., 2009, Rahm et al., 2013, Song et al., 2017).

The emotional "word-face" test, in which negative or positive words are overlaid on negative or positive facial expressions, is a second emotional Stroop task type (Arioli et al., 2021, Lunn and Chen, 2022). Participants are asked to identify the emotional expression of the faces while ignoring or discarding the superimposed emotionally charged words, which are either incongruent or congruent with the emotion communicated by the visual stimuli. . Incongruent conditions are defined as facial expressions that differ from the emotional valence of the word (e.g., the word "happy" with an "angry" face). As a consequence, unlike the standard emotional color-word Stroop test, this second emotional Stroop task type creates an acceptable conflict, resulting in more acute emotional interference because it requires more effort to complete (Etkin et al., 2006, Chechko et al., 2009, Rey et al., 2014, Song et al., 2017).

The "priming" task is the third type of emotional Stroop task in which an emotional or neutral visual is shown before "classic Stroop task" trials (e.g., counting Stroop, or color-word Stroop) (Gajewski et al., 2020 , Tonjes, 2021). This activity can be used to look at how emotional priming affects cognitive conflict. This type, like the second, causes emotional interference as well as semantic conflict, necessitating more effort than the conventional Stroop test. (Hart et al., 2010, Melcher et al., 2011, Adams and Nelson, 2015, Song et al., 2017)

2.2 Mindfulness

Mindfulness can be characterized as non-judgmental attention to the present moment. Although mindfulness and meditation are connected, the phrases are not interchangeable. Moreover, formal meditation exercises (e.g., paying attention to the body, lying on the ground, or walking slowly with a sense of awareness of one's surroundings) as well as informal exercises (e.g., fully immersed in what one is doing or feeling at a certain moment) (Alberts and Hülsheger, 2015, Janssen et al., 2018). Mindfulness has been found to help people manage their emotions more effectively and to improve their physical and mental health (Kang et al., 2012, Musket et al., 2021). Emotional awareness, or the degree to which an individual is aware of his or her current emotional state, is a critical component of mindfulness as it relates to the process of regulating emotions. The ability to recognize and distinguish between distinct emotions has been advocated as a first step toward adaptively managing emotions (Musket et al., 2021).

2.2.1 Type of Mindfulness

Mindfulness can be delivered to an individual through face to face and online methods. However, the target group for mindfulness therapy varies among individuals. It could be given to people who have serious depression, anxiety disorders, borderline personality disorders, chronic pain, or eating disorders, as well as non-clinical people like students and employees who want to improve their subjective well-being. Mindfulness-based stress reduction (MBSR) and mindfulness-based cognitive therapy (MBCT) are the two main types of mindfulness interventions (Frostadottir and Dorjee, 2019)

The most common secular mindfulness-based programme is Mindfulness-Based

Stress Reduction (MBSR) training (Kriakous et al., 2021). MBSR was developed with the purpose of reducing pain in chronic pain patients. It includes eight 2.5-hour weekly sessions and one 7-hour silent day. Homework is a crucial part of the training: six days a week, 45 minutes of daily exercise at home using CDs and given exercises (Janssen et al., 2018). The body scan (paying attention to what the body is experiencing), sitting meditation (paying attention to respiration, noises, feelings, physical sensations, thoughts and emotions), simple movement exercises including walking or standing meditation, or lying yoga exercises (paying close attention to what the body is feeling; discovering and having to accept boundaries), and unofficial meditation exercises (paying complete attention to everyday routines (e.g., brushing one's teeth, watching a show) are all instances of MBSR. Mindfulness-Based Cognitive Therapy (MBCT) is group-based psychotherapy that combines elements of mindfulness-based stress reduction (MBSR) and cognitive behavioral therapy (CBT) (Frostadottir and Dorjee, 2019). Patients engage in mindfulness exercises (such as body scans) to increase their awareness of their thoughts, emotions, and physical sensations. MBCT integrates MBSR-based systematic mindfulness meditation training. MBCT also includes CBT elements including psychoeducation about the role of cognition in depression and activities that show how one's thoughts, emotions, and behaviors can cause and prolong depressive symptoms. The integration of mindfulness and CBT in MBCT is thought to help people detect and disengage from dysfunctional cognitive processes including ruminative and negative thoughts in order to lessen depressive symptoms and the risk of relapse in the future (Mackenzie et al., 2018, Janssen et al., 2018)

2.2.2 Duration of mindfulness

Furthermore, the duration of mindfulness can be long-term (e.g., eight weekly 2.5-hour sessions, eight-hour daylong retreats, one 2.5-hour session per month for ten months) or short-term (e.g., eight weekly 2.5-hour sessions, eight-hour daylong retreats, one 2.5-hour session per month for ten months) (e.g., four weekly 30-minute sessions). A high dose of mindfulness intervention would be eight weekly 3-hour sessions and 45 minutes of daily mindfulness practice and a low dose would be 30-minute sessions and 15–20 minutes of daily mindfulness practice (Leroy et al., 2013, Poulin et al., 2013, Amutio et al., 2014, Janssen et al., 2018).

2.3 Functional Magnetic Resonance Imaging

In the world of neuroscience, functional neuroimaging is a set of methods that investigate how the brain operates to link changes in activity in one region to certain task performances, experiences, or behaviors (Whitten, 2012). fMRI is a noninvasive imaging technique that employs nuclear magnetic resonance and magnetic field gradients to produce pictures with a range of contrasts such as T1 weighting, T2 weighting, susceptibility, and velocity (Glover, 2011). It is conducted with conventional MRI scanners and does not require contrast agents to be injected. Although fMRI does not use radioactive probes, it has a high degree of consistency and allows researchers to analyze not only changes in brain morphology that affect the activation of a given region, but also its connectivity to other brain regions (Dimoka, 2012, Mier and Mier, 2015). Increased localized brain activity leads to increased energy consumption and blood flow, according to all fMRI measurements. The results of indirect brain function determination are frequently represented as a statistical map that shows regional activity. The transfer of

information between neurons is a metabolically demanding process that necessitates a higher flow of oxygenated blood, also known as oxyhemoglobin (Soares et al., 2016). Along with the local influx of oxygenated blood, the ratio of oxygenated arterial blood to deoxygenated venous blood rises, resulting in a net increase in the balance of oxygenated arterial blood to deoxygenated venous blood, which is associated with higher deoxyhemoglobin. The MRI signal increases when the oxy-/deoxy-hemoglobin ratio exceeds that of the surrounding tissue. It's worth noting that, following an intrinsic delay, regional dilation and flow increase as local brain activity rises.

Figure 1 explains fMRI's workflow. To undertake the most appropriate fMRI study, researchers/clinicians must first grasp the primary application domains, intrinsic hemodynamic characteristics (A), and how to design the experiment [resting state (B), block (C), event-related (D), or mixed (E) designs] (either task-based or resting state). Identifying the most appropriate acquisition techniques (F) and recognizing the primary artefacts involved are essential (G). The preprocessing of the collected data includes stages such as acquisition quality control (H), format conversion (I), slice timing (J), motion correction (K), spatial transformations (L), spatial smoothing (M), and temporal filtering (N). The desired analysis methods, whether task-based (O) or resting-state fMRI (P), should be used, and statistical conclusions drawn (Q). A variety of approaches can be used to supplement analysis in multimodal research (R).

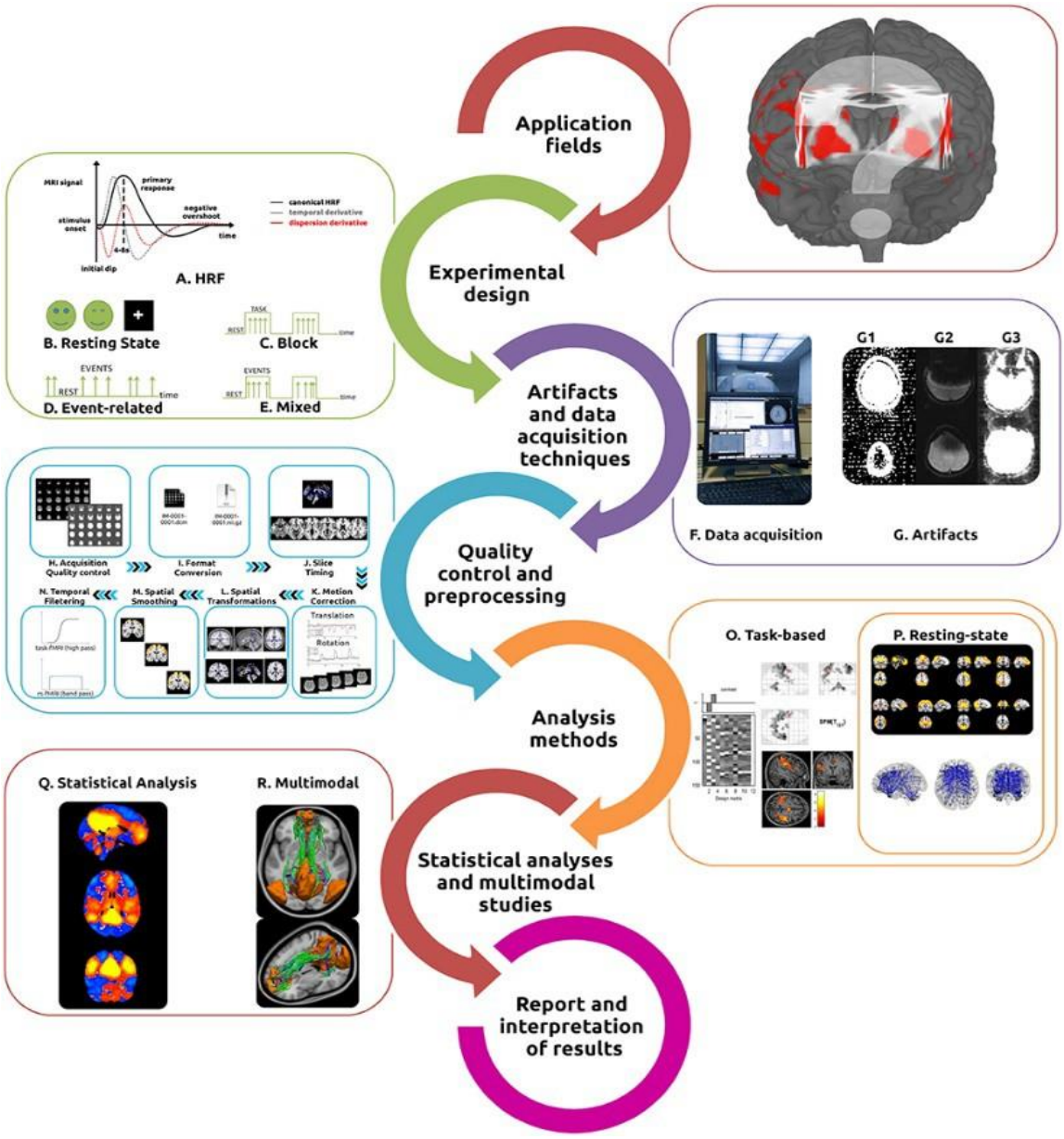

Figure 1. fMRI Workflow adapted from Soares et al., (2016)

Furthermore, the hemodynamic response function (HRF) is a mathematical model of the neurovascular relationship between local brain activity and the fMRI signal that is reliant on blood oxygenation levels (Rangaprakash et al., 2021). It's also a local vascular network-based mechanism that happens several seconds after the increase in activity. The BOLD signal can be identified by the form of this HRF, which shows its vascular origin. The HRF is typically modelled in fMRI software using a set of gamma functions known

as canonical HRF, which are characterized by a gradual rise, peaking 5–6 s after the stimulus, followed by a return to baseline (about 12 s after the stimulus) and a small undershoot before stabilizing again, 25–30 s after the stimulus which is shown in Figure 1 A (Miezin et al., 2000, Buxton et al., 2004, Handwerker et al., 2012, Soares et al., 2016) , the interpretation of the results should be done with the utmost caution (Soares et al., 2016). The HRF usually has a tiny initial fall, then a high peak, and then varied post-stimulus undershoots. The first dip is irregular and unpredictable, and it is more common in very high fields. The BOLD response is dominated by the positive dominating peak, which swiftly overwhelms the slight early fall. Regional cerebral blood flow increases out of proportion to acute metabolic needs during this period. The post-stimulus undershoot is vary, although it's most typical in prolonged-stimulus studies. Its cause is unknown; however, it is thought to be due to a combination of sluggish arterial blood volume recovery and a late stimulus- and brain-state-dependent drop in regional cerebral blood flow (Hu and Yacoub, 2012).

Block design (Figure 1C), event-related design (Figure 1D) and mixed block/event-related (Figure 1E) design are the most common forms of fMRI experiments. Block designs record overall brain activity over the course of a task block, resulting in a single magnitude of activity that encompasses both sustained and transient BOLD activity. Jittered trials are used in event-related design to mimic the transient responses of various trial types. The persistent BOLD activity and transitory activity at block transitions are ignored in this model. Mixed block/event-related designs allow for simultaneous modelling of transient, trial-related BOLD activity and sustained, task-related BOLD activity (Petersen and Dubis, 2012). Blocked designs are better for detecting activated brain areas with a specific HRF shape, whereas event-related designs are better for

estimating HRF shape (Maus et al., 2010). An alternating boxcar design was presented in this study. It is made up of blocks of two conditions that alternate. One of these situations is a null block, which happens when there is no systematic or task-related activation (Maus et al., 2010).

fMRI also employs a paradigm design, which is described as the temporal allocation of stimuli to obtain BOLD responses from the individual. Specific paradigms containing stimuli or events are employed in an fMRI experiment to elicit a hemodynamic response or brain activity in the subject. A precise and successful paradigm design is required for a complete fMRI investigation. At present, there are many software packages available for designing fMRI paradigms such as Cogent (Laboratory of Neurobiology, Wellcome Trust, London, UK;), E-Prime (Psychology Software Tools, Inc. Pennsylvania, USA), and Presentation (Neurobehavioral Systems, Inc.; California, USA) (James et al., 2014). However, this study used E-Prime to design the paradigm.

Behavioral data could be obtained from the fMRI through response time. Response times (RTs) are a natural type of data to study cognitive processes behind the performance on cognitive tests(De Boeck and Jeon, 2019). Reaction time (RT) is "the amount of time required for an individual to manifest a quick voluntary reaction in response to aural or visual stimuli"(Prabu Kumar et al., 2020). RT is the amount of time that passes between a person being presented with a certain sensory stimulus and acting in reaction to it. This stimulation might be visual, aural, tactile, or something else entirely. The speed at which the human body reacts to diverse stimuli varies. For example, it reacts to auditory stimuli more quickly than visual stimuli. RT is a crucial component of information processing and is regarded as a measure of both the processing speed of data and the reaction time of programmes. There are other RT kinds, including the basic RT (the amount of time

between the display of the stimulus and the reaction), the recognition RT (the response to one stimulus but not to others), and the choice RT (different stimuli requiring different responses) (Prabu Kumar et al., 2020).

2.4 fMRI in Mindfulness and emotion regulation

Mindfulness meditation showed proof of emotion-regulating consequences for the neural level during a passionate assumption task. There are expanded enactment in mind areas related to feeling guidelines, alongside decreased initiation in cerebrum districts engaged with the preparing of enthusiastic valence and excitement (Falcone and Jerram, 2018). In both the region of interest and the complete mind investigation, the mindfulness group revealed increased activation in the dorsomedial prefrontal cortex and other prefrontal areas when compared to the fundamental group during the supposition for perhaps regrettable or highly increases (Lutz, 2014). Furthermore, mindfulness training reduced activity in areas linked to emotion regulation, despite negative increases in the right amygdala, parahippocampal, and solitary districts. During the assumption of negative images, movement in the dorsomedial prefrontal cortex and insula was associated with trait awareness in the opposite direction (Lutz, 2014).

In addition, the study findings may contribute to knowing that the amygdala may show decreased activation and increased left-sided prefrontal activations (inferior dorsolateral prefrontal cortex, middle and inferior frontal gyrus) in the presence of mindfulness during a negative stimulus. During an emotional expectancy challenge, a 15-minute mindfulness intervention showed indications of emotion-regulating benefits on the brain level. There was an increase in activity in brain areas linked with emotion control, as well as a decrease in activation in brain regions involved in emotional valence

processing (Lutz et al., 2014). Brief Mindfulness had a significant impact on the intensity of pleasant and negative emotions, emotional memory, and negative emotional attention bias, according to Wu et al., (2019). The Brief Mindfulness Meditation group did not show any detrimental effects on mood. The author also stated that in the Brief Mindfulness group, emotional intensity toward negative stimuli decreased after the intervention. Several studies have found that mindfulness meditation has a favorable influence on nurturing emotional mental health in clinical populations such as anxiety and depression, as well as healthy populations (Bohlmeijer et al., 2010, Fjorback et al., 2011)

Generalized anxiety disorder (GAD) and emotion dysregulation were investigated in a study by (Li et al., 2020). Patients with GAD tend to overreact to emotional stimuli and have problems with emotional regulation. As a result, participants in this study were required to perform an emotional face identification task while undergoing fMRI scanning (fearful, neutral, happy facial expression). There were thirty participants (16 GAD patients, 14 Healthy Controls (HC)). This study used a block design, with each block containing five photos of the same type. Each image was shown for 4 seconds. A 20-second cross appeared on the screen before each block was presented. The challenge was divided into 12 sections and took 8 minutes to complete. There were no images repeated. The fMRI data were collected at Nanjing Brain Hospital using a 3.0 Tesla Siemens Medical System scanner. Each participant was told to do the task they had prepared before scanning during the 8-minute (240 volume, 36 slices for each volume) fMRI scan. The following scan parameters were used to gather imaging data using the echo-planar imaging (EPI) sequence: The field of view (FOV) is 240 mm 240 mm, slice thickness is 4 mm, spacing between slices is 4 mm, 36 slices, repetition time (TR) is 2000 ms, echo time (TE) is 30 ms, and flip angle (FA) is 90 degrees. Emotions can be formed from the

'bottom up', in reaction to a stimulus's fundamentally emotional perceptual aspects or from the 'top down', in response to the stimulus's inherently emotional perceptual features in response to cognitive appraisals of an event (McRae et al., 2012). In comparison to HCs, GAD patients demonstrated stronger bottom-up but less top-down connectivity, independent of condition. More bottom-up connections but less top-down connections could imply that GAD patients lack top-down control, supporting the idea of inadequate top-down control.

Individuals with significant depression have reduced control of attention and emotions, according to a study by Loeffler et al. (2019), which used functional magnetic resonance imaging and emotion regulation. Both processes have conceptual similarities and may share mechanics. The goal of this research is to investigate attention management and how it relates to cognitive emotion regulation in depression. The participants were asked to score photos from the FACES database of 42 sad and 42 cheerful Caucasian faces (balanced for age and sex). The data for the fMRI was collected using a 24-channel head coil on a 3 T Siemens PRISMA scanner. A T2*-weighted echo-planar sequence (TR: 2000 ms, TE:30 ms, FoV: 210 mm, 36 slices (ACPC), voxel size: 3.3 3.3 3.0 mm, flip angle: 77°, distance factor: 20% (=0.6 mm)) was used to collect functional data. Attention control and cognitive emotion management abilities appear to be connected at both the behavioral and neurological levels, according to the results of brain activity. Interventions that target attention regulation, particularly in the processing of pleasant stimuli, may ameliorate emotional disturbances in depression, according to shared processes (Loeffler et al., 2019).

Furthermore, a study conducted by Seidel et al., (2018) on the regulation of negative emotions in anorexia nervosa individuals with an fMRI shows that increased

dorsolateral prefrontal cortex activation in anorexia nervosa during passive viewing of negative stimuli is in line with the hypothesis that the disorder may be characterized by excessive self-control. Participants were given the option of viewing a collection of negative, positive, and neutral images passively or actively downregulate any emotions elicited by the negative and positive images. Structural T1- and functional EPI-Images were collected using standard sequences with a 3T whole-body MRI scanner (TRIO, Siemens) equipped with a standard head coil between 8 and 9 AM following an overnight fast. SPM 8 was used to process the imaging data. Table 1 shows the summary of literature review for fMRI carried out on mindfulness and emotion regulation.

In recent years, there has been a rise of interest in mindfulness-based interventions, with several research in both clinical and non-clinical groups. Furthermore, additional research is needed to assess the impacts of mindfulness to acquire a better understanding of their potential effects, particularly in Malaysia, where studies in this area are still sparse. A higher number of studies may enable the replication of such programmes in other socioeconomic circumstances, resulting in a considerable public health impact.

Table 1 shows the summary of the literature review for fMRI carried out on mindfulness and emotion regulation.

Author, Year & Title	Task	Results
Li, Jian; Zhong, Yuan; Ma, Zijuan; Wu, Yun; Pang, Manlong; Wang, Chiyue; Liu, Na; Wang, Chun; Zhang, Ning	Participants were instructed to complete an emotive face recognition exam while undergoing fMRI scanning (fearful, neutral, or joyful	In comparison to HCs, GAD patients exhibited stronger bottom-up but less top-down connectivity. In

(2020). *Emotion reactivity-related brain network analysis in generalized anxiety disorder:*	facial expression). A Bayesian network-based technique was used in each case to identify the brain network, which included several pre-hypothesized regions of interest (ROIs) (negative, positive, neutral). In total, six graphs were created. In a suitable situation, each of them represented the group's common brain network.	comparison to HCs, the insula was more connected while the amygdala was less connected. Even in the neutral situation, the results showed that GAD sufferers and HCs had highly different brain network responses
Loeffler, Leonie Anne Kathrin; Satterthwaite, Theodore Daniel; Habel, Ute; Schneider, Frank; Radke, Sina; Derntl, Birgit (2019). *Attention control and its emotion-specific association with cognitive emotion regulation in depression.*	During conducting fMRI, the participants completed an emotional face-word Stroop test as well as a cognitive emotion management challenge. In both tasks, patients and controls behaved similarly. Participants were better at modulating their happiness across groups who were less diverted from cheerful faces by the incongruent term "sadness" (Stroop task) (emotion regulation task).	The left supramarginal gyrus was recruited in both the Stroop and emotion regulation tasks. In the Stroop task, only patients demonstrated a relative attentional disengagement from positive versus negative stimuli. In both the Stroop and emotion regulation tests, the left supramarginal gyrus was activated. Only patients showed a relative attentional disengagement from positive versus negative stimuli in the Stroop task. Attention

		control and cognitive mood regulation appear to be linked at both the behavioural and neural levels. Therapies that target attention management, particularly in the processing of pleasurable stimuli, may alleviate emotional disturbances in depression, according to shared processes.
Seidel, Maria; King, Joseph A.; Ritschel, Franziska; Boehm, Ilka; Geisler, Daniel; Bernardoni, Fabio Beck, Matthias; Pauligk, Sophie; Biemann, Ronald; Strobel, Alexander; Goschke, Thomas; Walter, Henrik; Roessner, Veit; Ehrlich, Stefan (2017). *Processing and regulation of negative emotions in anorexia nervosa: An fMRI study. NeuroImage:*	Participants were given the option of viewing a collection of negative positive, and neutral images passively or actively downregulate any emotions triggered by the negative and positive images. Participants in the passive watching condition were told to simply look at the picture without trying to control their feelings. In the regulation condition, individuals were told to use the reappraisal approach 'detachment' (distancing) to downregulate their feelings by pretending to be an uninvolved observer	These findings add to prior evidence of impaired processing of key emotional inputs in AN, but they do not indicate a general lack of control over negative emotions. Increased dlPFC activation in AN during passive viewing of negative stimuli supports the theory that the illness is characterised by a lack of self-control. Taken together, the evidence suggests that detachment reappraisal may be an effective method for