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**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

**Investigating the impact of a non-pharmaceutical online
intervention on anxiety and subsequent working memory
function.**

Wesley Harmer

A thesis submitted to the University of Huddersfield in partial fulfilment of the requirements
for a MSc in Psychology

September 2021

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

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Abstract

Anxiety disorders are on the rise, with a great deal of research exploring the factors and consequences of this. However, less focus has been given to the prevalence of subclinical anxiety and its effects on cognition with the rise coinciding with clinical anxiety. Furthermore, treatment has become more digitised with a lack of research vetting the effectiveness of this. This study sought to explore the effects of an online-based progressive muscle relaxation (PMR) on anxiety levels in a sample of participants with subclinical anxiety. In addition to this, changes in anxiety were correlated with changes in working memory performance, measured using a Reverse Corsi Block Task (RCBT). A diverse sample of 162 participants was collected and pseudo-randomly allocated into two groups, the PMR experimental group (n = 97) and the control group (n = 65). In a four-week study, participants within the experimental group were asked to complete the PMR exercise three times a week whilst the control was inactive. Data was collected regarding anxiety levels at the beginning of the study and every two weeks subsequently using the GAD-7. The RCBT was used to collect working memory data across the same timepoints. The findings show that there was a significant decrease in reported anxiety levels for those in the experimental group compared to those in the control group, whereas due to conflicting correlations, no significant correlation could be established between the levels of anxiety and working memory. This shows that there is potential for online PMR to be effective, however further research is required. Attrition rates were measured and the implications for the attrition on the results and the effectiveness of online-based PMR was discussed.

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Introduction

Anxiety is defined as a feeling of worry and tension with physiological components (for example elevated blood pressure). In cases which the anxiety suffered is considered pathological, individuals are diagnosed with an anxiety disorder. There are a range of anxiety disorders with the diagnosis dependent on both the severity of the anxiety as well as the cause of it. The pathology of these disorders is outlined within diagnostic criteria, the most prominent of which is the DSM-V (APA, 2013). The most prevalent anxiety disorder is Generalised Anxiety Disorder (GAD). The DSM-V diagnostic criteria for this includes feelings of excessive anxiety and uncontrollable worry that persists for at least six months. This must be accompanied by at least three of the following symptoms: restlessness, tiredness, poorer concentration than usual, irritability, muscle soreness and inhibited sleep.

Anxiety disorders more broadly are the most prevalent psychological conditions (Kessler et al., 2005). It is estimated that 33% of all adults in the United States will experience pathological anxiety at least once in their life (Bandelow & Michaelis, 2015). Additionally, within the UK the number of people at risk for clinical anxiety rose from 6.2/1000 in 2003 to 14.7/1000 in 2018 and diagnosis of anxiety incidents rose from 13.2/1000 to 15.3/1000 in the same period (Archer et al., 2021). The prevalence of anxiety and discussions regarding anxiety in contemporary society is one of the defining cultural zeitgeists and is emblematic of a greater focus and knowledge of one's mental wellbeing. This is particularly notable amongst younger people, which has contributed to the rise in anxiety cases (Archer et al., 2021). Indeed, as understanding and acceptance has increased culturally, the prevalence of self-reported anxiety has increased (Somers et al., 2006). It must

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be noted that this link has not been demonstrated to be causal, although acceptance has been posited as a key factor for introspecting on one's own mental well-being (Fleming et al., 2013). Whilst introspection has increased, there has also been a coinciding rise in broader cultural trends that induce anxiety. This includes cultural factors, such as a greater focus on materialistic goals in place of communal enrichment, and technological development, such as social media, that has precipitated the rise of anxiety (Twenge et al., 2010). It is important to note that the rise in anxiety is not limited to clinical anxiety disorders, but rather anxiety as an acute emotion (Somers et al., 2006).

Subclinical anxiety

Due to the nature of the diagnostic criteria, there is a subsection of individuals who suffer from anxiety at a rate which is considered problematic but does not meet the threshold for a diagnosis, this is phenomena is termed 'subclinical anxiety'. A good example of subclinical GAD would be individuals meeting the two core tenants of GAD (worry and anxiety) but only having two of the necessary three aforementioned symptoms for a GAD diagnosis. Discerning the impact of subclinical anxiety is a difficult as acute elevated levels of anxiety are common, which limits the ability to draw conclusions when examining the general population. It has been demonstrated that elevated levels of subclinical anxiety reduce quality of life (Gostoli et al., 2017). Quality of life measured in Gostoli et al. (2017) was measured using the MOS 36-Item Short Form Health Survey (SF-36) (Ware, 1999). This measure accounts for physical as well as psychological wellbeing with scales focused defined as Mental Health and General Health. The study found that there was a significant decrease in both physical and psychological related quality of life with subclinical anxiety and this decrease was seen across the domains of the SF-36. These domains include social functioning, mental health and general vitality which pertain to anxiety specifically.

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Furthermore, subclinical anxiety has been associated with a reduction in broad cognitive capabilities (Derakshan & Eysenck, 2009; Ansari & Derakshan, 2010), this includes a decrease in task efficiency pertaining to working memory (Derakshan et al. 2009) meaning the speed the task was completed in as well as the utilisation of the resources provided. Subclinical anxiety was also demonstrated to reduce planning performance, this was demonstrated in Unterrainer et al. (2018). This study used a population-based sample of participants aged between 40-80 and measured their proficiency at the Tower of London task. This task required participants to cognitively plan their moves in order to succeed in the allotted number of moves. It was found that subclinical anxiety was associated with lower performance in the Tower of London task, independent of age, and that anxiety levels were the only measure with predictive value on cognition. However, the permanence of these effects is directly tied to the rate at which the anxiety is present, with the aforementioned factors returning to the average for the individual after the anxiety has dissipated. It should be noted that subclinical anxiety can manifest in two ways, as an acute heightened level of stress or anxiety tied to a particular event, this is common with students during exams which can have an indelible impact on their future (Khoshhal et al., 2017). The other manifestation is low level chronic anxiety which more so impacts daily life, including socialising and maintaining basic needs (Crisan et al., 2016). Research focusing on solutions for these issues have predominantly focused on acute anxiety with exam anxiety a particular area of focus. This has resulted in suggestions for coping techniques (Shimave et al., 2020) and structural changes to the examination process, including making UK primary school SATS non-statutory by 2023. It must be noted that exam anxiety can manifest as both acute anxieties, whilst completing the exam, and chronically for the months preceding the exam, as evidenced

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with elevated anxiety in the months prior to exams (Lotz & Sparfeldt, 2017). However, as it is an event orientated anxiety, the anxiety is reduced once the event has finished.

Research into reducing trait subclinical anxiety has been mostly focused on preventive interventions such as exercise (Smits et al., 2008; Herring et al., 2018), psychological education and a modified version of Cognitive Behavioural Therapy (Norton, 2008). However, these interventions have only been demonstrated to reduce anxiety sensitivity, which can be defined as the fear of anxiety and the related symptoms (Hovenkamp-Hermelink et al., 2019). This reduction has been correlated to a decrease in anxiety (Olatunji & Wolitzky-Taylor, 2009) however, it is dependent on the participant demonstrating a heightened sensitivity to anxiety and anxiety sensitivity is not predictive of anxiety. The Contemporary Transdiagnostic Preventative Intervention (CTPI) for anxiety was designed by Korte and Schmidt (2020), this incorporates elements from prior anxiety disorder prevention but attempts to encompass anxiety broadly compared to prior incarnations focusing on specific anxiety disorders (Gardenswartz & Craske, 2001). The research demonstrated that the CTPI was effective at reducing anxiety symptoms after a week, however it was not a significant mediator after one month.

When discussing the implications and treatments for subclinical anxiety it is important to establish what constitutes pathological anxiety. The DSM-V outlines eleven distinct anxiety diagnosis (American Psychiatric Association, 2013). These anxiety disorders can explain the cause for the anxiety (such as agoraphobia) or how the anxiety itself manifests (such as panic disorder). As mentioned prior, GAD is the most predominant pathological anxiety diagnosis, with an estimated 5.9% of UK residents diagnosed (McManus et al., 2016). The threshold criteria for a GAD diagnosis have been demonstrated to exclude a

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robust cohort of individuals who are negatively impacted by anxiety. A critical literature review conducted by Haller et al. (2014) demonstrated that subthreshold GAD impeded social and psychological functioning when compared to a non-anxious control. This included, greater levels of distress, with 83.7% of younger people and 75% of older people with subthreshold GAD considered to have a distress impairment, lower levels of psychosocial functioning, poorer sleep quality and an increase in suicide attempts as compared to a healthy control. This further demonstrates that subclinical anxiety has measurable negative effects which provides the rationale to investigate ways to mitigate it. Additionally, it solidifies the notion that the clinical/non-clinical dichotomy is an incomplete lens through which to view anxiety. Indeed, the absence of specialised or codified approaches to subclinical anxiety is problematic as there is no treatment no universal treatment for them, making the issue difficult to address (Korte & Schmidt, 2020).

The literature review by Haller et al (2014) also indicated that sub-clinical anxiety was comorbid with other mental disorders, in particular major and minor depressive disorders, as well as physiological disorders. This is supported by the multitude of research that has demonstrated the presence of sub-clinical anxiety in a range of chronic diseases and the adverse impacts it has on recovery (Munafò & Stevenson, 2001; Agarwal & Agarwal, 2011; Chun et al., 2018). Regarding mental health, anxiety and depressive disorders have long been intertwined with comorbidity as high as 85% between depression and major anxiety symptoms (Gorman, 1996). The presence of elevated anxiety is problematic as it reduces help-seeking behaviour which is not limited to anxiety related conditions but for healthcare broadly (Heinig et al., 2021). It is plausible that reducing subclinical anxiety could in turn increase participation within healthcare for those with other comorbid disorders.

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It is important to note that the literature review by Haller et al (2014) also asserted the subthreshold GAD was a risk factor for the future onset of pathological GAD. Indeed, an assertion presented in Rucci et al. (2003) was that subthreshold GAD could possibly a necessary part of the manifestation of threshold GAD. Essentially, that the delineation between clinical and subclinical is potentially arbitrary and should be considered on a greater spectrum. This demonstrates the need for greater focus on subclinical anxiety in order to reduce the rate of GAD diagnoses and other pathological anxieties, as well as improving help-seeking behaviour for other conditions.

An assertion made by Haller et al. (2014) was that the prevalence of subthreshold GAD was double that of diagnosed GAD. Presently, this large group of non-pathological anxious individuals (according to traditional diagnostic criteria), does not have a standardised recommended treatment compared to clinical anxiety. It must be noted that prior research concludes that clinical level treatments for GAD were deemed unfit for those with subthreshold GAD (Rucci et al., 2003), therefore efforts should be made to find effective treatments pertaining to subclinical anxiety.

An advantage of a diagnosis is that it can provide clarity on the type of anxiety a patient is suffering from. In the absence of a diagnosis, the nuances of the anxiety may be missed. This includes the trigger of the anxiety, and the way anxiety manifests. Indeed, two distinct dimensions of anxiety have been categorised: anxious apprehension and anxious arousal, as first defined in Heller et al. (1997). Anxious apprehension is defined as future or past orientated thinking, which typically manifests as worrying and anxious arousal is anxiety derived from immediate or present anxiety inducing stimuli, this is often associated with the somatic components of anxiety. There has been a litany of research supporting this assertion

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(Nitschke et al., 1999; Engels et al., 2007; Engels et al., 2010). An example of the evidence found supporting this assertion was in relation to brain function connectivity. In particular, Default Mode Network connectivity differs with lower connectivity found to be associated with anxious apprehension and higher connectivity associated with anxious arousal (Burdwood et al., 2016). This pertains to clinical anxiety as research into the neural connectivity of subclinical anxiety has yet to conclude whether the relationship is the same for subclinical anxieties.

The GAD-7

Prior research tends to support the use of the GAD-7 as a widely accepted measure of anxiety (Spitzer et al. 2006). The GAD-7 is a short retrospective questionnaire measuring participants' mood for the two weeks prior. It has been validated for assisting in the diagnosis of GAD (Bártolo et al., 2017) with strong cross-culture data supporting its effectiveness (Donker et al., 2011; Parkerson et al., 2015; Hinz et al., 2017; Muñoz-Navarro et al., 2017; Silva et al., 2018; Ahn et al., 2019; Teymoori et al., 2020; Borgogna et al, 2021). Pertinently for the present study, the GAD-7 was validated for use in measuring subclinical anxiety (Löwe et al., 2008). This research also indicated that the GAD-7 is internally consistent as well as consistent with comparable measures, lending credence to the GAD-7 as a valid measure for subclinical anxiety. In order to establish its effectiveness for subclinical anxiety, the researchers conducted face to face interviews on a nationally representative sample of 5030 participants. The data collected included the GAD-7 scores and other established anxiety measures (the Rosenberg Self-Esteem Scale and Patient Health Questionnaire) as well as demographic data. The GAD-7 was found to have strong correlations with the aforementioned anxiety measures, which led the researchers to conclude the GAD-7 is an appropriate measure for anxiety on the general population.

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A core component of an effective measurement of subclinical anxiety is the sensitivity to granular change in anxiety levels. Indeed, within Löwe et al (2008) the average anxiety for the non-clinical group was 2.95, suggesting that a sufficiently sensitive measure should be used. The sensitivity of the GAD-7 was assessed by Toussaint et al. (2020), in which comorbid anxiety change was measured in a cohort with major depressive disorder. It found that the change in the GAD-7 score matched the other measures used in the study, with the author noting that the GAD-7 is sensitive to minor changes in anxiety. This is particularly necessary for measuring change in subclinical anxiety as the level of change is unlikely to be great.

A systematic review conducted by Plummer et al. (2016) found that a reported score of 7-10 was the point where pathological anxiety could begin. It must be noted that this is contrary to the initial assertion made in Spitzer et al. (2006), which argued that a score of 10 was required to show GAD. It can be inferred that below these scores, anxiety can be considered subclinical. It is important to consider that the GAD-7 is not definite in the diagnosis of GAD, meaning that if a participant or patient scores highly on the test, it does not necessitate the presence of GAD. Often it is used in collaboration with interviews of patients and provides insight to the practitioner regarding the potential for a diagnosis. The validity of the measure is key, as it is a simple anxiety measure that can be readily conducted by an individual who is concerned with their anxiety levels. In theory, having a measure that is accessible could help reduce avoidant behaviour prevalent in those with anxiety (Cook et al., 2012).

Anxiety and Cognition

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Anxiety's impact on broad cognitive functions is varied, effectively illustrated by Robinson et al. (2013). The findings of the study indicated that survival cognitive abilities (for example vigilance) were improved when in distress (McAuley et al., 2009; Kastner-Dorn et al., 2018; Wermes et al., 2018) which results in both adaptive and maladaptive consequences. Conversely higher order cognitive ability (like memory) were negatively impacted. This broadly affirms the dual-processes approach to stress/anxiety, that thinking can be separated into intuitive and deliberate, with intuitive thinking enhanced by stress and deliberate inhibited. One area of note is perception, evidence provided by Bar-Haim et al. (2007) demonstrated that perception is fundamentally altered when anxiety rises, with a greater sensitivity to discrepancies. This can be seen as an early threat detection mechanism which has adapted for anxiety. Research lends credence to this, with anxiety improving perception and attention focus more broadly (Hallion et al., 2019; Pacheco-Unguetti et al., 2010), however excessive anxiety can lead to poorer levels of selective attention (Fernández-Castillo & Caurcel, 2015). An area that intersects two areas of cognition is eyewitness testimony. This is dependent on perceptual awareness at the time and memory retention. Seminal research conducted by Loftus et al. (1987) indicated that memory recall was negatively impacted when the level of arousal felt during the incident was greater. Since then, eyewitness testimony research has largely supported these findings, with the caveat that a medium level of arousal produces the best recollection (for example, Dutton & Carroll, 2001), with the causes of the poorer recollection elucidated. This includes the weapon focus effect (Fawcett et al., 2013).

The effects of task complexity were investigated in a study by Diamond et al. (2005) which illustrated that memory recollection is dependent on the complexity of the task, not

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solely the level of anxiety. The study corroborated two theories of anxiety and cognition. The first was the Yerkes-Dodson Law (1908) which proscribes that a base level of anxiety or other form of stimulation is required for optimum memory and the second was the dual processes theory. Whilst these theories explain the result of the outcomes, they are not able to establish a cause for why excessive levels of anxiety lead to reduced cognitive capabilities. An explanation for this is provided by Eysenck's Attentional Control Theory (ACT) developed by Eysenck et al. (2007). This theory argues that when anxiety increases, the ability to effectively assign one's cognitive resources decreases. This reduction, it is argued, is due to a limit on a person's ability to pay attention if the anxiety or stress of a situation is too great. It has been demonstrated that this disruption in assigning cognitive resources significantly reduces working memory function (Sari et al., 2017).

Working Memory

The function of working memory is best described as temporary memory maintenance and manipulation necessary for complex tasks (Baddeley, 1996). The Working Memory Model (WMM), developed by Baddeley and Hitch (1974), is comprised of two levels, the first is the Central Executive, which coordinates the subsidiary systems in addition to delegating stimuli and cognitive resources to the appropriate systems. The second level contains the two subsidiary systems: the Visuo-spatial Sketchpad, which processes information in a visual or spatial form and the Phonological Loop, which processes spoken and written materials as well as accounts for the inner voice, which rehearses information. Conceptual evidence for the systems can be observed by how deficits in memory occur. Articulatory suppression impeded verbal working memory (Hanley & Bakopoulou, 2003) as well as the ability to rehearse (Nees & Leong, 2018). Furthermore, the effect of task

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irrelevant stimuli in prolonging the time taken to respond to a task lends credence to the central executive as a designatory role (Bocincova et al., 2017). Additionally, neurological evidence supports the WMM with fMRI scans indicating that the subsidiary systems work within the lateral prefrontal cortex (Funahashi, 2017), and the central executive process occurs in the dorsolateral prefrontal cortex (Owen, 2000). In spite of this, there is a growing sentiment in the research that the WMM is limited. The primary disagreement pertains to the central executive, with the argument that a centralised system that assigns tasks is flawed. Indeed, the initial intention of the central executive was to represent many complex cognitive mechanisms that interact thus functioning as the organiser. Logie (2016) provided such an argument with the assertion that research has thoroughly explored the mechanisms within the central executive enough that the concept of a unified central executive is unnecessary. Further criticism for the model is levied by Aben et al. (2012) with the assertion that working memory and short-term memory are only separated conceptually to explore the separate forms of memory, however they share many of the same constructs and systems. Despite this, there is a consensus in the literature that working memory is a complex form of memory that requires cognitive control and is important for everyday functioning and can be influenced by anxiety.

Anxiety and working memory

The notion that excessive anxiety overloads working memory has merit when considering how anxiety affects other cognitive mechanisms. Anxiety has been demonstrated to alter the threat detection, making it sensitive and facilitating threat related information having an undue influence on behaviour and emotion (Etkin & Wager, 2007; Waechter & Stolz, 2015). Additionally, the greater prevalence of intrusive thoughts (Otto et al., 2016) implies that cognition is in flux during an anxious episode. An illustration of this is in the

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study conducted by Zainal and Newman (2017). They sought to investigate prospective links between broad cognitive function with GAD diagnosis in the future with the rationale that the symptomology of a poorly functioning executive function maps onto GAD. The results were that a global cognition score predicted higher GAD diagnoses and worse symptoms within nine years. Working memory was demonstrated to predict GAD diagnosis, however episodic memory was not. It must be noted that the focus of this research is on pathological anxiety rather than elevated subclinical anxiety. This theory argues that the restriction in memory is due to restrictions to the executive function, which dictates top-down attentional control in favour of bottom-up cognitive processes, therefore the deficit in working memory only occurs if the task requires attentional shifts (Derakshan & Eysneck, 2009; Cocks et al., 2016).

The literature broadly reaffirms that individuals who are chronically anxious tend to perform worse on a variety of memory tasks compared to a control group (Stout et al., 2013; Ng & Lee, 2015; Yao et al., 2018; Moriya, 2020). However, the association with acute anxiety is not as definitive, indeed research has indicated that high levels of acute anxiety from participants who are not considered to have trait anxiety did decrease working memory (Robinson et al., 2008; Berggren et al., 2017). It must be noted however, research has also shown that the reduction to working memory is not to capacity but rather efficiency across both acute and chronic anxiety. This was demonstrated by Coombes et al. (2009) pertaining to motor planning and by Hadwin et al. (2005) pertaining to a phonological task. This lends partial credence to the ACT as the impact of the efficiency of responses is due to deficiencies in attentional control, as demonstrated by the extended time needed to solve the tasks. It should be noted that the field is not unanimous, this is exemplified by Ward et al. (2020). In this study memory capacity decreased, rather than efficiency in filtering task-irrelevant

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stimuli with participants in acute anxiety inducement. This experiment was conducted by measuring the Contralateral Delay Activity (CDA). CDA is a slow wave EEG that is validated as a measure for visual working memory (Luria et al., 2016). The reduction in memory capacity was also demonstrated in Qi et al. (2014) with participants considered to have chronic anxiety. It is likely, due to the evidence, that different working memory types are impacted differently by anxiety, with visual working memory decreasing independently of reductions in attentional control.

Research measuring within group changes in anxiety and working memory are sparse. This is a particular issue as the relationship between anxiety and working memory has been demonstrated as a bidirectional relationship. Indeed, a memory training exercise, named Dual *N*-Back, developed by Jaeggi et al. (2008) was designed to increase fluid intelligence, as defined as the ability to resolve novel problems independent of prior knowledge. This training involves participants identifying whether the visual stimuli (the location of the block) or the audio stimuli (the letter spoken) are the same. Research has demonstrated that this exercise over extended period of time has resulted in a reduction of anxiety (Brunoni et al., 2014, Beloe & Derakshan, 2020). The rationale for this decrease is that the task improves attention (Lilienthal et al., 2013) as well as filtering through irrelevant stimuli (Owens et al., 2013). This, it is speculated, enables effective processing of worries which in turn reduces the anxiety. This was demonstrated when the Dual *N*-Back was conducted in tandem with a wellness training (Course-Choi et al., 2017). It is posited that the reduction in anxiety can be understood through the lens of the ACT, with the reduction due to the increase activity in the central executive attentional control processes. However, Balderston et al. (2016) demonstrated that high load working memory trials decrease state anxiety, with the assertion

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that maintenance processes that are independent of the central executive was able to reduce the overall anxiety, questioning the necessity of activating the central executive.

This lack of clear research investigating the impact of anxiety reduction and the subsequent effect on memory is problematic as research should be able to show that if an individual's anxiety decreases there is a follow-on effect on their working memory.

Theoretically, this should occur however this has yet to be investigated directly which informs the rationale of the intended study.

Reverse Corsi Block Task

A method used to assess working memory is the Corsi Block Task, a task created by Corsi (1973) and standardised by Kessels et al. (2000), which requires participants to recall a sequence of blocks in the correct order. The Reverse Corsi Block Task (RCBT), selected for use in this study, is the inverse of the standard Corsi Block Task, requiring participants to recall the sequence in reverse order. The RCBT was chosen specifically for this experiment, rather than other working memory tasks such as the reverse digit span, as this task has a large component of spatial memory, which is the area of interest as even minor levels of anxiety can impact spatial working memory as compared to verbal working memory (Vytal et al., 2016). The Corsi block task has a significant research presence focusing on the effectiveness of supplementary cognitive support for neurodegenerative disorders (Mandigout et al., 2020; Niemeijer et al., 2020) as well as measuring the progression of Parkinson's disease (Stoffers et al., 2003; Smith et al., 2021). Furthermore, the task has been used to help assist in mapping the structure of the brain (Chechlacz et al., 2014; Lancia et al., 2018). The effectiveness of the RCBT at measuring working memory is well established, with evidence suggesting that it measures the effectiveness of the visual working memory (Smyth & Scholey, 1994; Berch et

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al., 1998; Kessels et al., 2000), whilst also measuring the executive function due to the reorganisation of the blocks requiring a higher order cognitive demand (Vandierendonck et al., 2004; Monaco et al., 2013). This is of note as visual working memory has been demonstrated to decrease with anxiety (Grosdemange et al, 2015) and executive function is associated with attention which is decreased by acute anxiety (Qi et al, 2014). This means that the RCBT is a valid measure for the measuring anxiety influenced working memory.

It should be noted that multiple studies have indicated that the forward Corsi Block Task also required central executive function (Hester et al.,2004; Kessels et al., 2008). Higo et al. (2014) demonstrated that articulatory suppression (designed to inhibit the central executive) only reduced the performance in the RCBT, suggesting that the central executive is vital in RCBT. Indeed, evidence suggests that broadly the RCBT is more difficult (Wilde et al., 2004), therefore may be more sensitive to detecting effects of interest than the forward Corsi Block Task (Cornoldi & Mammarella, 2008).

Anxiety Treatment

As a result of the increased anxiousness, a greater emphasis has been placed on not only understanding anxiety but how to treat it. Pharmaceutical approaches have been accepted by most medical systems to be effective at reducing anxiety and this has support from the literature. For example, SSRIs and antidepressants have been demonstrated to reduce the overall anxiety felt by the individual (Stein et al., 2004; Yamada et al., 2020). However, limitations pertaining to the side effects of these pharmaceuticals have been discovered. Antidepressants resulted in decrease to executive function and to working memory (Tempesta et al., 2013) and SSRIs have resulted in a decreased memory (Wadsworth et al., 2005).

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Wellness training and anxiety

The effectiveness of pharmaceuticals is limited solely to pathological anxiety as they are not appropriate for subclinical use as the potential side effects outweigh the potential gain. This means that individuals with subclinical anxiety must find alternative ways to decrease their anxiety. Wellbeing and mindfulness have been at the epicentre of non-pharmaceutical treatments for subclinical anxiety. Mindfulness, as defined by the American Psychiatric Association (2013), is a state in which the individual is able to see their current experiences non-judgementally. From this, mindfulness training or therapies have been developed. These trainings can vary however they do feature core concepts, such as meditation exercises and breathing training. Indeed, mindfulness-based stress training has been demonstrated to reduce anxiety levels amongst subclinical anxiety groups as well as clinically anxious groups (Hofmann et al., 2010; Song & Lindquist, 2015). Hofmann et al. (2010) demonstrated the efficacy of general mindfulness therapies by conducting a meta-analysis. This found that the therapies were moderately effective for reducing the level of anxiety participants felt (with a Hedges' $g = 0.63$). It should be noted that the meta-analysis contained a range of therapies, therefore a definite statement regarding the efficacy of individual therapies cannot be made. However, the findings do indicate that mindfulness is a valid approach to anxiety, which provides the onus needed to investigate individual mindfulness tasks.

As mentioned prior, there are multiple forms of mindfulness therapies, one such is yoga. Yoga is a broad category that encompasses many exercises; however, these exercises have a set of core principles. These are to challenge the body in repetitive and deliberate ways to build strength whilst also meditating to build mindfulness. There is also a focus on breathing to assist in achieving a meditated state. Research has demonstrated that

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physiological health can impart benefits for mental well-being, an example of this was presented by Mackay and Neil (2010) in which exercising outdoors significantly improved the anxiety as compared to a control which did not exercise. Interestingly, the exercise specifics did not factor into the reduction in anxiety, this includes the duration and the intensity of the workout, rather the prominence of greenness was key for anxiety reduction. This indicates that although the physical component of exercise does assist with anxiety, the mindfulness component of exercise is seemingly more important. As the etiology and pathophysiology of anxiety is not fully understood, the assertions for the decrease associated with exercise specifically are numerous. For brevity only two will be discussed to demonstrate the effectiveness of exercise. One assertion is that neurogenesis in the hippocampus region is poorer in individuals with anxiety, this has been demonstrated utilising rats in animal studies (Uno et al., 1989; Jin et al., 2016). This results in poorer emotional control, which is what leads to anxiety. It has been demonstrated that exercise can improve hippocampal neurogenesis within an animal study (Duman et al., 2001) which in turn reduces stress and anxiety. The second explanation of a psychological mechanism which is associated with anxiety is self-efficacy, with a lower self-efficacy resulting in greater levels of anxiety (Tahmassian & Moghadam, 2011). Exercise enables an individual to feel like they are mastering a task in which improves self-efficacy (Matsuo et al., 2015). Research has demonstrated that a yoga intervention which focused on reducing heart rate, successfully decreased anxiety as well as blood pressure, which is considered a physiological symptom of anxiety within groups of clinical and subclinical anxiety (Forfylvow, 2011; Yoshihara et al., 2011; Roche & Hesse 2014; Roche et al., 2016). In spite of the advantages of yoga, participation is difficult to acquire and maintain with cultural and economic factors

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influencing the participation levels (Spadola et al., 2017; Cagas et al., 2021) as well as perceived social stigma derived from body consciousness and distress tolerance (Baird et al., 2016). These factors lead to a demand for an easily accessible mindfulness activity which can be practiced with minimal spending or social stigma.

Progressive Muscle Relaxation

Progressive Muscle Relaxation (PMR) is one such method. This exercise involves deliberately focusing on each muscle group, tensing them, and then relaxing them whilst breathing methodically. The PMR has numerous variants, however the core principles of focusing on each muscle group remains constant. The categorisation of PMR as a wellness treatment is disputed, with the relaxation technique often accompanied by more explicit wellness training, however, the exercise requires deliberate breathing and relaxing and whereas it does not have explicit meditation, the manner in which the individual relaxes is akin to yoga. There have been attempts to ascertain whether PMR is a form of wellness training by comparing the relative effects to an already established wellness technique. This was explored by Gao et al (2017), with the effects of PMR compared to Present Awareness Mindfulness training. The results indicated both measures resulted in significant improvements in mindfulness and reduction in stress, implying that PMR embodies similar effects to mindfulness training. However, the researchers posited that the fundamental mechanisms underlying the interventions were different. It must be noted that for the purposes of this study PMR will be treated as a wellness technique, although the lack of clarity of the category of wellness leaves that assertion as subjective.

PMR has been demonstrated as an effective intervention with reducing both chronic and acute anxiety, when completed habitually or as a singular occurrence (Brown &

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Schiraldi, 2004; Ahmadnejad et al., 2011; Dehghan-nayeri & Adib-Hajbaghery, 2011). The effectiveness of PMR was exemplified in a meta-analysis conducted by Manzoni et al. (2008). This meta-analysis consisted of 27 studies which found a medium-large effect size in the treatment of anxiety. It must be noted that this analysis was comprised of studies that used both clinical and subclinical populations as well as face to face PMR training, however as this meta-analysis was conducted in 2008 it was limited in the forms of PMR training that could be examined. The one of particular note for the present study is PMR via the internet. Furthermore, there were multiple forms of muscle relaxation training used, however the concept behind them is the same. PMR is a physical mindfulness activity, akin to yoga, for this reason, the effectiveness of PMR is more pronounced in groups with physiological issues with subclinical anxiety as the physical pain is decreased with deliberate muscle relaxation (Lolak et al., 2008; Pan et al., 2012; Novais et al., 2016). It is for this reason research into PMR as a supplementary treatment for recovery from chronic illness is plentiful, with the evidence suggesting that PMR is an effective support in reducing anxiety in those with co-occurring illnesses (Cheung et al., 2003; Jorm et al., 2004; Dehdari et al., 2009; Zhao et al., 2012; Farquhar et al., 2018). Indeed, PMR utilises the same underlying concepts of yoga, however the focus is more on stress and pain relief compared to other interventions.

Understanding the improvements in wellbeing associated which PMR requires an analysis of which cognitive and physiological processes are influenced by PMR and how they interact. PMR has been demonstrated to improve cognition in participations suffering from both clinical and subclinical anxiety (Khanna et al., 2007; Francesco et al., 2010; Tyndall et al., 2016). Of particular interest is Tyndall et al (2016), which utilised a brief, one-time PMR exercise lasting eleven minutes. Participants were shown to improve on a relational

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responding task. It should be noted that this looks at acute PMR just prior to the activity rather than a longitudinal PMR over many weeks.

This improvement can be viewed through the lens of ACT, with the decrease in stress allowing more efficient executive function. It should also be noted that PMR has been effectively implemented to improve sleep within anxious individuals (Xiao et al., 2020). Sleep deficit can be seen as a secondary effect of anxiety, with excessive worrying reducing sleep (Kalmbach et al., 2018). Additionally, a lack of quality sleep and a negative association with sleeping results in a greater susceptibility to anticipation anxiety (Grupe & Nitschke, 2013). This creates a cycle of anxiety; hence why effective wellness treatments are based upon relaxation. Physiologically, PMR has been demonstrated to alter hormone production. Research conducted by Chellew et al. (2015) found that cortisol levels in participants post PMR were reduced compared to a non-active control. This evidence suggests that biological markers for stress are reduced rather than self-reported anxiety. Research focused on salivary cortisol further lends credence to these findings with salivary cortisol significantly lower in participants who participated in a muscle relaxation exercise compared to the control (Pawlow & Jones, 2005). Research pertaining to the impact of PMR on the cardiovascular system indicates that utilising PMR reduces blood pressure and regulates heart rate (Sheu et al., 2003; Dolbier & Rush, 2012). Reduction in these biological markers for anxiety results in a decrease of perceived anxiety (Özpelit et al., 2015).

Due to the effectiveness of PMR, it has sustained institutional support from the NHS, who promote their own version of PMR for general relaxation and anxiety as well as anxiety hotlines which utilise similar methods (Cumbria, Northumberland, Tyne & Wear NHS Foundation Trust, 2017). The practical effectiveness of PMR is demonstrated in Merakou et

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al., (2019) in which they sampled long-term unemployed people to compare the effectiveness of an eight weeklong PMR course in reducing anxiety compared to a control group. The results indicated that stress and anxiety related symptoms decreased significantly. The basis for this study was the economic crisis in Greece and the subsequent anxiety associated with the fallout. This sample was therefore based on an acute trigger whereas the present study is focused on general subclinical anxiety. Furthermore, the study did not utilise an internet-based approach, rather a face-to-face training period designed to coach participants.

Telehealth and remote access to interventions

With the increased access to the internet and rising technology literacy (Eshet-Alkalai & Chajut, 2009), the viability and importance of remote methods of addressing ailments is increasing. Telehealth, as defined as healthcare provided via telecommunications, has been recommended for physical illness, such as pulmonary conditions (McLean & McKinstry, 2012; Pinnock & McKinstry, 2018; Bohingamu-Mudiyanselage et al., 2019). However, recent evidence suggests its efficacy for assisting with mental conditions. Indeed, research conducted by Lichstein et al. (2013) found that remote Cognitive Behavioural Therapy (CBT) was effective with hard to access patients. This finding is of particular interest for research pertaining to anxiety as anxious individuals tend to be hard to access (Roness et al., 2004; Alosaimi et al., 2014; Fine et al., 2018). It is important to differentiate two types of anxiety, anxiety which is preventing patients from engaging the healthcare system for other ailments (as investigated in Alosaimi et al., 2014) and anxiety which is the sole issue the individual has (shown in Roness et al., 2004). Standard telehealth assists individuals in the first group but not the second, as the anxiety is not addressed, rather it is navigated around. This does not mean that telehealth methods are not useful for helping with anxiety, just the treatment would

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have to be specifically for anxiety. An effective example of this was provided in Lu et al. (2021), within this study adolescents with social anxiety engaged with anxiety therapies via a mobile app. Overall, the researchers argue that the mobile based treatment allowed the participants to feel more comfortable with the initial therapy, which the participants claim they would have not been. Social anxiety and the general worrying regarding novel environments present anxiety is the main concern that can be addressed effectively in telehealth.

To determine the effectiveness of telehealth in treating subclinical anxiety, it is important to take a multifaceted approach. Indeed, as mentioned earlier it provides greater access to hard to access individuals, however it still remains to be seen if it is as effective as face-to-face treatment. A meta-analysis conducted by Krzyzaniak et al. (2021) sought to investigate this concern. It was shown that there was no significant difference in the satisfaction rating when in person was compared to remote as well as no significant differences in the change of anxiety symptoms. This means that remote healthcare was at least comparable to in person treatments.

The intention of this study is to measure the efficacy of remote anxiety interventions. Evidence prior suggests that online based anxiety interventions are effective, indeed research by Dent et al. (2018) discusses effective ways of implementing a remote CBT. However, these interventions are tailored towards individuals who are clinically anxious, furthermore they require an active practitioner to work alongside the participants. An alternative to this has been explored via the use of wellness apps and their subsequent effects on anxiety. These apps utilise wellness technique including mediation. Research into the effectiveness of wellness apps conducted by Hwang and Jo (2019) indicated that the apps were effective in

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reducing perceived stress and improve broad well-being, however the apps provided no significant improvement to anxiety. In addition to the concerns of effectiveness, there is a litany of privacy concerns that are dominant within the wellness app industry. For example, evidence presented by Huckvale et al. (2015), demonstrated that of 79 wellness apps certified by the NHS, 89% transmitted information to other online services. Additionally, 23 of the apps that sent data digitally did not use encryption which left it vulnerable to hacking. Regarding data, it has long been a concern that wellness apps are not forthright with how the data collected may be used. This is well explained in the prior study mentioned. Issues regarding how data is collected and used have been hard to engage with due to the fact that wellness apps are not considered intended for medical use in the USA. This was explored in Kasperbauer and Wright (2020) with the premise of the study designed to illustrate why wellness apps should be regulated as a medical app. The primary reason is that, in spite of disclaimers, users tend to utilise wellness as a healthcare and tend to share information pertinent to their health. This allows the apps to extract and use the data with less caution compared to medical records.

It is for these safety concerns and potential issues with the effectiveness of wellness apps for treating anxiety why an alternative remote intervention should be explored. As mentioned prior the PMR has been placed online from the NHS as a simple method of reducing stress. Research into the specific effectiveness of online based PMR on subclinical anxiety have not been explored.

The current study

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The effectiveness of PMR has been demonstrated throughout numerous studies, including its use with hospital patients and the elderly, however there is a dearth of research focusing on PMR effectiveness regarding individuals with subclinical anxiety. In addition to this, the effectiveness of PMR as an internet-based solution for anxiety has not been fully explored. As anxiety is potentially a self-perpetuating state, with the results an anxious episode leading to deliberate isolation which leads to further anxiety (McNeil et al., 2014), an effective long-remote treatment needs to be a priority. Without easily accessible outlets, it is difficult for people suffering from anxiety to maintain a healthy anxiety level. This is problematic due to the aforementioned consequences of elevated anxiety, as well as that untreated low-level anxiety can manifest into an anxiety disorder which typically has a long recovery phase and greater stress (Stahl et al., 2007). Indeed, enacting early preventive interventions has been demonstrated to more effectively reduce the severity of the subthreshold anxiety as compared to anxiety treated later (Grenier et al., 2011), hence why a quick and readily available intervention is required

The importance of evaluating internet based PMR is due to the core tenant of mindfulness, that the tasks should be accessible. PMR was chosen for this specifically due to its ease of accessibility with easy-to-follow instructions. This is pronounced when compared to forms of CTPI as it requires time with both generic and specialised requirements based on an individual's symptoms which makes it difficult to generalise. A greater insight into the effectiveness of participant led online-based PMR would help elucidate whether in person directed learning PMR is necessary or if an easily accessible internet-based intervention would suffice. Anxiety is a state which limits one's desire to put themselves in risk, whether real or imaged, hence why a safe and easily accessible version is preferable.

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One area of great interest in this study is the level of adherence as an intervention is only as effective as one's willingness to adhere to it. Research focusing on adherence indicates that internet-based support assists adherence to a medication schedule (Bass et al., 2015) and that internet-based replacement therapies have similar levels of attrition when compared to the face-to-face counterparts (van Ballegooijen et al., 2014; Beintner et al., 2014). However, these do not measure the effectiveness of anxiety reduction methods or wellness techniques, furthermore the studies were conducted on diagnosed patients so the adherence rate for non-clinical participants has not been assessed.

This study also intended to measure the effect of anxiety on working memory. In line with prior research (Lukasik et al, 2019), it would be expected that as anxiety decreases, working memory increases, however, there has been little investigation into how long-term subclinical anxiety may impact working memory, rather than short intervals of anxiety inducement. Also, the use of Reverse Corsi Block Task should provide further insight whether the impact of anxiety is solely limited to efficiency or to capacity as the task has unlimited time. Additionally, it will address the dearth in research focusing on within group anxiety changes and how that corresponds to changes in working memory function.

It is important to note that this study was conducted during the Coronavirus pandemic. This caused a greater rate of anxiety (Albery et al., 2021; Rudenstine et al., 2021) especially anxiety with patients who were diagnosed with other chronic illnesses (Salari et al., 2020; Spence, 2020). In addition to this, medical assistance was limited due to the high demand. This study does not focus on the pandemic, or the specific anxieties related to it, rather it displayed an extreme circumstance in which greater mental health aid is required whilst also being remote.

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The aims and hypotheses

The prospective study aimed to:

- Contribute to the literature regarding the effectiveness of non-pharmaceutical interventions on subclinical anxiety.
- Investigate the feasibility of internet based and participant driven PMR.
 - To further the understanding of the relationship between working memory and anxiety

The hypotheses of this study are as follows:

- PMR will significantly reduce the level of reported anxiety over time, compared to an inactive control.
- As the anxiety of the participant decreases the performance of the Corsi Block memory task will increase.

An area of note pertaining to the study is the attrition rate of participants. A key aim of this research is to investigate whether online based interventions are effective, and a high attrition rate could infer that although it may appear that the participants find it useful, the ones who do not would have dropped out artificially influencing the results.

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Method

Ethical Standards

Ethical approval for this study was provided by the University of Huddersfield via the **School of Human and Health Sciences – School Research Ethics and Integrity Committee. Reference: SREIC/2021/007.**

Participants

A longitudinal sample of participants was recruited over a period of two months. During this time, 161 participants enrolled, with 655 additional participants excluded from the experiment due to not passing the screening test or engaging in activity deemed to signify botting. Of the remaining participants, 58 participants were male, and females comprised the remaining 104, with a mean age of 25.83 years. Regarding the nationalities of the cohort, the majority resided in the UK (39.5%), and the United States (13%) with further demographic breakdown present in Table 1. The inclusionary criteria consisted of:

- 1) Participants must be fluent in English.
- 2) Participants must be 18 years of age or older.
- 3) Participants must have access to an email address and laptop or PC.
- 4) Participants must have not been diagnosed with an anxiety disorder.

It must be noted that some participants' scores on the anxiety measure exceeded the level which can be considered signs of a clinical anxiety disorder. It was decided that the participants should remain in the study and receive the debrief once completed with the links regarding anxiety and mental well-being. This is because the GAD-7 alone cannot be used to diagnose GAD, therefore it would be inappropriate to exclude the participants. As a result of

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this, the participant data was analysed as normal, however if the findings are of note, they will be discussed in the analysis.

Recruitment

Participant recruitment was based entirely online, with advertisements placed in student forums, University recruitment tools (SONA), social media (Facebook, Reddit, & LinkedIn) and psychology-based forums. Participants were not requested to recruit other participants, however a number of participants noted they discovered the study via a friend. An incentive for participation was included. Participants who completed the were placed in a lottery with 20 chances to win a £10 gift voucher. The use of this incentive was due to the increased number of online based studies due to the Coronavirus lockdowns, which presumed to reduce the number of participants in the study. Furthermore, due to the concerns of attrition leading to unusable results, a pseudo-randomised sample was used rather than entirely random. This weighted sampling added participants to each variable group reactively depending on the total number of participants currently active within each group. In addition, the sampling sought to address concerns with the gender imbalance within experimental groups as gender is a known influence on anxiety. The use of pseudo-randomised sampling to ensure that the data collected was applicable to the research aims has support from the literature (Bartlett, 2020).

The problematic nature of botting on online based participation has been acknowledged and discussed prior, notably in Pozzar et al. (2020). This issue was mitigated via three levels of detection. The first was the native bot detection in Qualtrics (the survey software platform used), the second was the RCBT portion of the study was located on a third-party website that was redirected to after completing the survey. This resulted in only

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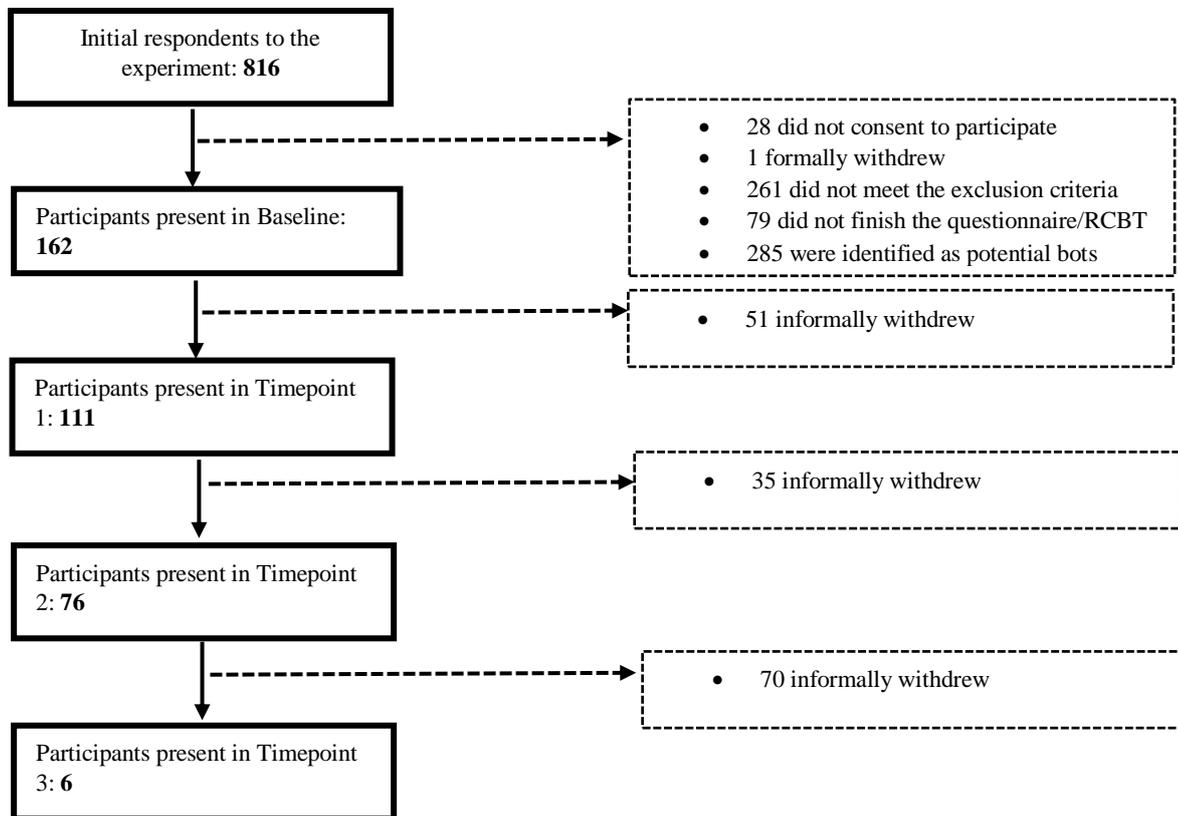
sophisticated bots completing the full study. The third step was designed to remove sophisticated bots, this was that the study required an active email address for follow up timepoints to be sent to, bots accounts typically use a database of known email addresses, however they do not have access to the inboxes. This manual authentication again limits the potential for bots to complete the full study. The effectiveness of manual authentications as screening for participants is established in the literature (Bowen et al., 2008; Godinho et al., 2020). Overall, it was estimated that 285 of the initial respondents were considered to be potential bots and were duly removed from participation.

The level of retention in the study was measured throughout, as displayed in Figure 1. To ensure retention participants were emailed with the necessary links to the following stages of the experiment when it was time to complete them. The emails contained reminders of participant ID and the experimental group they were assigned to. Participants were given up to a week to complete the tasks, after which they received a confirmation email within 24 hours. No reminders were sent out to participants aside from the initial email, this was to ensure that there was a more natural attrition rate which is more comparable to the use of the interventions outside of the experiment.

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Figure 1

Participation and attrition at each timepoint



Note. Informal withdrawal refers to participants leaving the study without informing the researchers.

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Materials

Prior to starting the experiment, participants were required to complete an integrated screening questionnaire which filtered out those who did not meet the inclusionary criteria (see the Participants section).

Questionnaires

There was a questionnaire for participants to complete before the GAD-7. All together there were three distinct questionnaires which were used at varying timepoints. The first questionnaire was for the Baseline, see Appendix A, this was used specifically to gain formal consent and enforce the inclusion criteria. Additionally, it provided useful demographic data used later in the analysis. The second questionnaire was format was used in both Timepoints 1 and 2, see Appendix B. There were minor word changes between the questionnaires, but the fundamentals remained the same. This questionnaire was designed to gain further consent for participation and ensuring that the data was assigned to the correct participant. In addition to this, the questionnaire asked the participants in the experimental group how many times they completed the PMR exercise per week. In order to measure the participants opinions on the intervention, participants were also asked how effective they believed PMR was for reducing anxiety as well as how motivated they were to complete the allotted PMR exercises. The phrasing of the question made it apparent that the timescale interested in was intermediate two weeks between surveys. The final questionnaire was presented at Timepoint 3, see Appendix C. This questionnaire repeated the same questions as the prior questionnaire, however it also requested participants to state positives and negatives of the PMR. The intent was to quantify the qualitative data and analyse it. Additionally, it also requested participants to state how

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they felt their anxiety has changed throughout the course of the experiment. This was asked to validate the anxiety change measured over the course of the experiment.

GAD-7

In order to establish the level of anxiety felt by the participants, the GAD-7 was used (Spitzer et al., 2006). A sample GAD-7 questionnaire can be viewed at Appendix D. This is a self-report questionnaire consisting of seven questions pertaining to anxiety over the prior two weeks, the frequency of the feeling as the determining variable. The scoring ranges from 0 with the response “Not at all” and 3 with the response “Nearly every day”, with the total accumulated score of the questions resulting in an anxiety score. A total score of 7-10 has been considered indicative of GAD (Spitzer et al., 2006; Plummer et al., 2016). The GAD-7 was chosen as it is a simple and accessible measure of anxiety that can be completed with minimal guidance (Donker et al., 2011; Ruiz et al., 2011). This measure has been demonstrated to be a valid measure of anxiety, with findings comparable to other established measures of anxiety (Kroenke et al., 2007; Bártolo et al., 2017; Byrd-Bredbenner et al., 2021). Furthermore, the GAD-7 has been used throughout the literature, in both clinical and non-clinical populations (Esser et al., 2018; Lee & Kim, 2019; Zachar-Tirado and Donders, 2021), thus further validating its use.

Reverse Corsi Block Task

This was utilised to measure the working memory of the participants more broadly. This task involved a static image of a number of blocks, starting at three and concluding at nine. After which the blocks flashed red and then return to white in a random sequence, each block change lasting for 0.5 seconds. Once each block had changed the participant had to click on the blocks using a mouse in the reverse order they appeared in, the response time was not recorded. An example of the RCBT sequence is shown in Figure 2. The sequence

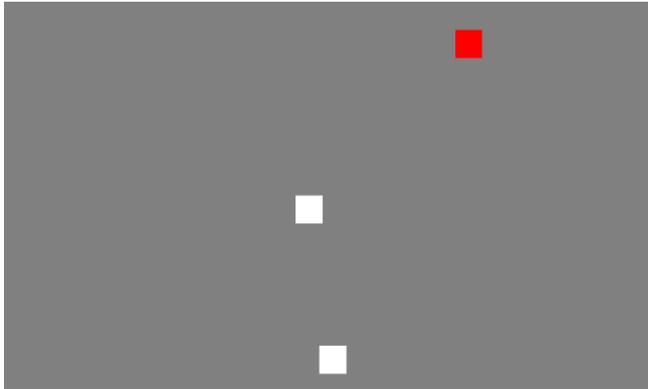
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length was chosen due to a design principle based on the average memory capacity (Miller, 1956). Each sequence is repeated three times, giving a total of 21 individual randomised sequences. From this, a score was determined on the number of blocks correctly identified in the correct serial position across all sequences rather than total sequences correct. This metric allows more sensitivity whilst also broadly tracking the total sequences correct (Brunetti et al., 2014).

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Figure 2

A three block RCBT task in progress



Note. The blocks will flash red sequentially, participants must wait for the complete sequence before repeating the sequence. Blocks cannot flash red twice, but blocks can be pressed twice in the participant's recollection.

The task was developed in PsychoPy3 software and was implemented online via the Pavlovia platform. It should also be noted that research into the difference between digitised RCBT and regular RCBT have not been fully explored, however preliminary research indicates the difference between the two are negligible (Claessen et al., 2015). It must be noted that this was research focused on tablets in which participants tapped on the screen to identify the sequence, whereas the task present in this study utilises PCs, however there is precedent for this approach with LeFevre et al. (2010).

Progressive Muscle Relaxation

This method was based on the work by Dr Jacobson, which is well illustrated in Mushtaq and Khan (2018). The PMR can be designed in many ways, including in written form as well as a shortened version. For the present study a video form of PMR was used that lasted around 12 minutes (The Newcastle upon Tyne Hospitals NHS Foundation Trust,

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2014). The relaxation technique itself begins with a focus on breathing and moves onto the deliberate tensing and relaxing the arms muscle group. The muscle relaxation gradually progresses to other muscle groups.

The reason this specific PMR video was selected was due to it being designed by the NHS, which lends credence to its legitimacy, as well as wider use by the general public, therefore using it as a baseline for PMR seemed appropriate. Indeed, the majority of research focusing on the benefits of PMR share fundamentals, therefore discrepancies in method chosen are usually focus on how it is conducted. As the intention of this study is to measure the effectiveness of internet-based, participant-driven interventions, the video format was preferable as it was an effective demonstration for how to conduct the relaxation exercise. It should also be noted that the video was not necessitated every time the participants would perform the PMR, rather it was recommended at the start to gain an understanding of the intervention.

Procedure

Participants found the study via a website link, either on advertisements or provided by someone they know. They begin the experiment with an information sheet explaining the study and the criterion for participation. Participants were then directed to the screening questions in which, if they failed to meet the aforementioned criteria, the participants were ejected from the study. The participants were then asked to provide an email address for correspondence, generic demographic data and to create their own participant ID. After this, they were asked to complete the GAD-7, after which they were redirected to the RCBT. Upon completion, the participants received an email within the proceeding 24 hours

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assigning them to an experimental group. There were two groups, an inactive control group and the experimental PMR cohort.

The experimental PMR group was asked to complete a PMR session three times a week for two weeks, with a video provided for guidance (although it was not mandatory to watch). After two weeks, the participants once again completed the GAD-7 and the RCBT. The participants then received a confirmation email within 24 hours with instructions to continue with the PMR sessions. This schedule was then repeated for four more weeks, resulting in a Baseline established at the start of the experiment and three timepoints in the subsequent six weeks. It is important to note that nonadherence to the intervention was not an issue, as the effectiveness of the intervention must encapsulate the willingness to complete the task. As for the control group, after completing the Baseline battery of tasks, they were given no active instruction during the interim two weeks. They were only requested to complete the tasks once every two weeks for six weeks. An inactive control was chosen due to concerns that even menial tasks conducted a couple times a week may act as pseudo-therapeutic and the control groups of typical unaltered anxiety levels were preferable as they better represent the general populace. Participants would remain in the study six weeks for completion, providing data for a Baseline, Timepoint 1, 2 and 3. After which, participants were debriefed and placed in the raffle if they so desired.

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Analysis

Participant Characteristics

The analysis was conducted using IBM SPSS Statistics for Windows, Version 26.0. To begin with, the scores for the GAD-7 and the RCBT were computed. From this, the descriptive statistics for the experiment were established. After this, a battery of analyses was conducted in order to provide a full description of the sample. The first was a simple T-test conducted to measure the difference in anxiety levels between males and females with the GAD-7. This was to test the validity of the sample as research indicates males have significantly lower reported anxiety levels as compared to females (McLean et al, 2011; Altemus et al., 2014). The second was a correlational analysis, conducted pertaining to anxiety levels and age, with the assumption that age is negatively correlated with anxiety levels (Jefferies and Ungar, 2020). Whilst these analyses cannot conclusively demonstrate that the sample is valid, it can provide insight into the results.

Attrition

As attrition was an area of interest, analyses focused on attrition were conducted. The primary attrition analysis was focused on the impact of the experimental group; therefore, it was conducted by using Chi-square with the rate in the experimental group compared to the frequency in which they remained in the study. The secondary attrition analysis was concerned with how anxiety impacted levels of attrition measured. The first approach was to use a T-test to compare the attrition rate compared to the anxiety levels whereas the second approach focused on levels of change in anxiety and attrition. This was conducted by measuring the level of change in anxiety from Baseline to Timepoint 1 and then comparing it to the level of adherence to the study. This form of analysis required a level of inference, as

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the level of anxiety and the relative change cannot be ascertained when the participant left the study, rather the prior rate of change must be used as a proxy. It should also be noted that both analyses were conducted whilst considering the experiment group of the participants. The third attrition analyses focused on demographics and how they correlated with attrition. Considering the engagement with the technique with gender is of particular interest as typically wellness activities have reduced male participation, which would ideally be addressed by an online PMR technique.

Primary Analyses

Parametric assumptions were checked and are described in the results section, and where assumptions were violated, non-parametric tests were used. To assess the changes in the anxiety levels reported, a mixed ANCOVA analysis was used. This utilised the Baseline scores for the GAD-7 as a covariate in order to ensure that the measured change took into consideration the impact of the initial level of anxiety. The between-subject factor was the experimental group, PMR or control and the within-subjects factor was the anxiety score measured by the GAD-7 over time. It is important to note that this analysis, as well as subsequent analyses, excluded Timepoint 3. This is due to excessive participant attrition which resulted in a very small group size.

In order to measure the relationship between anxiety and working memory, correlational analyses were conducted between the GAD-7 score and the RCBT score at Baseline, Timepoint 1 and 2. In the proceeding timepoints after the Baseline, the data was also split by the experimental group the participants were in, which was intended to identify any group specific effects.

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Supplementary analyses

To further support the veracity of the findings made pertaining to anxiety, a separate correlational analysis was conducted between the change in GAD-7 score with the perceived effectiveness of PMR in the prior two weeks, as reported by the participants. The perceived effectiveness was modified into a Likert scale, with the lowest ascribed effectiveness equalling 1 and the highest 4. The change in anxiety was measured between Baseline to Timepoint 1 and Timepoint 1 to 2. Additionally, a Paired Samples T-test was conducted to measure the change in perceived effectiveness as the experiment proceeded. There was further intention to measure the adherence to the intervention with the change in GAD-7 score, however the group who did not adhere but continued in the study was too small for analysis.

Further analysis was also conducted on the RCBT scores. RCBT score was analysed over time to measure if there was an improvement, regardless of the experimental group. The rationale for this analysis was to account for the potential learning effect of the RCBT and use that information to appropriately caveat the findings if necessary. The sample was non-parametric; therefore, a Friedman Rank Sum Test was selected. This was a repeated measures analysis across each Timepoint. As with the analysis prior, the intention was to include the third Timepoint, however due to attrition it was deemed not appropriate.

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Results

Treatment of Data

As both the GAD-7 and the subsequent RCBT completion were mandatory for the analysis, participants were unable to proceed in the experiment until they were finished with the measures. Of the 162 participants, 5 (or 3%) failed to complete the entire RCBT after having completed the GAD-7, due to this the data obtained from this group was limited to the prior timepoint they completed.

As mentioned prior, the analysis was ended at Timepoint 2 rather than at the intended Timepoint 3. The reason for this was a reduction in participant retention with six (four control group and two experimental group) of the remaining 76 completing the final timepoint. This was sample was too small to analyse effectively. The impacts of the removal of the last timepoint will be discussed further in the discussion.

Participant Characteristics

Table 1 and 2 shows the demographic information for the participants and their characteristics.

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Table 1*Demographics of the participants*

Variable	<i>n</i>	%
Gender		
Male	58	35.80
Female	104	64.20
Nationality		
Uk	64	39.51
USA	21	12.96
Canada	11	6.79
Singapore	1	0.62
India	6	3.70
Israel	1	0.62
Australia	1	0.62
Portugal	11	6.79
Denmark	3	1.85
Netherlands	18	11.11
ROI	2	1.23
France	4	2.47
Germany	7	4.32
Bahrain	1	0.62

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Norway	2	1.23
Romania	1	0.62
Brazil	1	0.62
Turkey	1	0.62
Mexican	2	1.23
UAE	1	0.62
Malaysia	1	0.62
Russia	1	0.62
Italy	1	0.62

Note. Due to rounding errors, percentages may not equal 100%.

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Table 2

Information of participants at baseline.

Variable	<i>M</i>	<i>SD</i>	<i>n</i>	<i>SE_M</i>	Min	Max	Skewness	Kurtosis
Age	25.83	7.24	162	0.57	18.00	57.00	1.93	4.77
GAD Baseline	6.32	4.59	162	0.36	0.00	21.00	1.03	0.81
RCBT Baseline	85.08	21.54	162	1.69	10.00	118.00	-1.79	3.34

Note: Information is present for all participants at baseline, including those who did not complete the study.

The mean level of anxiety for the entire sample at each timepoint was, $M = 6.32$, $SD = 4.59$ for the Baseline, $M = 4.85$, $SD = 3.82$ for Timepoint 1, $M = 4.76$, $SD = 3.38$ for Timepoint 2. The mean working memory score on the RCBT was, $M = 85.08$, $SD = 21.54$ for the Baseline, $M = 95.88$, $SD = 10.75$ for Timepoint 1, $M = 98.08$, $SD = 9.94$ for Timepoint 2. The two participant sample sizes were different, this was to address the earlier attrition observed within the experiment group. Table 3 shows the level of attrition within each group across each timepoint. Factors around attrition have been analysed later in this section. The sample also was weighted towards females, who comprised 64.20% of the total sample. This gender split was deemed not significantly different using a Chi-square at Baseline, $X^2(1, n = 162) = .059$, $p = .81$, therefore there was no need to covary gender in the subsequent analyses.

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Table 3

Level of attrition at timepoints categorised by experimental groups

Variable	Experimental groups	
	Control	PMR
Attrition Baseline-T1		
Remained in the study	46 (71%)	65 (67%)
Withdrew in the study	19 (29%)	32 (33%)
Total	65 (100%)	97 (100%)
Attrition T1-T2		
Remained in the study	32 (49%)	44 (45%)
Withdrew in the study	14 (22%)	21 (22%)
Total	46 (100%)	65 (100%)

Note. Due to rounding error, percentages may not sum to 100%.

An independent T-test was conducted to measure the difference in anxiety levels reported between genders. The analysis demonstrated that females ($M = 7.33$, $SD = 4.77$) were significantly more anxious than males ($M = 4.52$, $SD = 3.62$) as reported at the Baseline GAD-7, $t(145) = -4.21$, $p < .001$. In addition to this a Pearson correlational analysis was also conducted on the levels of anxiety reported at Baseline with the age of the participants. This

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analysis found that the correlation between anxiety and age was not significant, $r(161) = .12$, $p = .12$.

Attrition analysis

Attrition can be measured at two points during the experiment, between Baseline and Timepoint 1 and between Timepoint 1 and 2. The attrition from Timepoint 2 to 3 was not analysed as the change was too great to provide any meaningful analysis. A tabulated accounting of the attrition rates can be seen in Table 3.

The primary assumption for Chi-square is that less than 20% of the expected counts are less than 5 (Yates et al., 1999). All attrition analysis conducted had 0% expected counts less than 5. Furthermore, for the use of a 2x2 cell, all expected counts must be greater than 10 (Cochran, 1952). For the data at hand, all expected counts were greater than 10, meaning all assumptions were met. As all assumptions were found to be true, a Chi-square was conducted to measure the potential correlation between the attrition rate and the sample the participant was assigned to.

Of the initial 162 participants, 111 proceeded to participate in Timepoint 1, a 31.39% rate of attrition. Breaking this down into the experimental samples, of the 65 within the initial control group, 19 left constituting an attrition rate of 29.2% and for the PMR group, of the 97 initial participants 32 left, resulting in a 33% attrition rate. There was found to be no significant relationship between the attrition rate between the Baseline and Timepoint 1 with the assigned experimental group, $X^2(1,162) = .26$, $p = .61$.

The second point of attrition was between Timepoint 1 and 2. Of the remaining 111 participants, 76 remained within the study, resulting in an attrition rate of 31.53%. Breaking this down into the experimental samples, of the remaining 46 within the control group, 14 left

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constituting an attrition rate of 30.4% and for the PMR group, of the remaining 65 participants 21 left, resulting in a 32.3% attrition rate. It was demonstrated that there was no significant relationship between the attrition rate between Timepoint 1 and 2 and the assigned experimental group, $X^2(1,111) = .044, p = .83$.

The attrition separated by gender between Baseline and Timepoint 1 was of the 58 males in the starting cohort, 15 withdrew, resulting in an attrition rate of 25.9% and of the 104 females at the beginning, 36 withdrew, resulting in an attrition rate of 34.6%. A subsequent Chi-square test was conducted to ascertain the impact of gender of the level of attrition. There was found to be no significant relationship between the attrition rate between the Baseline and Timepoint 1 with gender, $X^2(1,162) = 1.32, p = .25$. The attrition separated by gender for second attrition analysis was of the 43 males, 11 withdrew, resulting in an attrition rate of 25.6% and of the 68 remaining females, 24 withdrew, resulting in an attrition rate of 35.3%. From this it was demonstrated that there was no significant relationship between the attrition rate between Timepoint 1 and 2 and the gender of the participant, $X^2(1,111) = 1.51, p = .28$.

In order to measure whether the change in anxiety resulted in participants remaining in the study, a T-test was conducted on the reported anxiety change between Baseline and Timepoint 1 and the attrition rate between Timepoint 1 and 2. The dataset was split by experimental group. For the experimental PMR group, a Levene's test for equality of variance was not significant, $F(63) = .38, p = .54$, therefore the assumptions of the T-test were met. The resulting T-test found there was not a significant interaction between the level of anxiety change and the willingness to proceed further in the study, $t(63) = -.54, p = .59$. For the control group, a Levene's test for equality of variance was not significant, $F(44) =$

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.72, $p = .40$, therefore the assumptions of the T-test were met. The resulting T-test found there was not a significant interaction between the level of anxiety change and the willingness to proceed further in the study, $t(44) = -.64$, $p = .53$.

Main Analysis

The intention of the following analyses was to directly address the hypothesis outlined prior.

GAD-7 anxiety scores and intervention

Anxiety scores per group at each timepoint are provided in Table 4. A T-test was conducted at the baseline between the groups to ensure there was a similar starting anxiety. This was to ensure the initial samples were comparable, otherwise the findings would have to be caveated. Overall, there was no significant difference between the experimental groups at the Baseline, $t(160) = -.52$, $p = .61$.

Table 4

Anxiety levels at each timepoint, as a total and per group

Variable	<i>M</i>	<i>SD</i>	<i>n</i>	<i>SE_M</i>	Min	Max	<i>Mdn</i>	Skewness	Kurtosis
GAD Score at Baseline	6.32	4.59	162	0.36	0.00	21.00	6.00	1.03	0.81
Control	6.09	4.47	65	0.55	0.00	20.00	6.00	1.02	0.83
PMR	6.47	4.68	97	0.48	0.00	21.00	6.00	1.04	0.76
GAD Score at T1	4.85	3.82	111	0.36	0.00	21.00	4.00	1.72	4.51
Control	5.13	3.43	46	0.51	0.00	16.00	4.00	1.03	1.25
PMR	4.65	4.09	65	0.51	0.00	21.00	3.00	2.04	5.68
GAD Score at T2	4.76	3.38	76	0.39	0.00	14.00	4.00	0.81	0.46

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Control	5.78	3.10	32	0.55	0.00	13.00	6.00	0.44	0.13
PMR	4.02	3.41	44	0.51	0.00	14.00	3.00	1.25	1.52

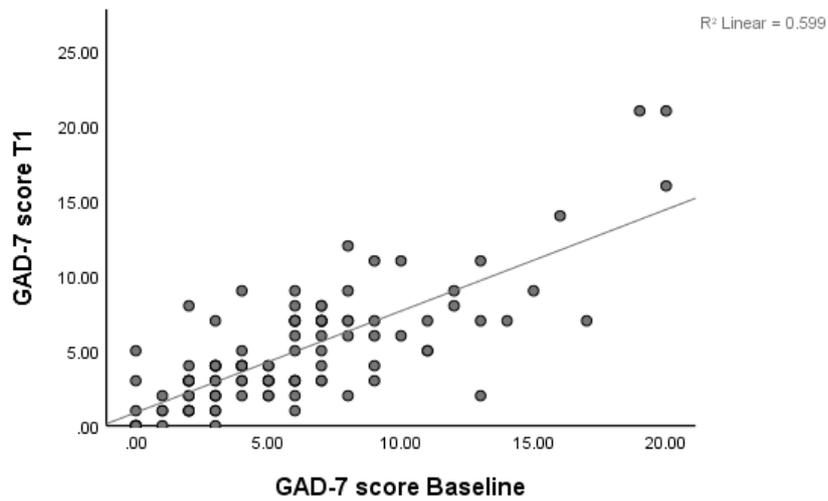
Note. Experimental groups presented below the representative timepoint.

Table 4 illustrates the descriptive values relevant to anxiety scores. From this, the data can be assessed in order to ensure the appropriate analysis was conducted. When the skewness is greater than 2, the variables are asymmetrical, in addition to this, when the kurtosis is greater than or equal to 3, then the distribution of variables are not on a normal distribution. These factors can both result in a greater number of outliers limiting the usefulness of the data (George & Mallery, 2010; Westfall & Henning, 2013). However, due to the robust size of the sample (greater than $N > 20$ per group), the mixed ANCOVA is still valid (Cox, 2010). Due to the different sample sizes in each group, the homogeneity of variances must be satisfied in order to meet the assumptions. Levene's Test of Equality of Error Variances was conducted on both dependent variables to ensure homogeneity. The test indicated equal variance, $F = 1.55, p = .22$; $F = .009, p = .92$, for Timepoint 1 and 2 respectively, ensuring the validity of the ANCOVA. Furthermore, to test the homogeneity of regression, an ANOVA was conducted to ensure that the interaction between the covariate, the Baseline anxiety score, and the between subject factor, the experiment group the participant was placed in, was not significant (Field, 2017). The ANOVA demonstrated that the interaction between the variables was not significant, $F(1,72) = .43, p = .52$, indicating the sample was eligible for the ANCOVA. The final assumption of linearity between the covariate and the dependent variables is demonstrated in the proceeding scatter plots (Figure 3 & 4), with Pearson's correlation demonstrating the correlation between the Baseline

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correlation with Timepoint 1 anxiety, $r(111) = .77$, $p < .001$, and Timepoint 2 anxiety, $r(76) = .669$, $p < .001$.

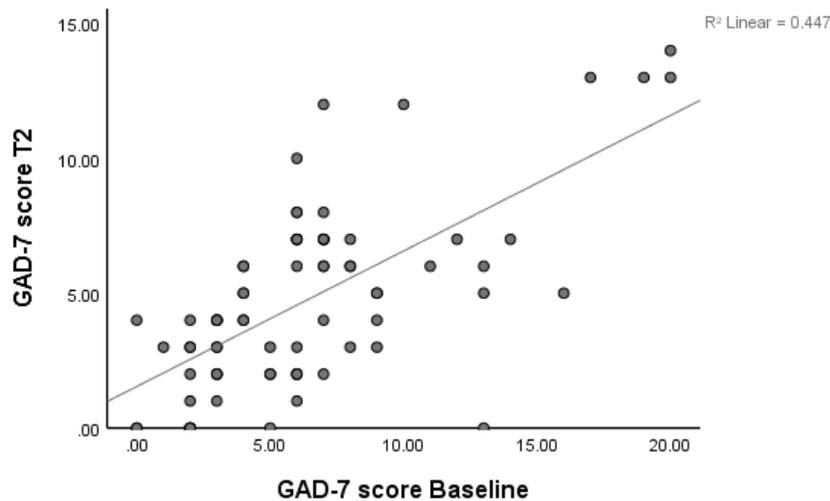
Figure 3
Scatterplot for GAD-7 score at Baseline and Timepoint 1



Note. Data present only contains participants who completed both Baseline and Timepoint 1.

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Figure 4
Scatterplot for GAD-7 score at Baseline and Timepoint 2



Note. Data present only contains participants who completed both Baseline and Timepoint 2.

As the dataset met the assumptions necessary, a mixed ANCOVA was conducted. The main effect for intervention group was significant, $F(1, 73) = 6.59, p = .012, \eta^2 = .083$, indicating that there were significant differences in anxiety at Timepoint 1 and 2 between the PMR group and the inactive control after controlling for anxiety at Baseline. The direction of the analysis indicates that anxiety in the PMR group was significantly lower as compared to the inactive control group with a medium effect size (Lakens, 2013) which is comparable to prior research in the field (Manzoni et al., 2008). For a visual representation of this, please see Figure 5 below. In order to conduct a power analysis, an additional effect size was measured, Cohen's f . This was to determine to have a medium effect size of $f^2 = 0.27$. A post-hoc power analysis found that with the sample at Timepoint 2, the observed power was .71. This falls short of the standardised .80 (Cohen, 1988), which suggests the probability of a

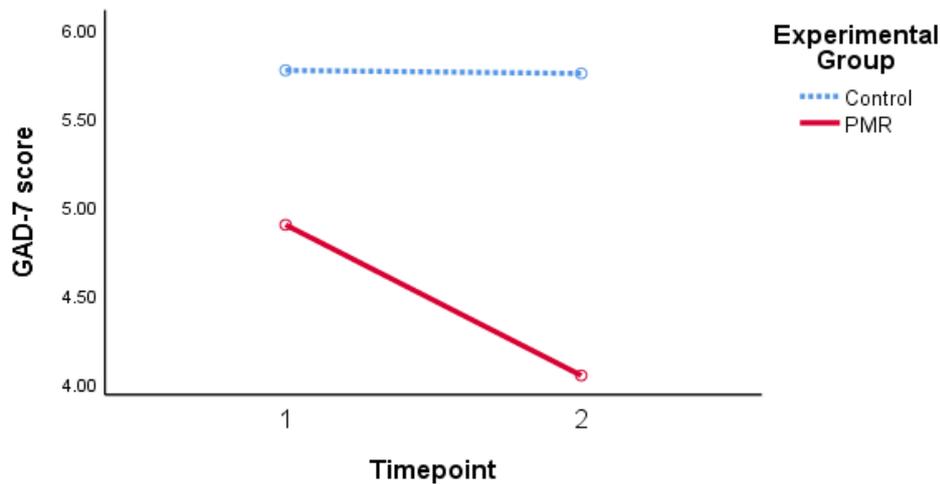
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type two error was higher than desired at 29%. An a-priori power analysis was conducted prior to the study to determine a sample size for a medium effect size ($f = .25$) whilst having an observed power of .80. This analysis indicated that 158 participants would have been required. The covariate, Baseline anxiety, was significantly related to anxiety levels at Timepoint 1 and 2, $F(1, 73) = 122.31, p < .001$, with a large effect size, $\eta^2 = .63$. The main effect for the within-subjects factor (Timepoint 1 and 2) was significant, $F(1, 73) = 4.95, p = .029$, indicating there were significant differences between the values of Timepoint 1 and 2 after controlling for anxiety at Baseline regardless of experimental group. The interaction effect between the within-subjects factor and experimental group was not significant, $F(1, 73) = 2.48, p = .120$, indicating that the relationship between Timepoint 1 and 2 was similar between the levels of experimental group. The interaction effect between the within-subjects factor and baseline anxiety was significant, $F(1, 73) = 15.07, p < .001$, indicating that the relationship between anxiety at Timepoint 1 and 2 differed significantly based upon the values present at baseline.

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Figure 5

Anxiety levels per experimental group with Baseline GAD as a covariate



Note. Covariates appearing in the model are evaluated at the following values: GAD Baseline score = 6.41

A post-hoc analysis of the mean contrasts was conducted with a Tukey Test. This was conducted to test the differences in the estimated marginal means for each combination of between-subject (the experimental group) and within-subject (the timepoints) effects. For PMR, a between-subject effect, the anxiety score at Timepoint 1 was significantly lower compared to the anxiety score at Timepoint 2, $t(73) = 2.48$, $p = .016$, validating that there was a significant decrease in GAD-7 score. No other significant differences were found within the control group.

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Correlational analysis for the levels of reported anxiety and RCBT performance

As the anxiety levels and RCBT scores were measured at each time interval, to adequately explore the potential correlation between the two variables, three separate analyses were conducted. A correlational analysis was chosen in order to establish whether the two are related to one another. The prior analytic method on the impact of PMR was not appropriate for analysis. This is because the intervention was not designed to impact working memory directly so a direct analysis would be inappropriate. Rather, the hypothesis was predicated on the theoretical links between working memory and anxiety, therefore a direct correlational analysis between the two better addressed the hypothesis. The participant group performance on the RCBT throughout the study can be seen in the Table 5.

Table 5
RCBT Score at each timepoint, as a total and per group

Variable	<i>M</i>	<i>SD</i>	<i>n</i>	<i>SE_M</i>	Min	Max	<i>Mdn</i>	Skewness	Kurtosis
RCBT Baseline	85.08	21.54	162	1.69	10.00	118.00	91.00	-1.79	3.34
Score									
Control	83.38	23.32	65	2.89	10.00	118.00	90.00	-1.62	2.42
PMR	86.22	20.31	97	2.06	11.00	113.00	92.00	-1.91	4.09
RCBT_T1_Score	95.88	10.75	111	1.02	44.00	114.00	98.00	-2.18	7.51
Control	95.30	13.08	46	1.93	44.00	114.00	98.00	-2.50	7.33
PMR	96.29	8.84	65	1.10	70.00	111.00	98.00	-0.93	0.91
RCBT_T2_Score	94.08	9.94	76	1.14	48.00	114.00	96.00	-1.54	5.18
Control	96.94	6.94	32	1.23	82.00	114.00	97.00	0.19	0.58

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PMR 92.00 11.27 44 1.70 48.00 108.00 95.00 -1.54 3.83

Note. Experimental groups presented below the representative timepoint.

As shown in Table 6 violations for the skew value (>2) and kurtosis (>=3) were present. Due to this, it cannot be asserted that the necessary assumptions are met, therefore a non-parametric test must be conducted in lieu of the intended analysis. Due to the non-parametric data, Kendall's tau-b was selected. This has smaller gross error sensitivity and the smaller asymptotic variance, which results in a more robust and more efficient measure (Croux and Dehon, 2010) than Spearman's Rho for correlational analysis.

Throughout each timepoint, there were no significant correlations between the level of anxiety reported and the performance on the RCBT. This is demonstrated in Table 6.

Table 6

Kendall Correlation Results between Anxiety and Working Memory at each interval

Combination	r_k	95% CI	p
GAD Baseline - RCBT Baseline	-0.10	[-0.32, 0.13]	.385
GAD T1 - RCBT T1	0.09	[-0.14, 0.31]	.455
GAD T2 – RCBT T2	0.10	[-0.13, 0.32]	.397

Note. $n = 76$. Holm corrections used to adjust p -values.

The results for Timepoint 1 and 2 when separated by experimental group were as follows. For the control group within Timepoint 1, there was a significant correlation between the GAD-7 score and the performance on the RCBT, $R\tau(46) = .32, p = .026$, indicating a positive relationship between the GAD-7 score and RCBT score. However there was no significant relationship between detected in the experimental group, $R\tau(65) = -.021, p$

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= .87. At Timepoint 2 there was also a significant correlation between the control group's GAD-7 score and the RCBT performance, $R\tau(32) = .40, p = .023$, once more a positive relationship between the variables, whereas no such relationship was found in the experimental group, $R\tau(44) = -.081, p = .60$.

A Fisher r-to-z transformation was then conducted on the significant results. The role of a Fisher r-to-z is to compare the magnitude of the two correlations and determine if they two groups differ significantly. This was necessary due to the uneven group sizes, therefore the differences between the samples may be exaggerated (Silver & Dunlap, 1987). However, this is dependent on a known r value, therefore a conversion from tau must be conducted (Gilpin, 1993; Walker, 2003). The converted r score for Timepoint 1's control group was 0.0088. Utilising this for the Fisher r-to-z transformation indicated that the relationship between anxiety and RCBT in the control group was not significantly different than that in the experimental group despite the coefficient met the significance in one group and not the other, $z = .04, p = .48$ (one tailed). The converted r score for Timepoint 2's control group was .011. Utilising this for the Fisher r-to-z transformation indicated that there was also not a significant difference in the relationship between anxiety and RCBT score regardless of the experimental group, $z = .05, p = .48$ (one tailed).

Supplementary analysis of the data

The intention of the following analyses is to provide further context for the prior findings. This was done to enable a thorough assessment of the results against the hypotheses, in addition to providing greater clarity for future research regarding PMR.

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Correlational analysis between perceived effectiveness of the PMR and anxiety change

The perceived effectiveness of the PMR was measured on a 1-4 Likert scale. The intention for this analysis is to provide greater clarity whether the intervention was the cause for changes in anxiety or whether the changes were due to standard anxiety fluctuation. The descriptive statistics for the perceived effectiveness of the PMR at Timepoint 1 and 2, as well as the GAD-7 change score for Baseline-Timepoint 1 and Timepoint 1-2 are shown in the Table 7.

Table 7

Perceived effectiveness and level of anxiety change

Variable	<i>M</i>	<i>SD</i>	<i>n</i>	<i>SE_M</i>	Min	Max	<i>Mdn</i>
Perceived effectiveness T1							
Control	-	-	-	-	-	-	-
PMR	2.94	0.92	65	0.11	1.00	4.00	3.00
Perceived effectiveness T2							
Control	-	-	-	-	-	-	-
PMR	2.59	0.95	44	0.14	1.00	4.00	3.00
Change in GAD Score T1							
Control	-0.52	2.15	46	0.32	-7.00	2.00	0.00
PMR	-1.35	3.15	65	0.39	-11.00	6.00	-1.00
Change in GAD Score T2							
Control	-0.03	2.18	32	0.38	-9.00	4.00	0.00

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PMR	-0.84	2.68	44	0.40	-8.00	6.00	-1.00
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Note. '-' indicates there is no valid measurement for this statistic.

Spearman's Rho was used for the correlational analysis due to the Likert scale resulting in ordinal data (LeBreton & Senter, 2008; Hauke & Kossowski, 2011). The correlation indicated that there was a significant negative correlation between the perceived effectiveness of the PMR and the reduction in anxiety levels from Baseline to Timepoint 1, $r_s = -.36, p = .003, n = 65$. This means that there was a greater reduction in anxiety associated with more positive opinions of the intervention. However, there was no significant correlation detected between perceived effectiveness and change in anxiety from Timepoint 1 to 2, $r_s = -.27, p = .051, n = 44$.

A paired samples T-test was conducted to measure the change in the perceived effectiveness of the PMR. The intention of this analysis was to track the change in opinion of the intervention. Whilst this data would not be definite it would help future research craft the optimum time to research the effectiveness of PMR. There was a significant decrease in perceived effectiveness from Baseline-Timepoint 1 ($M = 2.93, SD = .85$) to Timepoint 1-2 ($M = 2.59, SD = .95$), $t(43) = 3.17, p = .003, d = .47$. This effect size for this analysis was found to be small, according to the conventions established in Cohen (1988).

Measuring the improvement over time for RCBT performance

Measuring the improvement for RCBT regardless of was important to account for the potential of learning effects. This analysis was intended to provide insight into whether future studies should utilise alternating memory tasks or whether the use of the RCBT throughput is appropriate. Descriptive statistics for the RCBT at each timepoint are provided in Table 6.

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For the use of the repeated measures ANOVA, the dataset must be parametric. Mauchly's test was used to assess the assumption of sphericity (Field, 2017). The results showed that the variances of difference scores between repeated measurements were significantly different from one another, $p < .001$, indicating the sphericity assumption was violated. Furthermore, the assumption of normality was also violated, this was assessed using a Shapiro-Wilk test (Razali & Wah, 2011). The results of the Shapiro-Wilk test were significant, $W = .86$, $p < .001$. This result suggests the changes are unlikely to have been produced by a normal distribution, indicating the normality assumption is violated.

As the assumptions for the repeated measure ANOVA were violated, a non-parametric test must be conducted. Typically, the assumed non-parametric analysis is the Greenhouse-Geisser correction (Greenhouse & Geisser 1959), however this is only valid as a correction for sphericity, ergo it was not appropriate as analysis. Rather, the Friedman Rank Sum Test was selected as it does not share the repeated measures ANOVA's distributional assumptions (Zimmerman & Zumbo, 1993).

The results of the Friedman test were significant, $\chi^2(2) = 14.00$, $p < .001$, $W = .092$ indicating significant differences in the median values of the RCBT scores at Baseline, Timepoint 1 and 2 with a small effect size (Cohen, 1988). A pairwise analysis was conducted utilising the Wilcoxon Signed Rank Test (Woolson, 2008). This test reveal that there was a significant increase in RCBT performance from Baseline ($Mdn = 91$, $n = 162$) to Timepoint 1 ($Mdn = 98$, $n = 111$), $z = -4.033$, $p > 0.001$, as well as a significant increase in performance from Baseline to Timepoint 2 ($Mdn = 96$, $n = 76$), $z = -2.89$, $p = .004$. It should also be noted that the Wilcoxon Signed Rank Test indicated there was a significant decrease in the performance on the RCBT from Timepoint 1 to 2, $z = -2.89$, $p = .004$.

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Discussion

Key findings

The findings present indicate there is some evidence that online PMR is an effective intervention for subclinical anxiety. This assertion must be moderated due to the fact that the sample collected was an inactive control and the main effect had a below threshold power level. The inactive control was chosen due to the concerns of participant withdrawal, however because of this it is difficult to firmly assess whether the change was due to the intervention as opposed to a traditional active control. Active controls are more effective at minimising the contextual factors which could impact the results. Furthermore, the presence of an elevated chance of a type 2 error further demonstrates why further research must be conducted, with a more robust sample size.

The conclusion of uncertainty can be supported when examining the perceived effectiveness of PMR intervention and the corresponding reduction in anxiety. Indeed, the correlational analysis indicated that an increased perceived effectiveness of the PMR correlated with a greater decrease in anxiety report. However, this correlation was only present in the initial reduction in anxiety (from Baseline to Timepoint 1). Overall, the findings present are a strong foundation for future research to build off, but they cannot be definitive regarding the effectiveness of online-based PMR..

The correlational analysis between anxiety levels and working memory also provided nuanced data. In terms of the correlation between anxiety and working memory, no correlation was detected. However, when the correlation was conducted with split groups, a

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positive correlation was discerned, with increased anxiety resulting in increased RCBT performance. This correlation was seen in the control group for Timepoint 1 and 2. This finding was unexpected although explanations for it are presented later in the discussion.

From the data presented, no clear correlation between anxiety levels and working memory can be demonstrated. This conclusion is in part due to the conflicting correlations and due to Fisher's Z Transformation analyses failing to demonstrate that there was a tangible difference between the experimental groups. Furthermore, the differences in RCBT at each timepoint were compared from this, a pattern emerged that, regardless of experimental group, performance in the RCBT improved from Baseline to Timepoint 1 and from Baseline to Timepoint 2. This improvement coincides with the prior correlations, indicating that the improvement in RCBT performance was likely due to learning effects over time rather than anxiety levels. This was also account for the result found in the Fisher's transformation as the improvement encompassed both groups, hence the lack of tangible differences between them. It is interesting to note that no discernible change was detected between performance in Timepoint 1 and 2, the implications to which are discussed later.

In terms of attrition, excluding Timepoint 3, the analyses indicated there were no discernible factors which increased the propensity to remain or leave the study. One pattern that could be drawn was participation continuously decreased as the study continued. The implications for the attrition rate on both the feasibility of online PMR and on the findings of the study will be discussed further.

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PMR effectiveness

The effectiveness of PMR techniques for addressing anxiety is well established in the literature (for example, Ahmadnejad et al., 2011), however the effectiveness of the PMR was typically viewed through the lens of an intervention for anxiety when the participant was experiencing specific stressors, whether that be physiological ailments (Pan et al., 2012), psychological conditions with comorbid anxiety (Chen et al., 2009) or when facing situations where elevated anxiety or stress is to be expected (for example, Tsitsi et al., 2017). The present study addressed the effectiveness of PMR within a non-clinical sample focusing on the effectiveness of the PMR technique administered online via a video with minimal instruction. Whilst this premise has been explored, notably in Brown and Schiraldi (2004), the sample selected was solely students limiting its applicability to the wider population. This is of particular note as technology literacy and preference has been associated with age (Vroman et al., 2015; Kuerbis et al., 2017). This means the potential effectiveness of online based PMR may be limited to younger generations. However, the sample age issue persisted within the present study, with the average age of the participants significantly younger than the general population. Although the concerns raised pertaining to age and accessibility may not be entirely justified in the long term, with research suggesting the age gap for technological proficiency is decreasing (Eshet-Alkalai & Chajut, 2009). Building from this, internet based PMR experiments typically focused on participants with pathological or physiological conditions (Ramasamy et al, 2018; Minen et al., 2020). The studies demonstrated the potential effectiveness of the PMR, however that is not necessarily transferable to the non-clinical population. One major concern is that non-clinical individuals will not be as motivated to engage with PMR.

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One can make the assertion that the parity in attrition between the experimental group and the control group demonstrates that the PMR technique is an accessible measure that retains participants. However, comparing attrition rate in a study setting with a reward is fundamentally different than adherence without encouragement with individuals suffering from anxiety. This does not mean that the comparable attrition rate between groups is not a positive for internet based PMR, just that the extent to which assertions can be made must be tempered by the difference between studies and real-life practices.

It should also be noted that the effectiveness of the PMR intervention demonstrated within this study illustrates the effectiveness of a brief and easily accessible intervention. Indeed, the present experiment ran for six weeks, with the greatest drop in anxiety levels demonstrated between the Baseline and Timepoint 1. This is aligned in the literature with Abbreviated Progressive Muscle Relaxation training (APMRT) significantly improving anxiety levels (Carlson & Hoyle, 1993). Although a unified schedule for training was not used in the aforementioned study, the training would consist of one hours' worth of training, once every week for two weeks. This is a useful criterion for the effectiveness of online PMR as the prior APMRT were face to face training, which over a comparable period of time, provided similar results. Indeed, further evidence suggested that even a single 20-minute session of PMR improved stress reduction, reactivity and recovery as compared to a control (Rausch et al., 2006). From this, it can be posited that the briefness of the online PMR training is likely not impactful on total anxiety reduction.

The perceived level of effectiveness of the PMR was designed to elucidate whether the reduction in anxiety present in the experimental group was truly due to the PMR intervention. This was important to include as anxiety levels fluctuate, with changes in

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anxiety dependent on circumstances outside the control of this study. The perceived effectiveness of the PMR technique is rarely included in the analysis of its effectiveness (exemplified in the meta-analysis, Stevens et al., 2007), thus the present study addresses an area of anxiety reduction seldom considered. As mentioned in the key findings, the perceived effectiveness of PMR did not correlate with the changes in anxiety from Timepoint 1 to 2. This can be explained by the way in which the question was posed on the questionnaire. The question only pertained to the two weeks prior to the questionnaire, meaning that the perceived effectiveness reported was not representative of a holistic decrease in perceived effectiveness. It could be posited that the perceived effectiveness stagnated rather than decreased. There was the intention to measure the perceived effectiveness of the PMR throughout the experiment, however that question was present in Timepoint 3, and the study did not retain enough participants to provide useable data.

Use of an Inactive Control

It should be noted that prior research into anxiety have utilised inactive controls (Gujjar et al., 2019). Indeed, the concern for the discrepancy between active and inactive controls has been accounted for in specific analyses. For example, Hugh-Jones et al. (2021) conducted a meta-analysis which presented evidence regarding the utility of inactive control and active controls regarding school-based anxiety interventions. Importantly for the present study, it was found that there were no significant differences between an inactive control and an active control. The analysis also found that the interventions were effective, indicating that an inactive control was able to discern a significant effect as well as an active control. Contrary to this, a meta-analysis by Davies et al (2004) found a significant difference between the results of inactive control compared to active. Indeed, in a meta-analysis

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composed of studies on internet-based interventions into anxiety, the analysis indicated that inactive controls broadly showed a significant difference between the intervention group and control. However, within the active control studies, no such significance was found. This could imply that inactive controls are too uncontrolled and encapsulate more variables in the analysis than intended. Lending credence to this speculation are results from Leyro et al., (2021) which once more found that inactive controls were more likely to show significant changes as compared to their active counterparts.

It is important to note that the aforementioned studies were not intending to investigate whether active or inactive controls had an influence on the results, therefore the findings presented should be seen more as circumstantial evidence rather than definitive proof. Additionally, with the nature of this study, inactive controls were the most comparable to real life behaviour, and by having no instructions the participants' behaviour better represented natural behaviour. In spite of this, due to the theoretical concerns with the inactive control not controlling for extraneous variables and the prior research suggesting that inactive controls are more sensitive to finding significant changes, conclusive statements on ramifications of the findings of this research cannot be made.

Implications

This paper suggests that more research is needed to clarify whether PMR is an effective intervention for reducing anxiety. One specific way in which this can be addressed is by the use of an active control against the intervention group, which should allow more concrete assertions to be made. Future research could also focus on the effectiveness of online PMR against face-to-face. Additionally, the level of perceived effectiveness of the PMR correlated partially with improved anxiety. This could have implications for more

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patient and participant feedback being present in analysis for anxiety related experiments. Indeed, despite how effective the GAD-7 is at measuring retrospective anxiety, it does not provide a way for participants to show what the potential anxiety would have been without the intervention. From this, an analysis could be conducted to measure if the perceived benefit of an intervention accurately tracks the level of anxiety felt.

An area of potential research that can be developed due to the findings in the study is the relative effectiveness of PMR against another wellness or relaxation technique. Indeed, there is a diverse repertoire of wellness techniques, with varying levels of institutional and academic support. One intervention of interest is diaphragmatic breathing, the method involves very similar mechanisms as the PMR with a focus on deep breathing and relaxing. The effectiveness of this intervention in reducing anxiety has been demonstrated in research (Chen et al., 2017; Ma et al., 2017) as well as being recommended by the NHS for stress and anxiety issues (The Newcastle upon Tyne Hospitals NHS Foundation Trust, 2014). Further research could focus on understanding whether PMR can be considered a wellness activity by measuring the effects of PMR compared to a wide range of established wellness measures. This would require codifying what wellness is and what wellness training should result in, whilst that is out of the purview of this study, the evidence that the PMR reduces anxiety does lend some credence to the idea that PMR is a wellness technique.

An interesting area that was not addressed within the present research and has been reported in the literature is the effectiveness of the PMR at reducing both acute or induced anxiety and chronic anxiety (Zargarzadeh & Shirazi, 2014; Charalambous et al., 2015). The resulting decrease in both types of anxiety could be due to the increase in mindfulness and general wellbeing (Corbett et al., 2019), which has been demonstrated to reduce anxiety

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(Hofmann et al., 2010). This could be researched further using online based PMR, particularly with a focus on acute anxiety as that was not within the purview of this study.

Anxiety and Working Memory

Discussions pertaining to the anxiety and working are difficult as the correlations were contradictory. Although a definite statement cannot be made regarding the relationship between anxiety and working memory, the data provided findings that were worth considering.

From the data, it can be asserted that the relationship between anxiety and working memory has not been established. An explanation regarding the correlations in the changes in anxiety and working memory is provided by the notion that there is an optimal level of anxiety for working memory (Deffenbacher, 1985; Wilke et al., 1985). This assertion is predicated on the Yerkes-Dodson Law, with stress or anxiety needed to ensure that attention is paid to the stimuli, but excessive anxiety overwhelms cognition. For this assertion to be true, the control levels of anxiety would have had to coincidentally be at the optimal level, which cannot be demonstrated. Additionally, the optimal level of anxiety for performance is typically focused on the immediate anxiety (state anxiety), rather than the measured retrospective anxiety. Furthermore, academic evidence suggests that broadly lower anxiety is better for working memory and rather there is potentially an optimal level of stress (Luethi et al, 2009).

Arguments can be posited which would support the optimal level of anxiety assertion, for example that the anxiety levels in the moment cloud the perception of past levels of anxiety hence working memory may still be impacted. However, this would imply that the

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GAD-7 is not a valid measure for retrospective anxiety which has thoroughly demonstrated (Löwe et al., 2008). Heuristically, it appears that a potential transfer effect from a change in anxiety into a change in working memory seems unlikely. More plausibly, the change in RCBT performance was due to learning effects, rather than a change in working memory.

An area of concern prior to the analysis was the potential learning effect, meaning that as a task is repeated, the overall performance on that task improves regardless of intervening factors. It has been demonstrated in prior research that cognitive based repeated tasks will have a significant learning effect (Tao et al., 2019) as well as tasks that involve working memory capacity tasks (Scharfen et al., 2018). The randomness of the RCBT was designed to inhibit learning factors, however, it is apparent that this was unsuccessful. It can be argued that the learning effects may be exaggerated due to the reverse recollection, meaning that if the participant initially entered the forward sequence in a sequence, the improvement in the subsequent RCBT could be due to rectifying that mistake.

However, the learning effect assertion can be challenged due to the fact that performance significantly decreased from Timepoint 1 to 2, whereas it would be expected for the RCBT score to improve or plateau. It can be speculated that the decrease was due to the attrition of participants which had a greater level of learning effect. It is not certain whether anxiety change or learning effects were the cause of the correlations between GAD-7 score and RCBT score as the subtleties needed to investigate this were not within the remit of the study. However, when analysing the data, it appears that the learning effect had an undue influencing the analysis, regardless of if it accounted for all variation and correlations. An interesting aside pertaining to anxiety changes and working memory changes is the impact of training and subsequent transfer effects. Indeed, establishing transfer effects for

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working memory has been challenging with limited evidence in the literature showing long term effects of working memory training (Xin et al., 2014; Melby-Lervåg et al., 2016) A particular area of note is the lack of sustained improvement in working memory updating (WMU), which is defined as the function of manipulating stored information to address novel situations. WMU has been demonstrated to have a significant impact on academic performance (Carretti et al., 2005). A study conducted by Linares et al. (2019) concluded that WMU training only had selective benefits, particularly in tasks that were structured in a similar fashion as the training. This implies that the transfer effect from working memory training to a tangible outcome, such as academic performance, are difficult to attain. With this considered, it is not surprising that a change in anxiety levels would not have a clear transfer effect on a working memory task.

Although the correlations between anxiety levels and working memory were not significant at any timepoint, information can still be gleaned from the results. Indeed, the majority of the research in the field that demonstrates a correlation between working memory and anxiety focus on acute or induced anxiety that lasts no longer than the intended measure (Moran, 2016; Passolunghi et al., 2016). The impact of short-term anxiety impacting working memory can be viewed through the paradigm of the working memory model, with the temporary level of anxiety overwhelming the executive function temporarily. The GAD-7 measures anxiety levels over time for the prior two weeks which makes in effectual at measuring state level anxiety which would be of interest for working memory. The State Trait Anxiety Index STAI (STAI; Spielberger et al., 1983) would be an effective measure for investigating the relationship between anxiety and working memory, however the measure was deemed not as effective as the GAD-7 at examining anxiety change over the period of

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time the present study investigated (Julian, 2011). The STAI was not conducted in conjunction with the GAD-7 as there was concerns for participant exhaustion with two measures asking similar questions, which would have limited the sample size of the study. The most pertinent direction for research would be to elucidate the relationship between the types of anxiety (state and trait) and how they are connected to one another as well as how they impact working memory.

Implications

The main implication from this portion of the study was that the relationship between working memory and anxiety is complex. Future research will have to account for learning effects and transfer effects. There are two potential resolutions for the learning effect that future research can utilise, the first would be to measure the extent to which the learning effect improves performance on the RCBT then either covariate it or conduct the analysis after the learning effect has plateaued. The second would be to investigate the relationship between anxiety and working memory whilst utilising more than more working memory task. An alternative task could be the Flicker Task which has been validated to measure visual working memory (Pailian et al., 2020). It should be noted that the working memory tasks must address the same memory types in order to ensure a valid measurement of working memory.

One area which this paper did not address was the potential effects of state and trait anxiety, future research could account for the varying anxiety types.

Attrition

In order to discuss the rate of attrition, it must first be established why Timepoint 3 had high rates of attrition. This was due to two main factors, the first that a technical glitch on the Qualtrics site, where the GAD-7 was hosted reportedly left participants unable to

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complete the survey. This was not noticed until late into the time window of participation and many of the participants that were reached out to were not willing to complete the study. The second reason was due to the timing, with the last timepoint coinciding with the end of the university year, which likely reduced willingness to complete the study.

No pattern in characteristics was detected in those who remained in the study against those who left. Relative to the control group, the PMR experimental group was sampled more frequently in order to account for early levels of attrition and to balance the demographics of the groups. The presumption of attrition was informed by early participant activity in which the majority of the participants who left were in the experimental group and due to reading more broadly about the attrition rates in comparable studies (for example, Kabat-Zinn & Chapman-Waldrop, 1988; Bohlmeijer et al., 2010; Goyal et al., 2014). An area of note is that, in spite of prior research indicating that attrition of male participants would be significantly higher, there was no relationship between gender and attrition, meaning that potentially PMR techniques may avoid the greater attrition suffered for other mindfulness activities. However, it should be mentioned that the participation rate for males was much lower than females, implying that there is still potentially a barrier for equal male participation with PMR.

It should be noted that a literature review of studies using PMR indicates that the attrition rate in the present study was abnormally high, even when Timepoint 3 is removed. The higher rate of attrition was also present when compared to other online based PMR studies (Wilver et al., 2019; Cogle et al., 2020). One can speculate that this was due to the pandemic altering participant engagement or perhaps the security measures designed to detect and remove bots were too excessive. There is a possibility that the attrition rate impacted the

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results, however due to the composition of the attrition sample as well as the analysis of correlations between anxiety change and attrition this is unlikely.

Implications

The implications of the findings regarding attrition are numerous. There is indication that the PMR may avoid the gender attrition issues that other mindfulness-based therapies may face. This could be an effective research avenue which could investigate how the different genders interact with PMR and anxiety. The next implication is that future research may be able to rely on similar attrition between experiment group. This could allow for more efficient sampling of participants. It is important that the implications for attrition for an experiment are not applied directly to adherence levels for PMR use in the general population.

Strengths, limitations, and challenges

The GAD-7 was used to measure the anxiety levels of the participants during the phases of the study. Whilst the GAD-7 has strong empirical support and academic use, there has been criticisms for the measure. Kertz et al. (2013) posited that the GAD-7 is ineffective as a screener for GAD, but it is an effective measure of severity. This was further supported in Beard and Björgvinsson (2014), however both of the studies were based on clinical samples therefore the issues are not valid to the study presented. There has also been concern with overlapping between the individual items of the GAD-7, with items four to six demonstrated to have shared residual variance above what is to be expected, however it was deemed appropriate for use in measuring subclinical anxiety by the researchers (Bártolo et al., 2017). As mentioned prior the GAD-7 is a retrospective anxiety measure for the

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proceeding two week. A supplementary alternative anxiety measure testing state anxiety may have rounded out the results.

The RCBT was used to measure the levels of working memory in the participants. The use of the computerised version was effective, with participants understanding the task well. Issues did arise with accidentally pressing the block twice, which resulted in a botched sequence, however that was an abnormality rather than a persistent issue. Potentially, the random RCBT could result in more difficult tasks for participants due to the multiple potential block pathways (Busch et al., 2005). However, this issue was resolved due to a robust sample as well as a randomised sequence, which resulted in parity for difficulty across the participants. The decision to use a block score rather than a sequence score was also validated with nuanced changes in the scores as a result of the measure.

Further issues regarding RCBT but not tied to the program itself was the non-laboratory setting of the task. Indeed, due to concerns with attrition, participants were asked to complete their task remotely. Participants were provided instructions to find somewhere with no distractions but there is no certainty that it was abided by. This is of particular concern as distractions have been demonstrated to reduce working memory capacity and function (Magnussen et al., 1991; Nemes et al., 2011; Offergeld et al., 2020). With this considered, future research should aim for tasks to be completed in a lab environment with the intervention remaining remote. An advantage of the lab is also that it is much easier for participants to engage with the technician if they misunderstood the task, which would mitigate errors.

Concerns pertaining to the sample selected are present, with the average age of the sample being significantly younger than the general population as well as being biased

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towards female participants. The concerns of the two issues are minimal with no evidence suggesting that gender is an influencing factor on the effectiveness of PMR, nor has that been established for age. A concern for the age bias was that the sample would be bias towards more anxious participants. Indeed, by looking at the raw mean score for the GAD-7 at the Baseline, the average anxiety score was 6.32, this compared to the average score in a non-clinical population of 2.95 in Löwe et al. (2008). However, the change in anxiety levels can be explained by the coronavirus pandemic, which has resulted in similar levels of anxiety for those under 50 (Çopur & Karasu, 2021). Another issue with the sample was the use of the incentive due to its potential to impact the results, with participants retained who did not actively participate in the study. It was decided this potential impact was in order to recruit the necessary number of participants. Furthermore, the longitudinal format of the study and the participant driven nature of it would lead to participants who are solely there for the potential incentive to fail to adhere.

A concern for the data collected is that it does not delineate the different categories of anxieties, rather it combines all potential groups into one. This is of concern as individuals who were not diagnosed with clinical anxiety but have GAD-7 scores which indicated they could, were included in the analysis. Granted that as they have not been diagnosed, they by definition were non/sub-clinical, however, it has the potential to distort the intention of the study. Although this concern is valid it's a subset of a greater issue, that subclinical is a nebulous concept. In theory, all participants could be classified as subclinical as they have not been diagnosed with an anxiety disorder at the time of the study, however that encapsulates a much wider range than is likely intended. Proscriptively, it is best for future research to utilise discrete groups of anxiety (non and sub clinical and clinical). Whilst this will cause

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some issues deciding on what to define subclinical is on a quantitative scale, the validity of the data would most likely be greater than the present study.

As mentioned in the introduction, this study does not pertain to the pandemic, however it was conducted within it. It must be stated that although the experiment was not based on the pandemic it effectively illustrated the reason why it is important to find effective online-based interventions to reduce anxiety among the general population. When this study was conducted, the evidence suggests that the pandemic led to a significant increase in anxiety, with numerous studies positing that the pandemic has created a new distinction in anxiety based on the coronavirus with its own specialised scale (Lee et al., 2020; Orrù et al., 2021). In addition to this, the present study was longitudinal, therefore real culture change may have occurred during the participants time within the study. Indeed, preliminary data seems to suggest the phenomenon of lockdown anxiety, where anxiety increased greatly when lockdowns were in effect (Fountoulakis et al., 2021; Wakode et al., 2021). Therefore, it would stand to reason that if the lockdowns were relaxed, then anxiety would decrease which could account for some of the variance in anxiety reported within the cohort. This was likely the case as the data was collected from March 2021 to July 2021, with UK and US lockdowns and restrictions lightening at this point. This could lend even more credence to the PMR as the decrease in anxiety surpassed the average reduction in anxiety. Once more, this is based on preliminary studies and a more concrete understanding of the potential lingering anxiety effects will not be fully understood for some time.

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Conclusions

The current findings highlight the effectiveness of online PMR techniques for reducing anxiety however these findings are heavily caveated. Future research must be done to discern whether the potential conclusions of this study are true. In addition to this, no discernible factors could be established for influencing adherence to the experiment, including the experimental group and changes in anxiety level. Further investigations must be conducted to explore the relationship between anxiety and working memory and how working memory operates with acute and chronic levels of anxiety. Overall, the findings are inconclusive however there is potential that online PMR is an effective alternative when other outlets are limited. The effectiveness of online PMR versus face-to-face PMR has not been established, hence why online PMR is not recommended in all circumstances.

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References

- Aben, B., Stapert, S., & Blokland, A. (2012). About the distinction between working memory and short-term memory. *Frontiers in Psychology, 3*, 301-301.
<https://doi.org/10.3389/fpsyg.2012.00301>
- Agarwal, N., & Agarwal, S. (2011). Presence of subclinical anxiety in hypertensive patients. *Heart, Lung & Circulation, 20*, S17-S17. <https://doi.org/10.1016/j.hlc.2011.05.042>
- Ahmadnejad, S., Monjamed, Z., Pakravannejad, M., & Malekian, A. (2011). *The effect of relaxation training on first year nursing students anxiety in clinical setting*. Zenodo.
<https://doi.org/10.5281/zenodo.1333539>
- Ahn, J., Kim, Y., & Choi, K. (2019). The psychometric properties and clinical utility of the korean version of GAD-7 and GAD-2. *Frontiers in Psychiatry, 10*, 127-127.
<https://doi.org/10.3389/fpsyg.2019.00127>
- Albery, I. P., Spada, M. M., & Nikčević, A. V. (2021). The COVID-19 anxiety syndrome and selective attentional bias towards COVID-19-related stimuli in UK residents during the 2020–2021 pandemic. *Clinical Psychology and Psychotherapy*,
<https://doi.org/10.1002/cpp.2639>
- Alosaimi, F. D., Al-Sultan, O. A., Alghamdi, Q. A., Almohaimeed, I. K., & Alqannas, S. I. (2014). Gender-specific differences in depression and anxiety symptoms and help-seeking behavior among gastroenterology patients in riyadh, saudi arabia. *Neurosciences (Riyadh, Saudi Arabia), 19*(3), 203-209.
- Altemus, M., Sarvaiya, N., & Neill Epperson, C. (2014). Sex differences in anxiety and depression clinical perspectives. *Frontiers in Neuroendocrinology, 35*(3), 320-330.
<https://doi.org/10.1016/j.yfrne.2014.05.004>

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (5th ed.)*. <https://doi.org/10.1176/appi.books.9780890425596>
- Ansari, T. L., & Derakshan, N. (2010). Anxiety impairs inhibitory control but not volitional action control. *Cognition and Emotion*, 24(2), 241-254.
<https://doi.org/10.1080/02699930903381531>
- Archer, C., Turner, K., Kessler, D., Mars, B., & Wiles, N. (2021). Trends in the recording of anxiety in UK primary care: A multi-method approach. *Social Psychiatry and Psychiatric Epidemiology*, <https://doi.org/10.1007/s00127-021-02131-8>
- Baddeley, A. D. (1992). Working memory. *Science (American Association for the Advancement of Science)*, 255(5044), 556-559.
<https://doi.org/10.1126/science.1736359>
- Baddeley, A. D., & Hitch, G. (1974). *Working memory*. (pp. 47-89). Elsevier Science & Technology. [https://doi.org/10.1016/S0079-7421\(08\)60452-1](https://doi.org/10.1016/S0079-7421(08)60452-1)
- Baird, S. O., Hopkins, L. B., Medina, J. L., Rosenfield, D., Powers, M. B., & Smits, J. A. J. (2016). Distress tolerance as a predictor of adherence to a yoga intervention: Moderating roles of BMI and body image. *Behavior Modification*, 40(1-2), 199-217.
<https://doi.org/10.1177/0145445515612401>
- Balderston, N. L., Quispe-Escudero, D., Hale, E., Davis, A., O'Connell, K., Ernst, M., & Grillon, C. (2016). Working memory maintenance is sufficient to reduce state anxiety: Working memory maintenance reduces state anxiety. *Psychophysiology*, 53(11), 1660-1668. <https://doi.org/10.1111/psyp.12726>
- Bandelow, B., & Michaelis, S. (2015). Epidemiology of anxiety disorders in the 21st century. *Dialogues in Clinical Neuroscience*, 17(3), 327-335.

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.

Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M. J., & van IJzendoorn, M.

H. (2007). Threat-related attentional bias in anxious and nonanxious individuals: A meta-analytic study. *Psychological Bulletin*, *133*(1), 1-24.

<https://doi.org/10.1037/0033-2909.133.1.1>

Bartlett, J. W. (2020). Robustness of ANCOVA in randomized trials with unequal

randomization. *Biometrics*, *76*(3), 1036-1038. <https://doi.org/10.1111/biom.13184>

Bártolo, A., Monteiro, S., & Pereira, A. (2017). Factor structure and construct validity of the generalized anxiety disorder 7-item (GAD-7) among portuguese college students.

Cadernos De Saúde Pública, *33*(9), e00212716-e00212716.

<https://doi.org/10.1590/0102-311x00212716>

Bass, A. M., Farhangian, M. E., & Feldman, S. R. (2015). Internet-based adherence

interventions for treatment of chronic disorders in adolescents. *Adolescent Health, Medicine and Therapeutics*, *6*, 91-99. <https://doi.org/10.2147/AHMT.S56065>

Beard, C., & Björgvinsson, T. (2014). Beyond generalized anxiety disorder: Psychometric properties of the GAD-7 in a heterogeneous psychiatric sample. *Journal of Anxiety Disorders*, *28*(6), 547-552. <https://doi.org/10.1016/j.janxdis.2014.06.002>

Beintner, I., Jacobi, C., & Taylor, C. B. (2014). Participant adherence to the internet-based prevention program StudentBodies™ for eating disorders — A review. *Internet Interventions: The Application of Information Technology in Mental and Behavioural Health*, *1*(1), 26-32. <https://doi.org/10.1016/j.invent.2014.03.001>

Beloe, P., & Derakshan, N. (2020;2019;). Adaptive working memory training can reduce anxiety and depression vulnerability in adolescents. *Developmental Science*, *23*(4), e12831-n/a. <https://doi.org/10.1111/desc.12831>

<https://doi.org/10.1111/desc.12831>

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.

- Berch, D. B., Krikorian, R., & Huha, E. M. (1998). The corsi block-tapping task: Methodological and theoretical considerations. *Brain and Cognition*, 38(3), 317-338. <https://doi.org/10.1006/brcg.1998.1039>
- Berggren, N., Curtis, H. M., & Derakshan, N. (2017). Interactions of emotion and anxiety on visual working memory performance. *Psychonomic Bulletin & Review*, 24(4), 1274-1281. <https://doi.org/10.3758/s13423-016-1213-4>
- Bocincova, A., van Lamsweerde, A. E., & Johnson, J. S. (2017). The role of top-down suppression in mitigating the disruptive effects of task-irrelevant feature changes in visual working memory. *Memory & Cognition*, 45(8), 1411-1422. <https://doi.org/10.3758/s13421-017-0738-8>
- Bohingamu Mudiyansele, S., Stevens, J., Watts, J. J., Toscano, J., Kotowicz, M. A., Steinfors, C. L., Bell, J., Byrnes, J., Bruce, S., Carter, S., Hunter, C., Barrand, C., & Hayles, R. (2019). Personalised telehealth intervention for chronic disease management: A pilot randomised controlled trial. *Journal of Telemedicine and Telecare*, 25(6), 343-352. <https://doi.org/10.1177/1357633X18775850>
- Bohlmeijer, E., Prenger, R., Taal, E., & Cuijpers, P. (2010). The effects of mindfulness-based stress reduction therapy on mental health of adults with a chronic medical disease: A meta-analysis. *Journal of Psychosomatic Research*, 68(6), 539-544. <https://doi.org/10.1016/j.jpsychores.2009.10.005>
- Borgogna, N. C., Brenner, R. E., & McDermott, R. C. (2021). Sexuality and gender invariance of the PHQ-9 and GAD-7: Implications for 16 identity groups. *Journal of Affective Disorders*, 278, 122-130. <https://doi.org/10.1016/j.jad.2020.09.069>

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

- Bowen, A. M., Daniel, C. M., Williams, M. L., & Baird, G. L. (2008). Identifying multiple submissions in internet research: Preserving data integrity. *AIDS and Behavior, 12*(6), 964-973. <https://doi.org/10.1007/s10461-007-9352-2>
- Brown, S. L., & Schiraldi, G. R. (2004). Reducing subclinical symptoms of anxiety and depression: A comparison of two college courses. *American Journal of Health Education, 35*(3), 158-164. <https://doi.org/10.1080/19325037.2004.10603632>
- Brunetti, R., Del Gatto, C., & Delogu, F. (2014). eCorsi: Implementation and testing of the corsi block-tapping task for digital tablets. *Frontiers in Psychology, 5*, 939-939. <https://doi.org/10.3389/fpsyg.2014.00939>
- Brunoni, A. R., Boggio, P. S., De Raedt, R., Benseñor, I. M., Lotufo, P. A., Namur, V., Valiengo, L. C. L., & Vanderhasselt, M. A. (2014). Cognitive control therapy and transcranial direct current stimulation for depression: A randomized, double-blinded, controlled trial. *Journal of Affective Disorders, 162*, 43-49. <https://doi.org/10.1016/j.jad.2014.03.026>
- Burdwood, E. N., Infantolino, Z. P., Crocker, L. D., Spielberg, J. M., Banich, M. T., Miller, G. A., & Heller, W. (2016). Resting-state functional connectivity differentiates anxious apprehension and anxious arousal: Resting-state anxiety mechanisms. *Psychophysiology, 53*(10), 1451-1459. <https://doi.org/10.1111/psyp.12696>
- Busch, M. R., Farrell, K., Lisdahl-Medina, K., & Krikorian, R. (2005). Corsi block-tapping task performance as a function of path configuration. *Journal of Clinical and Experimental Neuropsychology, 27*(1), 127-134. <https://doi.org/10.1080/138033990513681>

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.

- Byrd-Bredbenner, C., Eck, K., & Quick, V. (2021). GAD-7, GAD-2, and GAD-mini: Psychometric properties and norms of university students in the united states. *General Hospital Psychiatry*, 69, 61-66. <https://doi.org/10.1016/j.genhosppsych.2021.01.002>
- Cagas, J. Y., Biddle, S. J. H., & Vergeer, I. (2021). Yoga not a (physical) culture for men? understanding the barriers for yoga participation among men. *Complementary Therapies in Clinical Practice*, 42, 101262-101262. <https://doi.org/10.1016/j.ctcp.2020.101262>
- Carlson, C. R., & Hoyle, R. H. (1993). Efficacy of abbreviated progressive muscle relaxation training: A quantitative review of behavioral medicine research. *Journal of Consulting and Clinical Psychology*, 61(6), 1059-1067. <https://doi.org/10.1037/0022-006X.61.6.1059>
- Carretti, B., Cornoldi, C., De Beni, R., & Romanò, M. (2005). Updating in working memory: A comparison of good and poor comprehenders. *Journal of Experimental Child Psychology*, 91(1), 45-66. <https://doi.org/10.1016/j.jecp.2005.01.005>
- Charalambous, A., Giannakopoulou, M., Bozas, E., & Paikousis, L. (2015). A randomized controlled trial for the effectiveness of progressive muscle relaxation and guided imagery as anxiety reducing interventions in breast and prostate cancer patients undergoing chemotherapy. *Evidence-Based Complementary and Alternative Medicine*, 2015, 270876-10. <https://doi.org/10.1155/2015/270876>
- Chechlacz, M., Rotshtein, P., & Humphreys, G. W. (2014). Neuronal substrates of Corsi block span: Lesion symptom mapping analyses in relation to attentional competition and spatial bias. *Neuropsychologia*, 64, 240-251. <https://doi.org/10.1016/j.neuropsychologia.2014.09.038>

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.

- Chellew, K., Evans, P., Fornes-Vives, J., Pérez, G., & Garcia-Banda, G. (2015). The effect of progressive muscle relaxation on daily cortisol secretion. *Stress (Amsterdam, Netherlands)*, 18(5), 538-544. <https://doi.org/10.3109/10253890.2015.1053454>
- Chen, W., Chu, H., Lu, R., Chou, Y., Chen, C., Chang, Y., O'Brien, A. P., & Chou, K. (2009). Efficacy of progressive muscle relaxation training in reducing anxiety in patients with acute schizophrenia. *Journal of Clinical Nursing*, 18(15), 2187-2196. <https://doi.org/10.1111/j.1365-2702.2008.02773.x>
- Chen, Y., Huang, X., Chien, C., & Cheng, J. (2017). The effectiveness of diaphragmatic breathing relaxation training for reducing anxiety. *Perspectives in Psychiatric Care*, 53(4), 329-336. <https://doi.org/10.1111/ppc.12184>
- Cheung, Y. L., Molassiotis, A., & Chang, A. M. (2003). The effect of progressive muscle relaxation training on anxiety and quality of life after stoma surgery in colorectal cancer patients. *Psycho-Oncology (Chichester, England)*, 12(3), 254-266. <https://doi.org/10.1002/pon.638>
- Chun, H. Y., Whiteley, W. N., Dennis, M. S., Mead, G. E., & Carson, A. J. (2018). Anxiety after stroke: The importance of subtyping. *Stroke (1970)*, 49(3), 556-564. <https://doi.org/10.1161/STROKEAHA.117.020078>
- Claessen, M. H. G., van der Ham, Ineke J. M, & van Zandvoort, Martine J. E. (2015). Computerization of the standard corsi block-tapping task affects its underlying cognitive concepts: A pilot study. *Applied Neuropsychology. Adult*, 22(3), 180-188. <https://doi.org/10.1080/23279095.2014.892488>
- Cochran, W. G. (1952). The chi square test of goodness of fit. *The Annals of Mathematical Statistics*, 23(3), 315-345. <https://doi.org/10.1214/aoms/1177729380>

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.

- Cocks, A. J., Jackson, R. C., Bishop, D. T., & Williams, A. M. (2016). Anxiety, anticipation and contextual information: A test of attentional control theory. *Cognition and Emotion, 30*(6), 1037-1048. <https://doi.org/10.1080/02699931.2015.1044424>
- Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences (2nd ed.)*. Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.
- Cook, J. A., Copeland, M. E., Floyd, C. B., Jonikas, J. A., Hamilton, M. M., Razzano, L., Carter, T. M., Hudson, W. B., Grey, D. D., & Boyd, S. (2012). A randomized controlled trial of effects of wellness recovery action planning on depression, anxiety, and recovery. *Psychiatric Services (Washington, D.C.), 63*(6), 541-547. <https://doi.org/10.1176/appi.ps.201100125>
- Coombes, S. A., Higgins, T., Gamble, K. M., Cauraugh, J. H., & Janelle, C. M. (2009). Attentional control theory: Anxiety, emotion, and motor planning. *Journal of Anxiety Disorders, 23*(8), 1072-1079. <https://doi.org/10.1016/j.janxdis.2009.07.009>
- Çopur, E. Ö., & Karasu, F. (2021). The impact of the COVID-19 pandemic on the quality of life and depression, anxiety, and stress levels of individuals above the age of eighteen. *Perspectives in Psychiatric Care, https://doi.org/10.1111/ppc.12730*
- Corbett, C., Egan, J., & Pilch, M. (2019). A randomised comparison of two 'Stress control' programmes: Progressive muscle relaxation versus mindfulness body scan. *Mental Health & Prevention, 15*, 200163. <https://doi.org/10.1016/j.mph.2019.200163>
- Cornoldi, C., & Mammarella, I. C. (2008). A comparison of backward and forward spatial spans. *Quarterly Journal of Experimental Psychology (2006), 61*(5), 674-682. <https://doi.org/10.1080/17470210701774200>

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.

Corsi, P. M. (1973). Human memory and the medial temporal region of the brain.

Dissertation Abstracts International, 34(2-B), 891.

Cogle, J. R., Wilver, N. L., Day, T. N., Summers, B. J., Okey, S. A., & Carlton, C. N.

(2020). Interpretation bias modification versus progressive muscle relaxation for social anxiety disorder: A web-based controlled trial. *Behavior Therapy*, 51(1), 99-112. <https://doi.org/10.1016/j.beth.2019.05.009>

Course-Choi, J., Saville, H., & Derakshan, N. (2017). The effects of adaptive working memory training and mindfulness meditation training on processing efficiency and worry in high worriers. *Behaviour Research and Therapy*, 89, 1-13.

<https://doi.org/10.1016/j.brat.2016.11.002>

Cox, N. J. (2010). Speaking stata: The limits of sample skewness and kurtosis. *The Stata Journal*, 10(3), 482-495. <https://doi.org/10.1177/1536867x1001000311>

Crisan, L. G., Vulturar, R., Miclea, M., & Miu, A. C. (2016). Reactivity to social stress in subclinical social anxiety: Emotional experience, cognitive appraisals, behavior, and physiology. *Frontiers in Psychiatry*, 7, 5-5. <https://doi.org/10.3389/fpsy.2016.00005>

Croux, C., & Dehon, C. (2010). Influence functions of the spearman and kendall correlation measures. *Statistical Methods & Applications*, 19(4), 497-515.

<https://doi.org/10.1007/s10260-010-0142-z>

Cumbria, Northumberland, Tyne & Wear NHS Foundation Trust. (June 2017). *Relaxation techniques*. Cntw, <https://www.cntw.nhs.uk/resource-library/relaxation-techniques/>.

Davies, E. B., Morriss, R., & Glazebrook, C. (2014). Computer-delivered and web-based interventions to improve depression, anxiety, and psychological well-being of

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.

university students: A systematic review and meta-analysis. *Journal of Medical Internet Research*, 16(5), e130-e130. <https://doi.org/10.2196/jmir.3142>

Deffenbacher, K. A. (1985). Eyewitness recall, the yerkes-dodson law, and optimal-level theory. *Medicine and Law*, 4(4), 361-372.

Dehdari, T., Heidarnia, A., Ramezankhani, A., Sadeghian, S., & Ghofranipour, F. (2009). Effects of progressive muscular relaxation training on quality of life in anxious patients after coronary artery bypass graft surgery. *Indian Journal of Medical Research (New Delhi, India : 1994)*, 129(5), 603-608.

Dehghan-nayeri, N., & Adib-Hajbaghery, M. (2011). Effects of progressive relaxation on anxiety and quality of life in female students: A non-randomized controlled trial. *Complementary Therapies in Medicine*, 19(4), 194-200. <https://doi.org/10.1016/j.ctim.2011.06.002>

Dent, L., Peters, A., Kerr, P. L., Mochari-Greenberger, H., & Pande, R. L. (2018). Using telehealth to implement cognitive-behavioral therapy. *Psychiatric Services (Washington, D.C.)*, 69(4), 370-373. <https://doi.org/10.1176/appi.ps.201700477>

Derakshan, N., & Eysenck, M. W. (2009). Anxiety, processing efficiency, and cognitive performance: New developments from attentional control theory. *European Psychologist*, 14(2), 168-176. <https://doi.org/10.1027/1016-9040.14.2.168>

Derakshan, N., Ansari, T. L., Hansard, M., Shoker, L., & Eysenck, M. W. (2009). Anxiety, inhibition, efficiency, and effectiveness: An investigation using the antisaccade task. *Experimental Psychology*, 56(1), 48-55. <https://doi.org/10.1027/1618-3169.56.1.48>

Diamond, D. M., Campbell, A. M., Park, C. R., Halonen, J., & Zoladz, P. R. (2007). The temporal dynamics model of emotional memory processing: A synthesis on the

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.

neurobiological basis of stress-induced amnesia, flashbulb and traumatic memories, and the yerkes-dodson law. *Neural Plasticity*, 2007, 60803-33.

<https://doi.org/10.1155/2007/60803>

Dolbier, C. L., & Rush, T. E. (2012). Efficacy of abbreviated progressive muscle relaxation in a high-stress college sample. *International Journal of Stress Management*, 19(1), 48-68. <https://doi.org/10.1037/a0027326>

Donker, T., van Straten, A., Marks, I., & Cuijpers, P. (2011). Quick and easy self-rating of generalized anxiety disorder: Validity of the dutch web-based GAD-7, GAD-2 and GAD-SI. *Psychiatry Research*, 188(1), 58-64.

<https://doi.org/10.1016/j.psychres.2011.01.016>

Duman, R. S., Nakagawa, S., & Malberg, J. (2001). Regulation of adult neurogenesis by antidepressant treatment. *Neuropsychopharmacology (New York, N.Y.)*, 25(6), 836-844. [https://doi.org/10.1016/S0893-133X\(01\)00358-X](https://doi.org/10.1016/S0893-133X(01)00358-X)

Dutton, A., & Carroll, M. (2001). Eyewitness testimony : Effects of source of arousal on memory, source-monitoring, and metamemory judgments. *Australian Journal of Psychology*, 53(2), 83-91. <https://doi.org/10.1080/00049530108255128>

Engels, A. S., Heller, W., Mohanty, A., Herrington, J. D., Banich, M. T., Webb, A. G., & Miller, G. A. (2007). Specificity of regional brain activity in anxiety types during emotion processing. *Psychophysiology*, 44(3), 352-363.

<https://doi.org/10.1111/j.1469-8986.2007.00518.x>

Engels, A. S., Heller, W., Spielberg, J. M., Warren, S. L., Sutton, B. P., Banich, M. T., & Miller, G. A. (2010). Co-occurring anxiety influences patterns of brain activity in

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

depression. *Cognitive, Affective, & Behavioral Neuroscience*, 10(1), 141-156.

<https://doi.org/10.3758/CABN.10.1.141>

Eshet-Alkalai, Y., & Chajut, E. (2009). Changes over time in digital literacy.

Cyberpsychology & Behavior, 12(6), 713-715. <https://doi.org/10.1089/cpb.2008.0264>

Esser, P., Hartung, T. J., Friedrich, M., Johansen, C., Wittchen, H., Faller, H., Koch, U.,

Härter, M., Keller, M., Schulz, H., Wegscheider, K., Weis, J., & Mehnert, A. (2018).

The generalized anxiety disorder screener (GAD-7) and the anxiety module of the hospital and depression scale (HADS-A) as screening tools for generalized anxiety disorder among cancer patients. *Psycho-Oncology (Chichester, England)*, 27(6),

1509-1516. <https://doi.org/10.1002/pon.4681>

Etkin, A., & Wager, T. D. (2007). Functional neuroimaging of anxiety: A meta-analysis of emotional processing in PTSD, social anxiety disorder, and specific phobia. *The American Journal of Psychiatry*, 164(10), 1476-1488.

<https://doi.org/10.1176/appi.ajp.2007.07030504>

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion (Washington, D.C.)*, 7(2), 336-353.

<https://doi.org/10.1037/1528-3542.7.2.336>

Farquhar, J. M., Stonerock, G. L., & Blumenthal, J. A. (2018). Treatment of anxiety in patients with coronary heart disease: A systematic review. *Psychosomatics*

(Washington, D.C.), 59(4), 318-332. <https://doi.org/10.1016/j.psych.2018.03.008>

Fawcett, J. M., Russell, E. J., Peace, K. A., & Christie, J. (2013). Of guns and geese: A meta-analytic review of the 'weapon focus' literature. *Psychology, Crime & Law*, 19(1), 35-

66. <https://doi.org/10.1080/1068316X.2011.599325>

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

- Fernández-Castillo, A., & Caurcel, M. J. (2015). State test-anxiety, selective attention and concentration in university students. *International Journal of Psychology, 50*(4), 265-271. <https://doi.org/10.1002/ijop.12092>
- Field, A. (2017). *Discovering statistics using IBM SPSS statistics: North American edition*. Sage Publications
- Fine, A., Nasiri, K., Fotinos, K., Anand, L., Furtado, M., Armata, R., Badali, K., Mincer, J., Mincer, M., Epstein, I., Cameron, C., Guthrie, A., Cook, S., Laidlaw, B., Sternat, T., & Katzman, M. (2018). Examining predictors of help-seeking behaviours in patients with mood and anxiety symptoms. *Psychiatry Research, 265*, 190-197. <https://doi.org/10.1016/j.psychres.2018.04.040>
- Fleming, J. E., & Kocovski, N. L. (2013). *The mindfulness and acceptance workbook for social anxiety and shyness: Using acceptance and commitment therapy to free yourself from fear and reclaim your life*. New Harbinger Publications.
- Forfylyow, A. L. (2011). Integrating yoga with psychotherapy: A complementary treatment for anxiety and Depression/Intégrer le yoga avec la psychothérapie : Un traitement complémentaire pour l'anxiété et la dépression. *Canadian Journal of Counselling and Psychotherapy (Online), 45*(2), 132.
- Fountoulakis, K. N., Apostolidou, M. K., Atsiova, M. B., Filippidou, A. K., Florou, A. K., Gousiou, D. S., Katsara, A. R., Mantzari, S. N., Padouva-Markoulaki, M., Papatriantafyllou, E. I., Sacharidi, P. I., Tonia, A. I., Tsagalidou, E. G., Zymara, V. P., Prezerakos, P. E., Koupidis, S. A., Fountoulakis, N. K., & Chrousos, G. P. (2021). Self-reported changes in anxiety, depression and suicidality during the COVID-19

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.

lockdown in greece. *Journal of Affective Disorders*, 279, 624-629.

<https://doi.org/10.1016/j.jad.2020.10.061>

Francesco, P., Mauro, M. G., Gianluca, C., & Enrico, M. (2010;1901;). The efficacy of relaxation training in treating anxiety. *International Journal of Behavioral and Consultation Therapy*, 5(3-4), 264-269. <https://doi.org/10.1037/h0100887>

Funahashi, S. (2017). Working memory in the prefrontal cortex. *Brain Sciences*, 7(5), 49.

<https://doi.org/10.3390/brainsci7050049>

Gao, L., Curtiss, J., Liu, X., & Hofmann, S. G. (2018). Differential treatment mechanisms in mindfulness meditation and progressive muscle relaxation. *Mindfulness*, 9(4), 1268-1279. <https://doi.org/10.1007/s12671-017-0869-9>

Gardenswartz, C. A., & Craske, M. G. (2001). Prevention of panic disorder. *Behavior Therapy*, 32(4), 725-737. [https://doi.org/10.1016/S0005-7894\(01\)80017-4](https://doi.org/10.1016/S0005-7894(01)80017-4)

George, D. and Mallery, P. (2010) *SPSS for Windows Step by Step: A Simple Guide and Reference 17.0 Update. 10th Edition*, Pearson, Boston.

Gilpin, A. R. (1993). Table for conversion of kendall'S tau to spearman'S rho within the context of measures of magnitude of effect for meta-analysis. *Educational and Psychological Measurement*, 53(1), 87-92.

<https://doi.org/10.1177/0013164493053001007>

Godinho, A., Schell, C., & Cunningham, J. A. (2020;2019;). Out damn bot, out: Recruiting real people into substance use studies on the internet. *Substance Abuse*, 41(1), 3-5.

<https://doi.org/10.1080/08897077.2019.1691131>

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

- Gorman, J. M. (1996). Comorbid depression and anxiety spectrum disorders. *Depression and Anxiety*, 4(4;2;), 160-168. [https://doi.org/10.1002/\(SICI\)1520-6394\(1996\)4:4<160::AID-DA2>3.0.CO;2-J](https://doi.org/10.1002/(SICI)1520-6394(1996)4:4<160::AID-DA2>3.0.CO;2-J)
- Gostoli, S., Roncuzzi, R., Urbinati, S., & Rafanelli, C. (2017). Clinical and subclinical distress, quality of life, and psychological Well-Being after cardiac rehabilitation. *Applied Psychology : Health and Well-being*, 9(3), 349-369. <https://doi.org/10.1111/aphw.12098>
- Goyal, M., Singh, S., Sibinga, E. M. S., Gould, N. F., Rowland-Seymour, A., Sharma, R., Berger, Z., Sleicher, D., Maron, D. D., Shihab, H. M., Ranasinghe, P. D., Linn, S., Saha, S., Bass, E. B., & Haythornthwaite, J. A. (2014). Meditation programs for psychological stress and well-being: A systematic review and meta-analysis. *JAMA Internal Medicine*, 174(3), 357-368. <https://doi.org/10.1001/jamainternmed.2013.13018>
- Greenhouse, S. W., & Geisser, S. (1959). On methods in the analysis of profile data. *Psychometrika*, 24(2), 95-112. <https://doi.org/10.1007/BF02289823>
- Grenier, S., Prévaille, M., Boyer, R., O'Connor, K., Béland, S. G., Potvin, O., Hudon, C., & Brassard, J. (2011). The Impact of DSM-IV Symptom and Clinical Significance Criteria on the Prevalence Estimates of Subthreshold and Threshold Anxiety in the Older Adult Population. *Am J Geriatr Psychiatry*, 19(4), 316–326. <https://doi.org/10.1097/JGP.0b013e3181ff416c>
- Grosdemange, A., Monfort, V., Richard, S., Toniolo, A., Ducrocq, X., & Bolmont, B. (2015;2014;). Impact of anxiety on verbal and visuospatial working memory in patients with acute stroke without severe cognitive impairment. *Journal of Neurology*,

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

Neurosurgery and Psychiatry, 86(5), 513-519. <https://doi.org/10.1136/jnnp-2014-308232>

Grupe, D. W., & Nitschke, J. B. (2013). Uncertainty and anticipation in anxiety: An integrated neurobiological and psychological perspective. *Nature Reviews*.

Neuroscience, 14(7), 488-501. <https://doi.org/10.1038/nrn3524>

Gujjar, K. R., van Wijk, A., Kumar, R., & de Jongh, A. (2019). Are technology-based interventions effective in reducing dental anxiety in children and adults? A systematic review. *The Journal of Evidence-Based Dental Practice*, 19(2), 140-155.

<https://doi.org/10.1016/j.jebdp.2019.01.009>

Hadwin, J. A., Brogan, J., & Stevenson, J. (2005). State anxiety and working memory in children: A test of processing efficiency theory. *Educational Psychology (Dorchester-on-Thames)*, 25(4), 379-393. <https://doi.org/10.1080/01443410500041607>

Haller, H., Cramer, H., Lauche, R., Gass, F., & Dobos, G. J. (2014). The prevalence and burden of subthreshold generalized anxiety disorder: A systematic review. *BMC Psychiatry*, 14(1), 128-128. <https://doi.org/10.1186/1471-244X-14-128>

Hallion, L. S., Tolin, D. F., Billingsley, A. L., Kusmierski, S. N., & Diefenbach, G. J. (2019). “Cold” cognitive control and attentional symptoms in anxiety: Perceptions versus performance. *Behavior Therapy*, 50(6), 1150-1163.

<https://doi.org/10.1016/j.beth.2019.04.002>

Hanley, J. R., & Bakopoulou, E. (2003). Irrelevant speech, articulatory suppression, and phonological similarity: A test of the phonological loop model and the feature model.

Psychonomic Bulletin & Review, 10(2), 435-444. <https://doi.org/10.3758/BF03196503>

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.

- Hauke, J., & Kossowski, T. (2011). Comparison of values of pearson's and spearman's correlation coefficients on the same sets of data. *Quaestiones Geographicae*, 30(2), 87-93. <https://doi.org/10.2478/v10117-011-0021-1>
- Heinig, I., Wittchen, H., & Knappe, S. (2021). Help-seeking behavior and treatment barriers in anxiety disorders: Results from a representative german community survey. *Community Mental Health Journal*, 57(8), 1505-1517. <https://doi.org/10.1007/s10597-020-00767-5>
- Heller, W., Nitschke, J. B., Etienne, M. A., & Miller, G. A. (1997). Patterns of regional brain activity differentiate types of anxiety. *Journal of Abnormal Psychology (1965)*, 106(3), 376-385. <https://doi.org/10.1037/0021-843X.106.3.376>
- Herring, M. P., Monroe, D. C., Gordon, B. R., & Campbell, M. J. (2018). Acute exercise effects among young adults with subclinical generalized anxiety disorder: Replication and expansion 1078 board #1 may 31 8 00 AM - 10 00 AM. *Medicine and Science in Sports and Exercise*, 50(5S), 249-250. <https://doi.org/10.1249/01.mss.0000535907.33670.95>
- Hester, R. L., Kinsella, G. J., & Ong, B. (2004). Effect of age on forward and backward span tasks. *Journal of the International Neuropsychological Society*, 10(4), 475-481. <https://doi.org/10.1017/S1355617704104037>
- Higo, K., Minamoto, T., Ikeda, T., & Osaka, M. (2014). Robust order representation is required for backward recall in the corsi blocks task. *Frontiers in Psychology*, 5, 1285-1285. <https://doi.org/10.3389/fpsyg.2014.01285>
- Hinz, A., Klein, A. M., Brähler, E., Glaesmer, H., Luck, T., Riedel-Heller, S. G., Wirkner, K., & Hilbert, A. (2016;2017;). Psychometric evaluation of the generalized anxiety

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

disorder screener GAD-7, based on a large German general population sample.

Journal of Affective Disorders, 210, 338-344.

<https://doi.org/10.1016/j.jad.2016.12.012>

Hofmann, S. G., Sawyer, A. T., Witt, A. A., & Oh, D. (2010). The effect of mindfulness-based therapy on anxiety and depression: A meta-analytic review. *Journal of Consulting and Clinical Psychology*, 78(2), 169-183.

<https://doi.org/10.1037/a0018555>

Hovenkamp-Hermelink, J. H. M., Veen, van de, Date C, Oude Voshaar, R. C., Batelaan, N. M., Penninx, Brenda W. H. J, Jeronimus, B. F., Schoevers, R. A., & Riese, H. (2019). Anxiety sensitivity, its stability and longitudinal association with severity of anxiety symptoms. *Scientific Reports*, 9(1), 4314-4314. <https://doi.org/10.1038/s41598-019-39931-7>

Huckvale, K., Prieto, J. T., Tilney, M., Benghozi, P., & Car, J. (2015). Unaddressed privacy risks in accredited health and wellness apps: A cross-sectional systematic assessment. *BMC Medicine*, 13(1), 214-214. <https://doi.org/10.1186/s12916-015-0444-y>

Hugh-Jones, S., Beckett, S., Tumelty, E., & Mallikarjun, P. (2020;2021;). Indicated prevention interventions for anxiety in children and adolescents: A review and meta-analysis of school-based programs. *European Child & Adolescent Psychiatry*, 30(6), 849-860. <https://doi.org/10.1007/s00787-020-01564-x>

Hwang, W. J., & Jo, H. H. (2019). Evaluation of the effectiveness of mobile app-based stress-management program: A randomized controlled trial. *International Journal of Environmental Research and Public Health*, 16(21), 4270.

<https://doi.org/10.3390/ijerph16214270>

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.

- Jaeggi, S. M., Buschkuhl, M., Jonides, J., & Perrig, W. J. (2008). Improving fluid intelligence with training on working memory. *Proceedings of the National Academy of Sciences - PNAS*, *105*(19), 6829-6833. <https://doi.org/10.1073/pnas.0801268105>
- Jefferies, P., & Ungar, M. (2020). Social anxiety in young people: A prevalence study in seven countries. *PloS One*, *15*(9), e0239133-e0239133. <https://doi.org/10.1371/journal.pone.0239133>
- Jin, J., Kim, S., Liu, X., Zhang, H., Zhang, C., Seo, J., Kim, Y., & Sun, T. (2016). miR-17-92 cluster regulates adult hippocampal neurogenesis, anxiety, and depression. *Cell Reports (Cambridge)*, *16*(6), 1653-1663. <https://doi.org/10.1016/j.celrep.2016.06.101>
- Jorm, A. F., Christensen, H., Griffiths, K. M., Parslow, R. A., Rodgers, B., & Blewitt, K. A. (2004). Effectiveness of complementary and self-help treatments for anxiety disorders. *Medical Journal of Australia*, *181*(7), S29-S46. <https://doi.org/10.5694/j.1326-5377.2004.tb06352.x>
- Julian, L. J. (2011). Measures of anxiety: State-Trait anxiety inventory (STAI), beck anxiety inventory (BAI), and hospital anxiety and depression Scale-Anxiety (HADS-A). *Arthritis Care & Research (2010)*, *63*(S11), S467-S472. <https://doi.org/10.1002/acr.20561>
- Kabat-Zinn, J., & Chapman-Waldrop, A. (1988). Compliance with an outpatient stress reduction program: Rates and predictors of program completion. *Journal of Behavioral Medicine*, *11*(4), 333-352. <https://doi.org/10.1007/BF00844934>
- Kalmbach, D. A., Anderson, J. R., & Drake, C. L. (2018). The impact of stress on sleep: Pathogenic sleep reactivity as a vulnerability to insomnia and circadian disorders. *Journal of Sleep Research*, *27*(6), e12710-n/a. <https://doi.org/10.1111/jsr.12710>

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.

- Kasperbauer, T. J., & Wright, D. E. (2020;2019;). Expanded FDA regulation of health and wellness apps. *Bioethics*, 34(3), 235-241. <https://doi.org/10.1111/bioe.12674>
- Kastner-Dorn, A. K., Andreatta, M., Pauli, P., & Wieser, M. J. (2018). Hypervigilance during anxiety and selective attention during fear: Using steady-state visual evoked potentials (ssVEPs) to disentangle attention mechanisms during predictable and unpredictable threat. *Cortex*, 106, 120-131. <https://doi.org/10.1016/j.cortex.2018.05.008>
- Kertz, S., Bigda-Peyton, J., & Bjorgvinsson, T. (2013). Validity of the generalized anxiety disorder-7 scale in an acute psychiatric sample. *Clinical Psychology and Psychotherapy*, 20(5), 456-464. <https://doi.org/10.1002/cpp.1802>
- Kessels, R. P. C., Berg, E. v. d., Ruis, C., & Brands, A. M. A. (2008). The backward span of the corsi block-tapping task and its association with the WAIS-III digit span. *Assessment (Odessa, Fla.)*, 15(4), 426-434. <https://doi.org/10.1177/1073191108315611>
- Kessels, R. P. C., van Zandvoort, Martine J. E, Postma, A., Kappelle, L. J., & de Haan, Edward H. F. (2000). The corsi block-tapping task: Standardization and normative data. *Applied Neuropsychology*, 7(4), 252-258. https://doi.org/10.1207/S15324826AN0704_8
- Khanna, A., Paul, M., & Sandhu, J. S. (2007). A study to compare the effectiveness of GSR biofeedback training and progressive muscle relaxation training in reducing blood pressure and respiratory rate among highly stressed individuals [1]. *Indian Journal of Physiology and Pharmacology*, 51(3), 296-300.

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.

- Khoshhal, K. I., Khairy, G. A., Guraya, S. Y., & Guraya, S. S. (2017). Exam anxiety in the undergraduate medical students of taibah university. *Medical Teacher*, 39(sup1), S22-S26. <https://doi.org/10.1080/0142159X.2016.1254749>
- Korte, K. J., & Schmidt, N. B. (2020). Transdiagnostic preventative intervention for subclinical anxiety: Development and initial validation. *Journal of Psychiatric Research*, 126, 34-42. <https://doi.org/10.1016/j.jpsychires.2020.04.001>
- Kroenke, K., Spitzer, R. L., Williams, J. B. W., Monahan, P. O., & Löwe, B. (2007). Anxiety disorders in primary care: Prevalence, impairment, comorbidity, and detection. *Annals of Internal Medicine*, 146(5), 317-325. <https://doi.org/10.7326/0003-4819-146-5-200703060-00004>
- Krzyzaniak, N., Greenwood, H., Scott, A. M., Peiris, R., Cardona, M., Clark, J., & Glasziou, P. (2021). The effectiveness of telehealth versus face-to face interventions for anxiety disorders: A systematic review and meta-analysis. *Journal of Telemedicine and Telecare*, x, 1357633-1357633X211053738. <https://doi.org/10.1177/1357633X211053738>
- Kuerbis, A., Mulliken, A., Muench, F., A. Moore, A., & Gardner, D. (2017). Older adults and mobile technology: Factors that enhance and inhibit utilization in the context of behavioral health. *Mental Health and Addiction Research*, 2(2)<https://doi.org/10.15761/MHAR.1000136>
- Lancia, S., Cofini, V., Carrieri, M., Ferrari, M., & Quaresima, V. (2018). Are ventrolateral and dorsolateral prefrontal cortices involved in the computerized corsi block-tapping test execution? an fNIRS study. *Neurophotonics (Print)*, 5(1), 011019-011019. <https://doi.org/10.1117/1.NPh.5.1.011019>

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

- LeBreton, J. M., & Senter, J. L. (2008). Answers to 20 questions about interrater reliability and interrater agreement. *Organizational Research Methods, 11*(4), 815-852.
<https://doi.org/10.1177/1094428106296642>
- Lee, B., & Kim, Y. E. (2019). The psychometric properties of the generalized anxiety disorder scale (GAD-7) among korean university students. *Psychiatry and Clinical Psychopharmacology, 29*(4), 864-871.
<https://doi.org/10.1080/24750573.2019.1691320>
- Lee, S. A., Jobe, M. C., Mathis, A. A., & Gibbons, J. A. (2020). Incremental validity of coronaphobia: Coronavirus anxiety explains depression, generalized anxiety, and death anxiety. *Journal of Anxiety Disorders, 74*, 102268-102268.
<https://doi.org/10.1016/j.janxdis.2020.102268>
- LeFevre, J., Fast, L., Skwarchuk, S., Smith-Chant, B. L., Bisanz, J., Kamawar, D., & Penner-Wilger, M. (2010). Pathways to mathematics: Longitudinal predictors of performance. *Child Development, 81*(6), 1753-1767. <https://doi.org/10.1111/j.1467-8624.2010.01508.x>
- Leyro, T. M., Versella, M. V., Yang, M., Brinkman, H. R., Hoyt, D. L., & Lehrer, P. (2021). Respiratory therapy for the treatment of anxiety: Meta-analytic review and regression. *Clinical Psychology Review, 84*, 101980-101980.
<https://doi.org/10.1016/j.cpr.2021.101980>
- Lichstein, K. L., Scogin, F., Thomas, S. J., DiNapoli, E. A., Dillon, H. R., & McFadden, A. (2013). Telehealth cognitive behavior therapy for co-occurring insomnia and depression symptoms in older adults. *Journal of Clinical Psychology, 69*(10), 1056-1065. <https://doi.org/10.1002/jclp.22030>

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.

- Lilienthal, L., Tamez, E., Shelton, J. T., Myerson, J., & Hale, S. (2013). Dual n-back training increases the capacity of the focus of attention. *Psychonomic Bulletin & Review*, 20(1), 135-141. <https://doi.org/10.3758/s13423-012-0335-6>
- Linares, R., Borella, E., Teresa Lechuga, M., Carretti, B., & Pelegrina, S. (2019). Nearest transfer effects of working memory training: A comparison of two programs focused on working memory updating. *PloS One*, 14(2), e0211321-e0211321. <https://doi.org/10.1371/journal.pone.0211321>
- Loftus, E. F., Schooler, J. W., Boone, S. M., & Kline, D. (1987). Time went by so slowly: Overestimation of event duration by males and females. *Applied Cognitive Psychology*, 1(1), 3-13. <https://doi.org/10.1002/acp.2350010103>
- Logie, R. H. (2016). Retiring the central executive. *Quarterly Journal of Experimental Psychology (2006)*, 69(10), 2093-2109. <https://doi.org/10.1080/17470218.2015.1136657>
- Lolak, S., Connors, G. L., Sheridan, M. J., & Wise, T. N. (2008). Effects of progressive muscle relaxation training on anxiety and depression in patients enrolled in an outpatient pulmonary rehabilitation program. *Psychotherapy and Psychosomatics*, 77(2), 119-125. <https://doi.org/10.1159/000112889>
- Lotz, C., & Sparfeldt, J. R. (2017). Does test anxiety increase as the exam draws near? – students' state test anxiety recorded over the course of one semester. *Personality and Individual Differences*, 104, 397-400. <https://doi.org/10.1016/j.paid.2016.08.032>
- Löwe, B., Decker, O., Müller, S., Brähler, E., Schellberg, D., Herzog, W., & Herzberg, P. Y. (2008). Validation and standardization of the generalized anxiety disorder screener

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.

(GAD-7) in the general population. *Medical Care*, 46(3), 266-274.

<https://doi.org/10.1097/MLR.0b013e318160d093>

Lu, C., Chu, W., Madden, S., Parmanto, B., & Silk, J. S. (2021). Adolescent perspectives on how an adjunctive mobile app for social anxiety treatment impacts treatment engagement in telehealth group therapy. *Social Sciences (Basel)*, 10(10), 397.

<https://doi.org/10.3390/socsci10100397>

Luethi, M., Meier, B., & Sandi, C. (2009;2008;). Stress effects on working memory, explicit memory, and implicit memory for neutral and emotional stimuli in healthy men.

Frontiers in Behavioral Neuroscience, 3, 5-5.

<https://doi.org/10.3389/neuro.08.005.2008>

Luria, R., Balaban, H., Awh, E., & Vogel, E. K. (2016). The contralateral delay activity as a neural measure of visual working memory. *Neuroscience and Biobehavioral Reviews*, 62, 100-108. <https://doi.org/10.1016/j.neubiorev.2016.01.003>

Ma, X., Yue, Z., Gong, Z., Zhang, H., Duan, N., Shi, Y., Wei, G., & Li, Y. (2017). The effect of diaphragmatic breathing on attention, negative affect and stress in healthy adults.

Frontiers in Psychology, 8, 874-874. <https://doi.org/10.3389/fpsyg.2017.00874>

Mackay, G. J., & Neill, J. T. (2010). The effect of “green exercise” on state anxiety and the role of exercise duration, intensity, and greenness: A quasi-experimental study.

Psychology of Sport and Exercise, 11(3), 238-245.

<https://doi.org/10.1016/j.psychsport.2010.01.002>

Magnussen, S., Greenlee, M. W., Asplund, R., & Dyrnes, S. (1991). Stimulus-specific mechanisms of visual short-term memory. *Vision research*, 31(7-8), 1213–1219.

[https://doi-org.libaccess.hud.ac.uk/10.1016/0042-6989\(91\)90046-8](https://doi-org.libaccess.hud.ac.uk/10.1016/0042-6989(91)90046-8)

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

- Mandigout, S., Perrochon, A., Fernandez, L., Rezzoug, N., Encelle, B., Kanellos, I., Ricard, D., Bouet, M., Shneider, M., & Buffat, S. (2020). A multidimensional data acquisition as a preliminary step to the secondary prevention of the loss of autonomy for patients with traumatic injury and stroke: An AMISIA pilot study. *Ingénierie Et Recherche Biomédicale*, 41(6), 316-320. <https://doi.org/10.1016/j.irbm.2020.06.010>
- Manzoni, G. M., Pagnini, F., Castelnuovo, G., & Molinari, E. (2008). Relaxation training for anxiety: A ten-years systematic review with meta-analysis. *BMC Psychiatry*, 8(1), 41-41. <https://doi.org/10.1186/1471-244X-8-41>
- Matsuo, E., Matsubara, S., Shiga, S., & Yamanaka, K. (2015). Relationships between psychophysiological responses to cycling exercise and post-exercise self-efficacy. *Frontiers in Psychology*, 6, 1775-1775. <https://doi.org/10.3389/fpsyg.2015.01775>
- McAuley, J. D., Stewart, A. L., Webber, E. S., Cromwell, H. C., Servatius, R. J., & Pang, K. C. H. (2009). Wistar–Kyoto rats as an animal model of anxiety vulnerability: Support for a hypervigilance hypothesis. *Behavioural Brain Research*, 204(1), 162-168. <https://doi.org/10.1016/j.bbr.2009.05.036>
- McLean, C. P., Asnaani, A., Litz, B. T., & Hofmann, S. G. (2011). Gender differences in anxiety disorders: Prevalence, course of illness, comorbidity and burden of illness. *Journal of Psychiatric Research*, 45(8), 1027-1035. <https://doi.org/10.1016/j.jpsychires.2011.03.006>
- McLean, S. C., & McKinstry, B. (2012). Meta-analysis on COPD: Comment on ‘Home telehealth for chronic obstructive pulmonary disease: A systematic review and meta-analysis. by J polisena et al.’. *Journal of Telemedicine and Telecare*, 18(4), 242-242. <https://doi.org/10.1258/jtt.2012.110005>

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

- McManus, S., Bebbington, P. E., Jenkins, R., & Brugha, T. (2016). *Mental health and wellbeing in england: The adult psychiatric morbidity survey 2014*. NHS Digital.
- McNeill, I. M., Dunlop, P. D., Skinner, T. C., & Morrison, D. L. (2016). Predicting risk-mitigating behaviors from indecisiveness and trait anxiety: Two cognitive pathways to task avoidance. *Journal of Personality, 84*(1), 36-45.
<https://doi.org/10.1111/jopy.12135>
- Melby-Lervåg, M., Redick, T. S., & Hulme, C. (2016). Working memory training does not improve performance on measures of intelligence or other measures of “Far transfer”: Evidence from a meta-analytic review. *Perspectives on Psychological Science, 11*(4), 512-534. <https://doi.org/10.1177/17456916166635612>
- Merakou, K., Tsoukas, K., Stavrinou, G., Amanaki, E., Daleziou, A., Kourmoussi, N., Stamatelopoulou, G., Spourdalaki, E., & Barbouni, A. (2019). The effect of progressive muscle relaxation on emotional competence: Depression–Anxiety–Stress, sense of coherence, health-related quality of life, and well-being of unemployed people in greece: An intervention study. *Explore (New York, N.Y.), 15*(1), 38-46.
<https://doi.org/10.1016/j.explore.2018.08.001>
- Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 63*(2), 81-97.
<https://doi.org/10.1037/h0043158>
- Minen, M. T., Adhikari, S., Padikkala, J., Tasneem, S., Bagheri, A., Goldberg, E., Powers, S., & Lipton, R. B. (2020). Smartphone-Delivered progressive muscle relaxation for the treatment of migraine in primary care: A randomized controlled trial. *Headache, 60*(10), 2232-2246. <https://doi.org/10.1111/head.14010>

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

Monaco, M., Costa, A., Caltagirone, C., & Carlesimo, G. A. (2015). Erratum to: Forward and backward span for verbal and visuo-spatial data: Standardization and normative data from an Italian adult population. *Neurological Sciences*, *36*(2), 345-347.

<https://doi.org/10.1007/s10072-014-2019-7>

Moran, T. P. (2016). Anxiety and working memory capacity: A meta-analysis and narrative review. *Psychological Bulletin*, *142*(8), 831-864. <https://doi.org/10.1037/bul0000051>

Moriya, J. (2020). Interactive effects of trait and state anxiety on visual spatial working memory capacity. *Psychologia*, , 2020-B003. <https://doi.org/10.2117/psysoc.2020-B003>

Munafò, M. R., & Stevenson, J. (2001). Anxiety and surgical recovery: Reinterpreting the literature. *Journal of Psychosomatic Research*, *51*(4), 589-596.

[https://doi.org/10.1016/S0022-3999\(01\)00258-6](https://doi.org/10.1016/S0022-3999(01)00258-6)

Muñoz-Navarro, R., Cano-Vindel, A., Moriana, J. A., Adrián Medrano, L., Ruíz-Rodríguez, P., Agüero, L., Rodríguez-Enríquez, M., Pizà, M. R., & Ramírez-Manent, I. (2017). Screening for generalized anxiety disorder in Spanish primary care centers with the GAD-7. *Psychiatry Research*, *256*, 312-317.

<https://doi.org/10.1016/j.psychres.2017.06.023>

Mushtaq, B., Khan, A. A. (2018). Jacobson muscle relaxation technique (jpmr) (20 min).

JOJ Nursing & Health Care, *8*(1) <https://doi.org/10.19080/JOJNHC.2017.08.555726>

Nees, M., & Leong, P. (2018). Articulatory suppression impairs working memory for ostensibly unvocalizable abstract sounds. *Auditory Perception & Cognition*, *1*(1-2), 131-147. <https://doi.org/10.1080/25742442.2018.1534195>

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.

- Nemes, V. A., Whitaker, D., Heron, J., & McKeefry, D. J. (2011). Multiple spatial frequency channels in human visual perceptual memory. *Vision Research (Oxford)*, *51*(23), 2331-2339. <https://doi.org/10.1016/j.visres.2011.09.003>
- Ng, E., & Lee, K. (2015). Effects of trait test anxiety and state anxiety on children's working memory task performance. *Learning and Individual Differences*, *40*, 141-148. <https://doi.org/10.1016/j.lindif.2015.04.007>
- Niemeijer, M., Sværke, K. W., & Christensen, H. K. (2020). The effects of computer based cognitive rehabilitation in stroke patients with working memory impairment: A systematic review. *Journal of Stroke and Cerebrovascular Diseases*, *29*(12), 105265-105265. <https://doi.org/10.1016/j.jstrokecerebrovasdis.2020.105265>
- Nitschke, J. B., Heller, W., Palmieri, P. A., & Miller, G. A. (1999). Contrasting patterns of brain activity in anxious apprehension and anxious arousal. *Psychophysiology*, *36*(5), 628-637. <https://doi.org/10.1017/S0048577299972013>
- Norton, P. J. (2008). An open trial of a transdiagnostic cognitive-behavioral group therapy for anxiety disorder. *Behavior Therapy*, *39*(3), 242-250. <https://doi.org/10.1016/j.beth.2007.08.002>
- Novais, P. G. N., Batista, K. d. M., Grazziano, E. d. S., & Amorim, M. H. C. (2016). The effects of progressive muscular relaxation as a nursing procedure used for those who suffer from stress due to multiple sclerosis. *Revista Latino-Americana De Enfermagem*, *24*, e2789-e2789. <https://doi.org/10.1590/1518-8345.1257.2789>
- Offergeld, T., Martinez, L. F., & Ferreira, A. I. (2020). A train of thought in product experientiality: Working memory, distraction, and inconsistencies in cue order effects.

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

Journal of Retailing and Consumer Services, 53, 101971.

<https://doi.org/10.1016/j.jretconser.2019.101971>

Olatunji, B. O., & Wolitzky-Taylor, K. B. (2009). Anxiety sensitivity and the anxiety disorders: A meta-analytic review and synthesis. *Psychological Bulletin*, 135(6), 974-999. <https://doi.org/10.1037/a0017428>

Orrù, G., Bertelloni, D., Diolaiuti, F., Conversano, C., Ciacchini, R., & Gemignani, A. (2021). A psychometric examination of the coronavirus anxiety scale and the fear of coronavirus disease 2019 scale in the Italian population. *Frontiers in Psychology*, 12, 669384-669384. <https://doi.org/10.3389/fpsyg.2021.669384>

Otto, M. W., Eastman, A., Lo, S., Hearon, B. A., Bickel, W. K., Zvolensky, M., Smits, J. A. J., & Doan, S. N. (2016). Anxiety sensitivity and working memory capacity: Risk factors and targets for health behavior promotion. *Clinical Psychology Review*, 49, 67-78. <https://doi.org/10.1016/j.cpr.2016.07.003>

Owen, A. M. (2000). The role of the lateral frontal cortex in mnemonic processing: The contribution of functional neuroimaging. *Experimental Brain Research*, 133(1), 33-43. <https://doi.org/10.1007/s002210000398>

Owens, M., Koster, E. H. W., & Derakshan, N. (2013). Improving attention control in dysphoria through cognitive training: Transfer effects on working memory capacity and filtering efficiency. *Psychophysiology*, 50(3), 297-307. <https://doi.org/10.1111/psyp.12010>

Özpelit, M. E., Özpelit, E., Doğan, N. B., Pekel, N., Ozyurtlu, F., Yılmaz, A., Saygı, S., Tengiz, İ., & Ercan, E. (2015). Impact of anxiety level on circadian rhythm of blood

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.

- pressure in hypertensive patients. *International Journal of Clinical and Experimental Medicine*, 8(9), 16252-16258.
- Pacheco-Unguetti, A. P., Acosta, A., Callejas, A., & Lupiáñez, J. (2010). Attention and anxiety: Different attentional functioning under state and trait anxiety. *Psychological Science*, 21(2), 298-304. <https://doi.org/10.1177/0956797609359624>
- Pailian, H., Simons, D. J., Wetherhold, J., & Halberda, J. (2020). Using the flicker task to estimate visual working memory storage capacity. *Attention, Perception & Psychophysics*, 82(3), 1271-1289. <https://doi.org/10.3758/s13414-019-01809-1>
- Pan, L., Zhang, J., & Li, L. (2012). Effects of progressive muscle relaxation training on anxiety and quality of life of inpatients with ectopic pregnancy receiving methotrexate treatment. *Research in Nursing & Health*, 35(4), 376-382. <https://doi.org/10.1002/nur.21486>
- Parkerson, H. A., Thibodeau, M. A., Brandt, C. P., Zvolensky, M. J., & Asmundson, G. J. G. (2015). Cultural-based biases of the GAD-7. *Journal of Anxiety Disorders*, 31, 38-42. <https://doi.org/10.1016/j.janxdis.2015.01.005>
- Passolunghi, M. C., Caviola, S., De Agostini, R., Perin, C., & Mammarella, I. C. (2016). Mathematics anxiety, working memory, and mathematics performance in secondary-school children. *Frontiers in Psychology*, 7, 1-8. <https://doi.org/10.3389/fpsyg.2016.00042>
- Pawlow, L. A., & Jones, G. E. (2005). The impact of abbreviated progressive muscle relaxation on salivary cortisol and salivary immunoglobulin A (sIgA). *Applied Psychophysiology and Biofeedback*, 30(4), 375-387. <https://doi.org/10.1007/s10484-005-8423-2>

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

Pinnock, H., & McKinstry, B. (2018). TeleHealth for chronic obstructive pulmonary disease:

Promises, populations, and personalized care. *American Journal of Respiratory and Critical Care Medicine*, 198(5), 552-554. <https://doi.org/10.1164/rccm.201803-0560ED>

Plummer, F., M.Sc, Manea, Laura, M.D., M.Sc., M.R.C.Psych, Trepel, D., Ph.D, &

McMillan, Dean, M.A., Ph.D., D.Clin.Psy. (2015;2016;). Screening for anxiety disorders with the GAD-7 and GAD-2: A systematic review and diagnostic metaanalysis. *General Hospital Psychiatry*, 39, 24-31.

<https://doi.org/10.1016/j.genhosppsy.2015.11.005>

Pozzar, R., Hammer, M. J., Underhill-Blazey, M., Wright, A. A., Tulsy, J. A., Hong, F.,

Gundersen, D. A., & Berry, D. L. (2020). Threats of bots and other bad actors to data quality following research participant recruitment through social media: Cross-sectional questionnaire. *Journal of Medical Internet Research*, 22(10), e23021-e23021. <https://doi.org/10.2196/23021>

Qi, S., Chen, J., Hitchman, G., Zeng, Q., Ding, C., Li, H., & Hu, W. (2014). Reduced

representations capacity in visual working memory in trait anxiety. *Biological Psychology*, 103, 92-99. <https://doi.org/10.1016/j.biopsycho.2014.08.010>

Ramasamy, S., Panneerselvam, S., Govindharaj, P., Kumar, A., & Nayak, R. (2018).

Progressive muscle relaxation technique on anxiety and depression among persons affected by leprosy. *Journal of Exercise Rehabilitation*, 14(3), 375-381.

<https://doi.org/10.12965/jer.1836158.079>

Rausch, S. M., Gramling, S. E., & Auerbach, S. M. (2006). Effects of a single session of

large-group meditation and progressive muscle relaxation training on stress reduction,

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

reactivity, and recovery. *International Journal of Stress Management*, 13(3), 273-290.

<https://doi.org/10.1037/1072-5245.13.3.273>

Razali, N. M., & Wah, Y. B. (2011). Power comparisons of Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors and Anderson-Darling tests. *Journal of Statistical Modeling and Analytics*, 2(1), 21-33.

Robinson, O. J., Vytal, K., Cornwell, B. R., & Grillon, C. (2013). The impact of anxiety upon cognition: Perspectives from human threat of shock studies. *Frontiers in Human Neuroscience*, 7, 203-203. <https://doi.org/10.3389/fnhum.2013.00203>

Robinson, S. J., Sünram-Lea, S. I., Leach, J., & Owen-Lynch, P. J. (2008;2007;). The effects of exposure to an acute naturalistic stressor on working memory, state anxiety and salivary cortisol concentrations. *Stress (Amsterdam, Netherlands)*, 11(2), 115-124. <https://doi.org/10.1080/10253890701559970>

Roche, L. T., & Hesse, B. M. (2014). Application of an integrative yoga therapy programme in cases of essential arterial hypertension in public healthcare. *Complementary Therapies in Clinical Practice*, 20(4), 285-290. <https://doi.org/10.1016/j.ctcp.2014.10.004>

Roche, L. T., Barrachina, M. T. M., & Fernandez, I. I. (2016). Effect of 'Exercise without movement' yoga method on mindfulness, anxiety and depression. *Complementary Therapies in Clinical Practice*, 25, 136-141. <https://doi.org/10.1016/j.ctcp.2016.09.008>

Roness, A., Mykletun, A., & Dahl, A. A. (2005). Help-seeking behaviour in patients with anxiety disorder and depression. *Acta Psychiatrica Scandinavica*, 111(1), 51-58. <https://doi.org/10.1111/j.1600-0447.2004.00433.x>

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.

Rucci, P., Gherardi, S., Tansella, M., Piccinelli, M., Berardi, D., Bisoffi, G., Corsino, M. A., & Pini, S. (2003). Subthreshold psychiatric disorders in primary care: Prevalence and associated characteristics. *Journal of Affective Disorders*, 76(1), 171-181.

[https://doi.org/10.1016/S0165-0327\(02\)00087-3](https://doi.org/10.1016/S0165-0327(02)00087-3)

Rudenshine, S., McNeal, K., Schulder, T., Ettman, C. K., Hernandez, M., Gvozdieva, K., & Galea, S. (2021). Depression and anxiety during the COVID-19 pandemic in an urban, Low-Income public university sample. *Journal of Traumatic Stress*, 34(1), 12-

22. <https://doi.org/10.1002/jts.22600>

Ruiz, M. A., Zamorano, E., García-Campayo, J., Pardo, A., Freire, O., & Rejas, J. (2010;2011;). Validity of the GAD-7 scale as an outcome measure of disability in patients with generalized anxiety disorders in primary care. *Journal of Affective Disorders*, 128(3), 277-286. <https://doi.org/10.1016/j.jad.2010.07.010>

Salari, M., Zali, A., Ashrafi, F., Etemadifar, M., Sharma, S., Hajizadeh, N., & Ashourizadeh, H. (2020). Incidence of anxiety in parkinson's disease during the coronavirus disease (COVID-19) pandemic. *Movement Disorders*, 35(7), 1095-1096.

<https://doi.org/10.1002/mds.28116>

Sari, B. A., Koster, E. H. W., & Derakshan, N. (2017). The effects of active worrying on working memory capacity. *Cognition and Emotion*, 31(5), 995-1003.

<https://doi.org/10.1080/02699931.2016.1170668>

Scharfen, J., Jansen, K., & Holling, H. (2018). Retest effects in working memory capacity tests: A meta-analysis. *Psychonomic Bulletin & Review*, 25(6), 2175-2199.

<https://doi.org/10.3758/s13423-018-1461-6>

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.

- Sheu, S., Irvin, B. L., Lin, H., & Mar, C. (2003). Effects of progressive muscle relaxation on blood pressure and psychosocial status for clients with essential hypertension in taiwan. *Holistic Nursing Practice*, 17(1), 41-47. <https://doi.org/10.1097/00004650-200301000-00009>
- Shimave, S., Cerkez, Y., & Baysen, E. (2020). An empirical study on the relationship between causes of teacher examination anxiety and dimensions of coping with pre-exam anxiety: A structural equation modelling approach. *Psychologica Belgica*, 60(1), 255-269. <https://doi.org/10.5334/PB.536>
- Silva, M. T., Caicedo Roa, M., Martins, S. S., da Silva, Andréa Tenório Correia, & Galvao, T. F. (2018). Generalized anxiety disorder and associated factors in adults in the amazon, brazil: A population-based study. *Journal of Affective Disorders*, 236, 180-186. <https://doi.org/10.1016/j.jad.2018.04.079>
- Silver, N. C., & Dunlap, W. P. (1987). Averaging correlation coefficients: Should fisher's z transformation be used? *Journal of Applied Psychology*, 72(1), 146-148. <https://doi.org/10.1037/0021-9010.72.1.146>
- Smith, D. T., Casteau, S., & Archibald, N. (2021). Spatial attention and spatial short term memory in PSP and parkinson's disease. *Cortex*, 137, 49-60. <https://doi.org/10.1016/j.cortex.2020.12.019>
- Smits, J. A. J., Berry, A. C., Rosenfield, D., Powers, M. B., Behar, E., & Otto, M. W. (2008). Reducing anxiety sensitivity with exercise. *Depression and Anxiety*, 25(8;2;), 689-699. <https://doi.org/10.1002/da.20411>
- Smyth, M. M., & Scholey, K. A. (1994). Interference in immediate spatial memory. *Memory & Cognition*, 22(1), 1-13. <https://doi.org/10.3758/BF03202756>

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

- Somers, J. M., Goldner, E. M., Waraich, P., & Hsu, L. (2006). *Prevalence and incidence studies of anxiety disorders: A systematic review of the literature*. SAGE Publications. <https://doi.org/10.1177/070674370605100206>
- Song, Y., & Lindquist, R. (2015). Effects of mindfulness-based stress reduction on depression, anxiety, stress and mindfulness in Korean nursing students. *Nurse Education Today*, 35(1), 86-90. <https://doi.org/10.1016/j.nedt.2014.06.010>
- Spadola, C. E., Rottapel, R., Khandpur, N., Kontos, E., Bertisch, S. M., Johnson, D. A., Quante, M., Khalsa, S. B. S., Saper, R. B., & Redline, S. (2017). Enhancing yoga participation: A qualitative investigation of barriers and facilitators to yoga among predominantly racial/ethnic minority, low-income adults. *Complementary Therapies in Clinical Practice*, 29, 97-104. <https://doi.org/10.1016/j.ctcp.2017.09.001>
- Spence, D. (2020). Isolated already, how COVID-19 has exacerbated anxiety for Australian cancer patients. *Psycho-Oncology (Chichester, England)*, 29(9), 1427-1429. <https://doi.org/10.1002/pon.5478>
- Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the State-Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychologists Press.
- Spitzer, R. L., Kroenke, K., Williams, J. B. W., & Löwe, B. (2006). A brief measure for assessing generalized anxiety disorder: The GAD-7. *Archives of Internal Medicine (1960)*, 166(10), 1092-1097. <https://doi.org/10.1001/archinte.166.10.1092>
- Stahl, S. M., Ahmed, S., & Haudiquet, V. (2007). Analysis of the rate of improvement of specific psychic and somatic symptoms of general anxiety disorder during long-term treatment with venlafaxine ER. *CNS Spectrums*, 12(9), 703-711. <https://doi.org/10.1017/S1092852900021544>

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

- Stein, M. B., Sherbourne, C. D., Craske, M. G., Means-Christensen, A., Bystritsky, A., Katon, W., Sullivan, G., & Roy-Byrne, P. P. (2004). Quality of care for primary care patients with anxiety disorders. *The American Journal of Psychiatry*, *161*(12), 2230-2237. <https://doi.org/10.1176/appi.ajp.161.12.2230>
- Stevens, S. E., Hynan, M. T., Allen, M., Braun, M. M., & McCart, M. R. (2007). Are complex psychotherapies more effective than biofeedback, progressive muscle relaxation, or both? A meta-analysis. *Psychological Reports*, *100*(1), 303-324. <https://doi.org/10.2466/pr0.100.1.303-324>
- Stoffers, D., Berendse, H. W., Deijen, J. B., & Wolters, E. C. (2003). Deficits on corsi's block-tapping task in early stage parkinson's disease. *Parkinsonism & Related Disorders*, *10*(2), 107-111. [https://doi.org/10.1016/S1353-8020\(03\)00106-8](https://doi.org/10.1016/S1353-8020(03)00106-8)
- Stout, D. M., Shackman, A. J., & Larson, C. L. (2013). Failure to filter: Anxious individuals show inefficient gating of threat from working memory. *Frontiers in Human Neuroscience*, *7*, 58-58. <https://doi.org/10.3389/fnhum.2013.00058>
- Tahmassian, K., & Moghadam, N. J. (2011). Relationship between self-efficacy and symptoms of anxiety, depression, worry and social avoidance in a normal sample of students. *Iranian Journal of Psychiatry and Behavioral Sciences*, *5*(2), 91-98.
- Tao, M., Yang, D., & Liu, W. (2019). Learning effect and its prediction for cognitive tests used in studies on indoor environmental quality. *Energy and Buildings*, *197*, 87-98. <https://doi.org/10.1016/j.enbuild.2019.05.044>
- Tempesta, D., Mazza, M., Serroni, N., Moschetta, F. S., Di Giannantonio, M., Ferrara, M., & De Berardis, D. (2013). Neuropsychological functioning in young subjects with generalized anxiety disorder with and without pharmacotherapy. *Progress in Neuro-*

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.

Psychopharmacology & Biological Psychiatry, 45, 236-241.

<https://doi.org/10.1016/j.pnpbp.2013.06.006>

Teymoori, A., Real, R., Gorbunova, A., Haghish, E. F., Andelic, N., Wilson, L., Asendorf, T., Menon, D., & von Steinbüchel, N. (2020). Measurement invariance of assessments of depression (PHQ-9) and anxiety (GAD-7) across sex, strata and linguistic backgrounds in a european-wide sample of patients after traumatic brain injury.

Journal of Affective Disorders, 262, 278-285.

<https://doi.org/10.1016/j.jad.2019.10.035>

The Newcastle upon Tyne Hospitals NHS Foundation Trust. (March 2014). *Progressive Muscle Relaxation - Female Voice*. Youtube,

<https://www.youtube.com/watch?v=912eRrbes2g>.

Toussaint, A., Hüsing, P., Gumz, A., Wingenfeld, K., Härter, M., Schramm, E., & Löwe, B. (2020). Sensitivity to change and minimal clinically important difference of the 7-item generalized anxiety disorder questionnaire (GAD-7). *Journal of Affective Disorders*, 265, 395-401.

<https://doi.org/10.1016/j.jad.2020.01.032>

Tsitsi, T., Charalambous, A., Papastavrou, E., & Raftopoulos, V. (2016;2017;). Effectiveness of a relaxation intervention (progressive muscle relaxation and guided imagery techniques) to reduce anxiety and improve mood of parents of hospitalized children with malignancies: A randomized controlled trial in republic of cyprus and greece.

European Journal of Oncology Nursing : The Official Journal of European Oncology Nursing Society, 26, 9-18. <https://doi.org/10.1016/j.ejon.2016.10.007>

Twenge, J. M., Gentile, B., DeWall, C. N., Ma, D., Lacefield, K., & Schurtz, D. R. (2010).

Birth cohort increases in psychopathology among young americans, 1938–2007: A

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.

- cross-temporal meta-analysis of the MMPI. *Clinical Psychology Review*, 30(2), 145-154. <https://doi.org/10.1016/j.cpr.2009.10.005>
- Tyndall, I. T., Howe, B. E., & Roche, B. T. (2016). Exposure to progressive muscle relaxation leads to enhanced performance on derived relational responding tasks. *The Psychological Record*, 66(2), 213-222. <https://doi.org/10.1007/s40732-016-0163-6>
- Uno, H., Tarara, R., Else, J., Suleman, M., & Sapolsky, R. (1989). Hippocampal damage associated with prolonged and fatal stress in primates. *The Journal of Neuroscience*, 9(5), 1705-1711. <https://doi.org/10.1523/jneurosci.09-05-01705.1989>
- Unterrainer, J. M., Domschke, K., Rahm, B., Wiltink, J., Schulz, A., Pfeiffer, N., Lackner, K. J., Münzel, T., Wild, P. S., & Beutel, M. (2018). Subclinical levels of anxiety but not depression are associated with planning performance in a large population-based sample. *Psychological Medicine*, 48(1), 168-174. <https://doi.org/10.1017/S0033291717002562>
- van Ballegooijen, W., Cuijpers, P., van Straten, A., Karyotaki, E., Andersson, G., Smit, J. H., & Riper, H. (2014). Adherence to internet-based and face-to-face cognitive behavioural therapy for depression: A meta-analysis. *PloS One*, 9(7), e100674-e100674. <https://doi.org/10.1371/journal.pone.0100674>
- Vandierendonck, A., Kemps, E., Fastame, M. C., & Szmalec, A. (2004). Working memory components of the corsi blocks task. *The British Journal of Psychology*, 95(1), 57-79. <https://doi.org/10.1348/000712604322779460>
- Vroman, K. G., Arthanat, S., & Lysack, C. (2015). "Who over 65 is online?" older adults' dispositions toward information communication technology. *Computers in Human Behavior*, 43, 156-166. <https://doi.org/10.1016/j.chb.2014.10.018>

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

- Vytal, K. E., Arkin, N. E., Overstreet, C., Lieberman, L., & Grillon, C. (2016). Induced-anxiety differentially disrupts working memory in generalized anxiety disorder. *BMC Psychiatry*, *16*(61), 62-62. <https://doi.org/10.1186/s12888-016-0748-2>
- Wadsworth, E. J. K., Moss, S. C., Simpson, S. A., & Smith, A. P. (2005). SSRIs and cognitive performance in a working sample. *Human Psychopharmacology*, *20*(8), 561-572. <https://doi.org/10.1002/hup.725>
- Waechter, S., & Stolz, J. A. (2015). Trait anxiety, state anxiety, and attentional bias to threat: Assessing the psychometric properties of response time measures. *Cognitive Therapy and Research*, *39*(4), 441-458. <https://doi.org/10.1007/s10608-015-9670-z>
- Wakode, N., Wakode, S., & Santoshi, J. (2020;2021;). Perceived stress and generalized anxiety in the indian population due to lockdown during the COVID-19 pandemic: A cross-sectional study. *F1000 Research*, *9*, 1233-1233. <https://doi.org/10.12688/f1000research.26371.3>
- Walker, D. A. (2003). JMASM9: Converting kendall's tau for correlational or meta-analytic analyses. *Journal of Modern Applied Statistical Methods*, *2*(2), 525-530. <https://doi.org/10.22237/jmasm/1067646360>
- Ward, R. T., Lotfi, S., Sallmann, H., Lee, H., & Larson, C. L. (2020). State anxiety reduces working memory capacity but does not impact filtering cost for neutral distracters. *Psychophysiology*, *57*(10), e13625-n/a. <https://doi.org/10.1111/psyp.13625>
- Ware, J. E., Jr. (1999). *SF-36 Health Survey*. In M. E. Maruish (Ed.), *The use of psychological testing for treatment planning and outcomes assessment* (pp. 1227–1246). Lawrence Erlbaum Associates Publishers.

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

Wermes, R., Lincoln, T. M., & Helbig-Lang, S. (2018). Anxious and alert? hypervigilance in social anxiety disorder. *Psychiatry Research*, 269, 740-745.

<https://doi.org/10.1016/j.psychres.2018.08.086>

Westfall, P. H., & Henning, K. S. S. (2013). *Texts in statistical science: Understanding advanced statistical methods*. Taylor & Francis.

Wilde, N. J., Strauss, E., & Tulskey, D. S. (2004). Memory span on the wechsler scales. *Journal of Clinical and Experimental Neuropsychology*, 26(4), 539-549.

<https://doi.org/10.1080/13803390490496605>

Wilke, P. K., Gmelch, W. H., & Lovrich, N. P. (1985). Stress and productivity: Evidence of the inverted U function. *Public Productivity Review*, 9(4), 342-356.

<https://doi.org/10.2307/3379944>

Wilver, N. L., & Cogle, J. R. (2019). An internet-based controlled trial of interpretation bias modification versus progressive muscle relaxation for body dysmorphic disorder. *Journal of Consulting and Clinical Psychology*, 87(3), 257-269.

<https://doi.org/10.1037/ccp0000372>

Woolson, R. F. (2008;2007;). In D'Agostino R. B., Sullivan L. and Massaro J.(Eds.), *wilcoxon signed-rank test*. John Wiley & Sons, Inc.

<https://doi.org/10.1002/9780471462422.eoct979>

Xiao, C., Lin, Y., Lin, R., Liu, A., Zhong, G., & Lan, C. (2020). Effects of progressive muscle relaxation training on negative emotions and sleep quality in COVID-19 patients: A clinical observational study. *Medicine (Baltimore)*, 99(47), e23185-e23185. <https://doi.org/10.1097/MD.00000000000023185>

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.

- Xin, Z., Lai, Z., Li, F., & Maes, J. H. R. (2014). Near- and far-transfer effects of working memory updating training in elderly adults. *Applied Cognitive Psychology*, 28(3), 403-408. <https://doi.org/10.1002/acp.3011>
- Yamada, N., Nakadoi, Y., Fukuma, R., & Ohmori, T. (2020). Two children exhibiting social withdrawal, school refusal, and underlying generalized anxiety disorder successfully treated using a selective serotonin reuptake inhibitor. *The Journal of Medical Investigation*, 67(3.4), 355-357. <https://doi.org/10.2152/jmi.67.355>
- Yao, N., Chen, S., & Qian, M. (2018). Trait anxiety is associated with a decreased visual working memory capacity for faces. *Psychiatry Research*, 270, 474-482. <https://doi.org/10.1016/j.psychres.2018.10.018>
- Yates, D., Moore, D., & McCabe, G. (1999). *The Practice of Statistics*. New York: Freeman.
- Yerkes, R. M. & Dodson, J. D. (1908). The relationship of strength of stimulus to rapidity of habit formation. *Journal of Comparative Neurology and Psychology*, 18, 459–482.
- Yoshihara, K., Hiramoto, T., Sudo, N., & Kubo, C. (2011). Profile of mood states and stress-related biochemical indices in long-term yoga practitioners. *BioPsychoSocial Medicine*, 5(1), 6-6. <https://doi.org/10.1186/1751-0759-5-6>
- Zachar-Tirado, C. N., & Donders, J. (2021). Clinical utility of the GAD-7 in identifying anxiety disorders after traumatic brain injury. *Brain Injury*, 35(6), 655-660. <https://doi.org/10.1080/02699052.2021.1895315>
- Zainal, N. H., & Newman, M. G. (2018). Executive function and other cognitive deficits are distal risk factors of generalized anxiety disorder 9 years later. *Psychological Medicine*, 48(12), 2045-2053. <https://doi.org/10.1017/S0033291717003579>

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- Zargarzadeh, M., & Shirazi, M. (2014). The effect of progressive muscle relaxation method on test anxiety in nursing students. *Iranian Journal of Nursing and Midwifery Research*, 19(6), 607-612.
- Zhao, L., Wu, H., Zhou, X., Wang, Q., Zhu, W., & Chen, J. (2012). Effects of progressive muscular relaxation training on anxiety, depression and quality of life of endometriosis patients under gonadotrophin-releasing hormone agonist therapy. *European Journal of Obstetrics & Gynecology and Reproductive Biology*, 162(2), 211-215. <https://doi.org/10.1016/j.ejogrb.2012.02.029>
- Zimmerman, D. W., & Zumbo, B. D. (1993). Relative power of the Wilcoxon test, the Friedman test, and repeated-measures ANOVA on ranks. *The Journal of Experimental Education*, 62(1), 75-86.

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Appendix A

Baseline questionnaire

This appendix consists of the digital questionnaire participants were provided at the Baseline stage of the experiment. The appendix has been downloaded directly from Qualtrics, which preserves the logic (the condition a participant must meet in order to discern what response they will receive) of the questionnaire. Page breaks have been truncated to reduce the number of pages and the question number presented do not represent when the questions were presented.

Start of Block: Information sheet

Q1 Information Sheet – Version 1 Title: Investigating the impact of non-pharmaceutical interventions on anxiety and subsequent working memory function. Thank you for considering taking part in this study. It is vital that you understand what will be asked of you as well as how your data will be used if you decide to participate in this study. Please read the following document carefully and if there is any confusion do not hesitate to ask for clarification. The research administrator can be reached at Wesley.Harmer@hud.ac.uk.

The purpose of the study

You are invited to participate in this study and help further the understanding of non-pharmaceutical anxiety interventions. Anxiety is present in our daily lives and has an impact on our mental and physical health. The intention of this study is to investigate the effectiveness of simple non-prescribed interventions for non-clinical anxieties. By focusing on remedies which are easily completed at home

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.

and do not require a professional diagnosis, we hope to assess the effectiveness of remedies that seek to improve the wellbeing of the general population.

Who can participate? The study is open to everyone **over** the age of 18. Participants must be fluent in English and have **no** clinical diagnosis related to anxiety. The study also requires the use of a **PC or laptop** due to the coding of the tasks.

What do I get if I participate?

You will help investigate the effectiveness of anxiety interventions which will add to the research into anxiety treatments. In addition, you will be entered in a **raffle with the chance to win one of 20 £10 Amazon gift vouchers**. To enter, you must complete the entire study and then after all the results are collected, the winners will be email. If you have any queries regarding the raffle, please email the research administrator (wesley.harmer@hud.ac.uk).

What we need from you This study will be a **longitudinal study**. That means it will last a period of **six weeks** from your initial sign up. Firstly, you will be asked to complete a survey to collect background information. After this, you will complete a **short quiz** regarding your anxiety that should not take more than **5 minutes** to fill out. An example of a question that will be asked is “do you have trouble relaxing?”. You will then be asked to complete a **memory task** called the **Reverse Corsi Block task**. This will involve memorising a short sequence of patterns of blocks then repeating the sequence back. It should not take longer than **20 minutes** to complete and instructions are provided prior to starting. Every participant will be asked to complete both tasks **once every two weeks**, which will total to completing the tasks **4 times** (including the baseline) over a **6-week period**. You will be given all the necessary information as you proceed in the study. **Note, to enter the raffle you must participate in the study for the full 6-week period.** If you are placed in the **control group** this is all that you will be asked to do. However, if you are placed in one of the experimental groups you will be asked to conduct a short anxiety relief intervention **three times a week**. The interventions are Progressive Muscle Relaxation and Diaphragmatic Breathing Techniques. These interventions will only take **20 minutes** at most to complete. You will be placed into a group randomly and you will

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receive instructions for how to complete the intervention prior to the taking them via email. We will require an email address to send you information regarding the study, this will be secured via a password protected document and it will not be used for commercial purposes. **All** emails pertaining to this study will be from the researcher administrator's email address (**wesley.harmer@hud.ac.uk**) and no additional personal data will be asked for over email. If you believe there is an issue with the emails you are receiving please contact one of the research supervisors (**g.hallam@hud.ac.uk** or **j.retzler@hud.ac.uk**).

Who will be conducting the experiment and who will see the data? I am a Masters student from The University of Huddersfield and I will be conducting the research independently, with oversight provided by certified researcher supervisors. The data in its raw form will only be visible to me and potentially members of staff at The University of Huddersfield.

Do I have to participate? **No.** The consent form is **not** a legally binding contract. You are free to withdraw whenever you like. After the study is finished, you can request to have your results removed for up to a week after the completion of the study and this right will be reaffirmed at the end of the study. You do not need a reason to withdraw nor will anyone ask you for one. If you stop completing the tasks but do not **formally withdraw** from the study your incomplete results **may** be used, therefore it is important if you wish to withdraw to email the research administrator at Wesley.Harmer@hud.ac.uk.

How will the data be stored? The data will be stored securely behind password protected documents. The data you provide **will not** be used for any reason except this study. Confidentiality will be maintained in accordance with the university's standards as well as GDPR. All data present in the study will be **anonymised** and no identifying information will be used within the study. **What will happen to the results?**

They will be analysed and anonymised and potentially published within scientific journals. You have full control over your results and can ask for them to be removed from the study as mentioned above. Also, a summary of the results can be provided if requested.

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

**This study has received ethical approval from the University of Huddersfield and Health
Sciences School Research Ethics Panel.**

Page Break

Q2 Consent Form - Version 1 1. I confirm that I have read and understood the information form, and that I am able to contact the researcher to ask questions about the study if necessary. 2. I confirm that, to my knowledge, I do not contradict any of the exclusionary criteria. 3. I confirm that I am willing to give my email address and I am willing to receive emails regarding the study. 4. I confirm that I am aware of my right to withdraw from the study at any time and have my data removed from the study up to a week after the completion of the study. 5. I consent that if I do not formally withdraw, my results may still be used in the study. 6. I confirm that I understand my data will be protected in line with GDPR and my results will be anonymised. These anonymised data sets may be made available in public repositories or viewable by researchers.

I agree that the projected named above has been explained adequately and I agree to participate in the study. (1)

I do not wish to participate in this study. (2)

Skip To: Q3 If Consent Form - Version 1 1. I confirm that I have read and understood the information form, and... = I do not wish to participate in this study.

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

Skip To: End of Block If Consent Form - Version 1 1. I confirm that I have read and understood the information form, and... = I agree that the projected named above has been explained adequately and I agree to participate in the study.

Q3 Thank you for considering our study. Please press the next arrow to end the study.

Skip To: End of Survey If Thank you for considering our study. Please press the next arrow to end the study. Is Displayed

Page Break

End of Block: Information sheet

Start of Block: Screening questions

Q4 The following questions are designed to ensure you are qualified to participate in this study

Page Break

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

Q5 What device are you using to complete this survey?

- Mobile phone (1)
- Tablet (2)
- PC/Laptop (3)
- Other (4)

Skip To: Q9 If What device are you using to complete this survey? = Tablet

Skip To: Q9 If What device are you using to complete this survey? = Mobile phone

Skip To: Q9 If What device are you using to complete this survey? = Other

Q6 Are you fluent in English?

- Yes (1)
- No (2)

Skip To: Q10 If Are you fluent in English? = No

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
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Q7 Do you have a diagnosed anxiety disorder?

Yes (1)

No (2)

Skip To: Q10 If Do you have a diagnosed anxiety disorder? = Yes

Q8 Are you at least 18 years old?

Yes (1)

No (2)

Skip To: End of Block If Are you at least 18 years old? = Yes

Skip To: Q10 If Are you at least 18 years old? = No

Q9 This study requires the use of a PC/Laptop to complete the tasks. Please ensure you are using a PC or a Laptop before recommencing the study. Thank you.

Skip To: End of Survey If This study requires the use of a PC/Laptop to complete the tasks. Please ensure you are using... Is Displayed

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

Q10 You do not meet the criteria for this study, therefore you cannot participate. Thank you for your interest and for completing this form.

Skip To: End of Survey If You do not meet the criteria for this study, therefore you cannot participate. Thank you for yo... Is Displayed

End of Block: Screening questions

Start of Block: Person details

Q11 The following section requests personal data, please read the prompts carefully and note that all personal data will be securely kept and deleted once it is no longer required.

Q12 Please enter your forename or preferred name, this is how you will be referred to in the email.

Please do not enter your surname.

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

Q13 Please enter how old you are.

Q20 Please enter the country you currently live in.

Q14 Please specify the gender you currently identify as:

Q15 Please enter an email address which you can be contacted through.

Q16 Where did you find this study? (e.g. SurveyCircle, SONA etc)

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
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Page Break

Q17 Please **create** your participant ID and enter it in the box below.

The ID **must** be comprised of **three** letters followed by **three** numbers e.g. QQQ123.

Please **avoid** using any revealing information such as initials or date of birth.

Please make a note of the ID you entered, as it will be **necessary** for continued participation in this study and will be used to resolve any technical difficulties you may have.

Page Break

Q18 Thank you for completing the questions, please click to the next arrow to begin the experimental phase.

End of Block: Person details

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
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Start of Block: Experimental block

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

Q19 Over the last 2 weeks, how often have you been bothered
by any of the following problems?

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	Not at all (1)	Several days (2)	More than half of the days (3)	Nearly everyday (4)
Feeling nervous, anxious or on edge? (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Not being able to stop or control worrying? (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Worrying too much about different things? (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Trouble relaxing? (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Being so restless that it is hard to sit still? (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Becoming easily annoyed or irritable? (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
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Feeling afraid as
if something
awful might
happen? (7)



End of Block: Experimental block

Start of Block: Thanks and link

Q20

Thank you for completing the questionnaire, we are now moving to the **second phase of the study**.

This will be a short task - in this task you will see a series of blocks on the screen that flash red in a particular sequence.

Your task is to follow each sequence and click on the boxes **IN THE REVERSE ORDER THE SEQUENCE APPEARED IN!** The sequences will be very short at first, and progressively get longer.

Remember, click the boxes **IN THE REVERSE ORDER!**

Also, please enter your participant ID in the box on the next screen.

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
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If there are issues with connecting, please contact the study administrator at
Wesley.Harmer@hud.ac.uk.

Once you have completed the task, you should receive an email within **24 hours** with more
information.

Press the arrow button below, which will take you to the task.

If you found this study through SurveyCircle : The Survey Code is: 6KTP-PZHC-4UG8-4PJK or
alternatively, go to www.surveycircle.com/6KTP-PZHC-4UG8-4PJK.

**Need survey respondents? Click this link to receive credits that earn you free respondents at
SurveySwap.io. --> <https://surveyswap.io/sr/a9jd9FOTDh2rEaCI>**

End of Block: Thanks and link

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
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Appendix B

Questionnaire for Timepoint 1 and 2

This appendix consists of the digital questionnaire participants were provided at Timepoint 1 and 2. The questionnaire present is the one participants received at Timepoint 1, however they are essentially the same questionnaire. The appendix has been downloaded directly from Qualtrics, which preserves the logic (the condition a participant must meet in order to discern what response they will receive) of the questionnaire. Page breaks have been truncated to reduce the number of pages and the question number presented do not represent when the questions were presented.

Start of Block: Information sheet

Q1 This is a follow up survey for the study into anxiety relief exercises. The questions and tasks will remain largely the same. Please follow the instructions provided on the following pages and if there are any issues do not hesitate to contact me at Wesley.Harmer@hud.ac.uk. **A laptop/PC is required to complete this survey.**

You have the right to withdraw from the study and all data will be anonymised and will be kept securely. Please ensure you have your participant number available as you will be asked to produce it later in the survey.

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
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Page Break

Q2 Consent Form - Version 2 1. I confirm that I have read the information form and understood it and that I could access to the researcher to ask questions about the study via the contact details provided. 2. I confirm that, to my knowledge, I do not contradict any of the exclusionary criteria 3. I confirm that I am aware of my right to withdraw from the study at any time and have my data removed from the study up to a week after the completion of the study. 4. I consent that if I do not formally withdraw my results can still be used in the study. 5. I confirm that I understand my data will be protected in line with GDPR and my results will be anonymised. These anonymised data sets may be made available in public repositories or viewable by researchers. 6. I confirm that I want to continue to participate in this study.

I agree that the projected named above has been explained adequately and I agree to continue participating in the study. (1)

I do not wish to continue participating in this study. (2)

Skip To: Q3 If Consent Form - Version 2 1. I confirm that I have read the information form and understood i... = I do not wish to continue participating in this study.

Skip To: End of Block If Consent Form - Version 2 1. I confirm that I have read the information form and understood i... = I agree that the projected named above has been explained adequately and I agree to continue participating in the study.

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
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Q3 Thank you for considering our study. Please click to the next page which will end the study. If this does not work you can also close the page

Skip To: End of Survey If Thank you for considering our study. Please click to the next page which will end the study. If t... Is Displayed

End of Block: Information sheet

Start of Block: Screening questionsQ4 What device are you using to complete this survey?

- Mobile phone (1)
- Tablet (2)
- PC/Laptop (3)
- Other (4)

Skip To: Q5 If What device are you using to complete this survey? = Tablet

Skip To: Q5 If What device are you using to complete this survey? = Mobile phone

Skip To: Q5 If What device are you using to complete this survey? = Other

Skip To: End of Block If What device are you using to complete this survey? = PC/Laptop

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
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Q5 This study requires the use of a PC/Laptop to make input to the tasks. Please ensure you are using a PC or a Laptop before recommencing the study. Thank you.

Skip To: End of Survey If This study requires the use of a PC/Laptop to make input to the tasks. Please ensure you are u... Is Displayed

End of Block: Screening questions

Start of Block: Person details

Q6 Please confirm you participant number

Q7 Please enter the email you used in the prior survey.

Page Break

Q8 Please enter the exercise group you were in.

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
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- Progressive Muscle Relaxation (1)
- Diaphragmatic Breathing Exercise (2)
- Control Group (no anxiety relief exercise) (3)
- I dont know (4)

Skip To: End of Block If Please enter the exercise group you were in. = Control Group (no anxiety relief exercise)

Q9 How many times did you complete the anxiety relief exercise per week? If you were in the control group and clicked by accident, please enter 0.

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
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Q10 How motivated were you to complete the anxiety relief exercise?

- Very motivated (1)
 - Somewhat motivated (2)
 - Not very motivated (3)
 - Not motivated at all (4)
 - Control group please click here (5)
-

Q11 How helpful are you finding the anxiety relief exercise?

- Very helpful (1)
- Somewhat helpful (2)
- Not that helpful (3)
- Not helpful at all (4)
- Control group please click here (5)

End of Block: Person details

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
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Q12 Over the last 2 weeks, how often have you been bothered
by any of the following problems?

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	Not at all (1)	Several days (2)	More than half of the days (3)	Nearly everyday (4)
Feeling nervous, anxious or on edge? (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Not being able to stop or control worrying? (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Worrying too much about different things? (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Trouble relaxing? (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Being so restless that it is hard to sit still? (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Becoming easily annoyed or irritable? (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

Feeling afraid as
if something
awful might
happen? (7)



Page Break

Q13

Thank you for completing the questionnaire, we are now moving to the second phase of this survey.

This will be a short task - in this task you will see a series of blocks on the screen that flash red in a particular sequence.

Your task following each sequence is to click on the boxes **IN THE REVERSE ORDER THE SEQUENCE APPEARED IN!**

The sequences will be very short at first, and progressively get longer.

Remember, click the boxes **IN THE REVERSE ORDER!**

If there are issues with connecting please contact the study administrator at
Wesley.Harmer@hud.ac.uk.

Press the arrow button below, which will take you to the task.

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
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End of Block: GAD-7

Appendix C

Questionnaire for Timepoint 3

This appendix consists of the digital questionnaire participants were provided at Timepoint 3. The appendix has been downloaded directly from Qualtrics, which preserves the logic (the condition a participant must meet in order to discern what response they will receive) of the questionnaire. Page breaks have been truncated to reduce the number of pages and the question number presented do not represent when the questions were presented.

Start of Block: Information sheet

Q1 This is the final follow up survey for the study into anxiety relief exercises. The questions and tasks will remain largely the same. Please follow the instructions provided on the following pages and if there are any issues do not hesitate to contact me at Wesley.Harmer@hud.ac.uk. A laptop/PC is

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
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required to complete this survey.

You have the right to withdraw from the study and all data will be anonymised and will be kept securely. Please ensure you have your participant number available as you will be asked to produce it later in the survey.

Page Break

Q2 Consent Form - Version 2 1. I confirm that I have read the information form and understood it and that I could access to the researcher to ask questions about the study via the contact details provided. 2. I confirm that, to my knowledge, I do not contradict any of the exclusionary criteria 3. I confirm that I am aware of my right to withdraw from the study at any time and have my data removed from the study up to a week after the completion of the study. 4. I consent that if I do not formally withdraw my results can still be used in the study. 5. I confirm that I understand my data will be protected in line with GDPR and my results will be anonymised. These anonymised data sets may be made available in public repositories or viewable by researchers. 6. I confirm that I want to continue to participate in this study.

I agree that the projected named above has been explained adequately and I agree to continue participating in the study. (1)

I do not wish to continue participating in this study. (2)

Skip To: Q3 If Consent Form - Version 2 1. I confirm that I have read the information form and understood i... = I do not wish to continue participating in this study.

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

Skip To: End of Block If Consent Form - Version 2 1. I confirm that I have read the information form and understood i... = I agree that the projected named above has been explained adequately and I agree to continue participating in the study.

Q3 Thank you for considering our study. Please click to the next page which will end the study. If this does not work you can also close the page

Skip To: End of Survey If Thank you for considering our study. Please click to the next page which will end the study. If t... Is Displayed

End of Block: Information sheet

Start of Block: Screening questions

Q4 What device are you using to complete this survey?

- Mobile phone (1)
- Tablet (2)
- PC/Laptop (3)
- Other (4)

Skip To: Q5 If What device are you using to complete this survey? = Tablet

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INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

Skip To: Q5 If What device are you using to complete this survey? = Mobile phone

Skip To: Q5 If What device are you using to complete this survey? = Other

Skip To: End of Block If What device are you using to complete this survey? = PC/Laptop

Q5 This study requires the use of a PC/Laptop to make input to the tasks. Please ensure you are using a PC or a Laptop before recommencing the study. Thank you.

Skip To: End of Survey If This study requires the use of a PC/Laptop to make input to the tasks. Please ensure you are u... Is Displayed

End of Block: Screening questions

Start of Block: Person details

Q6 Please confirm you participant number

Q7 Please enter the email you used in the prior survey.

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INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

Page Break

Q8 Please enter the exercise group you were in.

- Progressive Muscle Relaxation (1)
- Diaphragmatic Breathing Exercise (2)
- Control Group (no anxiety relief exercise) (3)
- I dont know (4)

Skip To: End of Block If Please enter the exercise group you were in. = Control Group (no anxiety relief exercise)

Q9 How many times did you complete the anxiety relief exercise per week? If you were in the control group and clicked by accident, please enter 0.

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

Q10 How motivated were you to complete the anxiety relief exercise throughout the course of this experiment?

- Very motivated (1)
 - Somewhat motivated (2)
 - Not very motivated (3)
 - Not motivated at all (4)
 - Control group please click here (5)
-

Q11 How helpful did you find the exercise throughout the course of this experiment?

- Very helpful (1)
 - Somewhat helpful (2)
 - Not that helpful (3)
 - Not helpful at all (4)
 - Control group please click here (5)
-

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
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Q16 Please enter any positives of your given anxiety relief exercise. If unsure enter n/a.

Q18 Please enter any negatives of your given anxiety relief exercise. If unsure enter n/a.

End of Block: Person details

Start of Block: Thanks and link

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

Q12 Over the last 2 weeks, how often have you been bothered
by any of the following problems?

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE

INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.

	Not at all (1)	Several days (2)	More than half of the days (3)	Nearly everyday (4)
Feeling nervous, anxious or on edge? (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Not being able to stop or control worrying? (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Worrying too much about different things? (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Trouble relaxing? (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Being so restless that it is hard to sit still? (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Becoming easily annoyed or irritable? (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
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Feeling afraid as
if something
awful might
happen? (7)



Q17 Over the course of the past **six weeks**, how do you feel your anxiety levels have changed?

- My anxiety has increased (1)
- My anxiety has stayed relatively similar (2)
- My anxiety has decreased (3)

Page Break

Q13

Thank you for completing the questionnaire, we are now moving to the second phase of this survey.

This will be a short task - in this task you will see a series of blocks on the screen that flash red in a particular sequence.

Your task following each sequence is to click on the boxes **IN THE REVERSE ORDER THE**

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
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SEQUENCE APPEARED IN!

The sequences will be very short at first, and progressively get longer.

Remember, click the boxes **IN THE REVERSE ORDER!**

If there are issues with connecting please contact the study administrator at
Wesley.Harmer@hud.ac.uk.

After this task has been complete, you will receive a debrief email within **24 hours**.

Press the arrow button below, which will take you to the task.

End of Block: Thanks and link

**INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE
INTERVENTION ON ANXIETY AND SUBSEQUENT WORKING MEMORY FUNCTION.**

Appendix D

The GAD-7

This appendix is a digitised form the GAD-7. Participants would select a single response per question which in turn provides the score to analyse.

	Not at all	Several days	More than half of the days	Nearly everyday
Feeling nervous, anxious or on edge?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Not being able to stop or control worrying?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Worrying too much about different things?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Trouble relaxing?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Being so restless that it is hard to sit still?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

INVESTIGATING THE IMPACT OF A NON-PHARMACEUTICAL ONLINE

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Becoming easily annoyed or irritable?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Feeling afraid as if something awful might happen?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>