The effects of sustained guided imagery practice on general stress, academic stress and academic motivation among first-year university students: A preliminary randomised control trial

[redacted]

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Abstract

Guided imagery is a relaxation technique used to reduce stress and anxiety levels. Several studies have indicated that guided imagery is effective as a stress reduction technique in various contexts and populations. the effectiveness of guided imagery as a stress-reduction technique in various contexts across different populations. However, little research has been conducted on the effectiveness of guided imagery practice in reducing academic stress among university students. Also, only few studies have examined the effects of sustained guided imagery practice (i.e., beyond a single session). The current study was a randomised control trial, in which participants were randomised to listen to 5-to-10-minute audios featuring guided imagery (treatment; n = 15) or breathing relaxation exercises (control; n = 18) for seven days. The audios were administered alongside single-item measures of general stress. Academic stress was assessed on Days 1 and 7, and, on Day 7, participants additionally completed tasks that reflected academic motivation. Linear mixed modelling analyses indicated a greater reduction in general stress in the imagery group from Day 1 to Day 7, but descriptive statistics indicated that this was largely due to stress being marginally statistically significantly higher at baseline in the imagery group (due to chance). The trajectory of academic stress and the degree of academic motivation did not differ across groups. Testing all participants in the same seven-day period would help reduce chance-based anomalies in the study.

Declaration

This thesis contains no material which has been accepted for the award of any other degree of diploma in any University, and, to the best of my knowledge, this thesis contains no material previously published except where due reference is made. I give permission for the digital version of this thesis to be made available on the web, via the University of Adelaide's digital thesis repository, the Library Search and through web search engines, unless permission has been granted by the School to restrict access for a period of time.

Contribution Statement

In writing this thesis, my supervisor and I collaborated to generate research questions, completed the ethics application and designed the appropriate methodology. While I collected the data, my supervisor implemented the analyses. The study was pre-registered on Open Science Framework listing the hypotheses and analysis of the study. I conducted the literature search and wrote up all aspects of the thesis.

Guided imagery (GI) is a technique sometimes implemented by mental health practitioners to reduce stress and anxiety levels in clients (Apóstolo & Kolcaba, 2009; Holmes & Mathews, 2005; Lindquist et al., 2014; Nguyen & Brymer, 2018; Norelli et al., 2021). Stress is generally characterised as feeling overwhelmed, tense and anxious when one encounters a situation, they feel they cannot handle (Australian Psychological Society, 2022; Epel et al., 2018). Stress is an experience felt when the environmental demands surpasses the individuals' ability to cope, especially when unpredictable and uncontrollable circumstances are present (Epel et al., 2018; Fitzgerald & Langevin, 2014; Koolhaas et al., 2011). GI utilises one's imagination of a pleasant scene across multiple sensory domains to reduce stress and elicit relaxation (Norelli et al., 2021; Rao & Kempber, 2016; Skeens, 2017).

GI can be delivered by a mental health practitioner or physician in a clinical setting. In a non-clinical setting, the individual can engage in GI themselves (Skeens, 2017). The session often centres around an audio tape or video, but another individual can guide the receiver using an imagery script as well (Boehm & Tse, 2013; Fitzgerald & Langevin, 2014; Galik et al., 2013). The text of the guided imagery exercise encourages the individual to mentally shift into a place where they are safe and relaxed, with some breathing exercises being introduced in the imagined space to facilitate further relaxation (Fitzgerald & Langevin, 2014; Krau, 2020; Lewandowski et al., 2010; Norelli et al., 2021; Roffe et al., 2005)

Imagery uses perceptual information that is retrieved from memory and gives rise to experiencing 'seeing with the minds eyes', 'hearing with the minds ear' and other similar experiences (Juslin, 2019; Kosslyn et al., 2001). Mental images can also be formed by

combining and altering the existing perception information in creative and innovative ways instead of only recalling previously perceived events (Kosslyn et al., 2001).

While the mechanisms through which GI reduces stress remain uncertain, a body of research has developed demonstrating the effectiveness of GI in some contexts. The present study assesses the effectiveness of GI among first-year university students – a group facing pressures around academic achievement and transition from school to university. For this group, GI might represent an accessible and low-cost aid to coping, especially if the guided imagery takes the form of a free and brief online intervention. That is the kind of intervention evaluated in this study.

Underpinnings of GI

The foundation of GI lies in the concept that the mind and the body are interconnected and thus have bidirectional interactions. GI uses external guidance to facilitate internal formation of images that elicit sensory experiences through multi-sensory domains and affect behavioural and physiological changes (Arbuthnott et al., 2001; Hart, 2008; Ji et al., 2016).

Research indicates that visuals in GI are sometimes sensed as actual scenes (Arbuthnott et al., 2002; Kealy & Arbuthnott, 2003; Mathews et al., 2013; O'Craven & Kanwisher, 2002). This could be a result of the sensory and contextual details in the GI events mirroring those of the actual experiences. Additionally, the visual imagery and visual perception have shared processing pathways in the brain (Borst & Kosslyn, 2008; Mathews et al., 2013). Since GI focuses on great sensory and contextual engagement, a significant perceptual detail of the visual is formed, which results in less discernible difference between the real and imagined scene

(Arbuthnott et al., 2002). However, Boschker et al. (2002) found that, although the mechanisms involved in imagery and real experiences are similar, the neurophysiological data suggest that imagery might not be the perfect replica of the real-world experience. In these situations, imagery becomes an effective tool because individuals might not wish to focus on the unpleasant feelings and sensations they receive from the real experiences, particularly if these are stressful or anxiety inducing. Holmes and Mathews (2010) implies that imagery is an emotional amplifier, having the ability to change emotional states.

According to the functional magnetic resonance imaging (fMRI), creating an image in one's mind activates the neural circuits and parts of the central nervous system that are involved when the individual is using their senses. For instance, imagining hearing a sound activates the neural circuits associated with hearing (Formisano et al., 2002; Gulyas, 2001; Kosslyn et.al, 2001; Kraemer et.al, 2005; Oxenham, 2018). Brain structures such as occipital, frontal and parietal areas are found to be involved during imagination (Agnati et al., 2013; Buckner & Carroll, 2006; Ganis et al., 2004; Ishai et al., 2000; Mechelli et al., 2004). Neural circuits covering the prefrontal, parietal, temporal and visual areas have been found to support the formation of mental images. Visual imagery is linked to early visual cortex, suggesting an overlap of imagery-associated processing with perception (Albers et al., 2013; Cui et al., 2007; Dijkstra et al., 2017; Keogh et al., 2020; Lee et al., 2012). Brain activation during imagination sometimes differ depending on the object being visualised. O'Craven and Kanwisher (2002) found parahippocampal place area (PPA) activated when indoor and outdoor scenes were visualised.

The perceived possibility of a future event occurring was found to rise with repeated imagination (Anderson, 1983; Carroll, 1978; Garry et al., 1996; Szpunar & Schacter, 2013). Anxiety levels can rise by repeated thinking and imagining anxiety-inducing future occurrences (Raune et al., 2005). On the other hand, repeatedly imagining that an event occurred in the past (even when it did not) can convince the individual to believe that it did (Garry et al., 1996). The likelihood that a person will carry out an action is influenced by the repeated imagination of that action (Libby et al., 2007). There are negative implications from imagination which includes of increased hand washing behaviour in OCD or repeated suicidal thoughts rising the likelihood of suicidal attempts (Crane et al., 2011). However, imagined rehearsal of an action can be useful in areas like sports psychology where increase of self-confidence and decrease in anxiety can be observed (Garza & Feltz, 1998; Post & Wrisberg, 2012). When imaginative practices are applied to help or favour the circumstances the individual is in, it can be useful. People with depression displays negativity biases especially when the uncertain situation is perceived as negative one. This can however be modified by strengthening positive emotional reactions through mental imagery (Gotlib & Joormann, 2010). A randomised control trial conducted by Blackwell et al., (2015) found that positive mental imagery was effective in reducing negative biases in depressive patients. Imagination has a therapeutic value which is seen through relaxation tools like GI particularly for reducing anxiety levels (Ji et al., 2016; Norelli et al., 2021; Selva, 2018; Skottnik & Linden, 2019).

Naparstek (1994) reviewed three main principles of GI. The first is that of the mind-body link, where the body receives cues from the mind regarding feelings and experiences. The mind signals the body especially when the scene imagined elicit multi-sensory memories and deep emotions are present. The second principle is that as a person enters an altered state of

consciousness (any state of awareness/consciousness that differs from normal waking awareness/consciousness), the biochemistry and the brain activity change, resulting in changes to emotion and cognition. The last and final principle is control. When an individual is aware that he or she has control over their lives, their functioning becomes improved.

GI has also been used extensively in pain management (Giacobbi et al., 2015; Hadjibalassi et al., 2018; Kwekkeboom & Bratzke, 2016; Posadzki et al., 2012). The mechanism of effect has tended to be explained in terms of the gate theory of pain, according to which activation of the cerebral cortex during imagination competes with the pain stimuli and prompts the release of neurotransmitters that suppress pain transmission (King, 2010; Krau, 2020). A systematic review by Hadjibalassi et al. (2018) investigated the effects of GI on critical illnesses and care. The findings support the use of GI in critical care as they found reduction of anxiety and pain mainly in cardiovascular patients. GI interacts early in the pathopsychological cascade where extreme stress episodes leads to adverse outcomes in critical illness by eliciting relaxation response. The relaxation response counteracts the extreme stress episodes in the limbic system. Parasympathetic nervous system signalling, and stress neuropeptides are activated. These intricate pathways regulate cardiorespiratory, immune and metabolic responses, leading to better patient outcomes.

Findings and gaps in the literature on the effectiveness of GI

A systematic review and metanalysis analysis conducted by Álvarez-García and Yaban (2020) suggested that GI was found to be effective in alleviating preoperative state anxiety in children and adults. GI was also shown to help alleviate postoperative pain in adults. Similarly, a systematic review by Woragidpoonpol et al. (2013) on postoperative pain in children and

adolescent suggested that GI was found to be effective in lowering pain. Likewise, a systematic review by Giacobbi et al. (2015) found GI to be effective in pain reduction and overall wellbeing of rheumatic diseases. A review conducted by King (2010) included five studies of pain and three of these studies found decrease in pain after using GI. A review and a meta-analysis by Singh and Dalmar (2014) concluded that GI was found to be effective in reducing pain and anxiety among patients undergoing surgery. A systematic and metanalysis by Sinha et al. (2021) found GI combined with progressive muscle relaxation to be effective in reducing stress and anxiety among breast cancer patients. The reduction in stress and anxiety was observed during the chemotherapy phase of treatment. A systematic review by Roffe et al. (2005) examined guided imagery as a sole adjuvant for cancer therapy. Out of the six randomised controlled trials included, three of them indicated significant differences in anxiety and emotional responses to patients underwent chemotherapy when compared to the control group. As a sole adjuvant therapy, GI may provide psycho-support and boost comfort.

On the other hand, a systematic review by Haruna et al. (2019) indicated insufficient evidence to confirm any benefits of GI for hypertension in pregnancy. Similarly, a systematic review of randomised clinical trials on the effectiveness of guided imagery in alleviating non-musculoskeletal pain was found to be inconclusive (Posadzki et al., 2012). Likewise, a randomised control trial by AJ et al. (2017) found no additional benefits of using brief GI for patients undergoing laparoscopic cholecystectomy.

Use of GI has been found to help the immune system to perform effectively (Bakke et al., 2002; Donaldson, 2000; Hall et al., 1994; Jasnoski & Kugler, 1987; Rider & Achterberg, 1989; Rider et al.,1990; Trakhtenberg, 2008; Zachariae et al., 1990). Changes in white blood cells and

neutrophil adherence are both correlated with changes in immunity system effectiveness (Krau, 2020; Trakhtenberg, 2008). Reduced cortisol levels in generalised anxiety disorder patients were observed following the use of GI. GI was found to be more effective than cognitive behaviour therapy in lowering cortisol levels (Jorm et al., 2004). A randomised control trial by Felix et al., (2018) found GI as an effective nursing intervention in reducing pre-operative anxiety. Pregnant African American women reported reduced stress levels, trait anxiety and fatigue after using GI for twelve weeks (Jallo et al., 2014). Similarly, Flynn and colleagues (2016) found that GI reduced both short-term and long-term stress among adolescents going through pregnancy. Weydert et al. (2006) found that among children suffering from abdominal pain, GI combined with progressive muscle relaxation was found to be effective in reducing recurrent abdominal pain as compared to breathing alone. GI has also shown to increase feelings of well-being, cultivate positive thoughts and develop coping strategies in stressful events. Reduced incidents of anger, insomnia and negative thoughts were also present after using GI (Carter, 2006). Gordon et al., (2021) conducted a study on the effectiveness of GI mobile app in reducing COVID-19 related stress. The findings suggest that participants found the app helpful in lowering their stress. Foji et al. (2015) conducted a study on the effectiveness of GI in reducing pain and anxiety among patients undergoing coronary angiography. Anxiety levels were shown to be reduced after using GI. Similarly, Gonzales (2010) found reduced anxiety levels in patients before operation after using GI. Antall (2004) and Halpin et al. (2002) examined the effect of GI in reducing pain and anxiety among elderly orthopaedic population and patients undergoing heart surgery. The results from both these studies indicated reduction in pain and anxiety in these populations. Kiley et al. (2018) found significant reduction in state anxiety among mental health works after using GI. Moreover, GI was found to improve their sleep quality.

Although studies indicate that GI is an effective technique to promote relaxation, a study conducted by Toussaint et al. (2021) suggests that relaxation techniques such as deep breathing, progressive muscle relaxation and GI are equally effective. These relaxation techniques can induce psychological relaxation states and none of them is superior.

The benefits of using GI have been explored in various contexts but not many studies have explored the effectiveness of sustained practice of using GI on general or academic stress. Longitudinal studies on the effectiveness of GI in reducing stress are limited. Having said that, a few studies have investigated the effectiveness of GI in reducing stress and pain as well as improving wellbeing over time in other contexts. Improved sleep, reduced pain and changes in trait anxiety were some of the positive effects from the use of GI for eight weeks' time period (Onieva-Zafra et al., 2019). Stress among African pregnant women was found to be reduced after using the intervention for twelve weeks (Jallo et al., 2014). Similarly, reduced stress and anxiety as well as increased comfort were found in psychiatric inpatients with depressive disorders following the use of GI for ten days (Apóstolo & Kolcaba, 2009). A study by Menzies et al (2012) examined the effects of GI on biobehavioural factors in women with fibromyalgia over ten weeks. The results suggested significant reduction in stress, depression, pain and fatigue.

However, from our knowledge, not much research has been done on sustained GI practice in reducing general stress and academic stress among university students. Thus, the current study aims to fill these research gaps.

The present study

Transitioning to university can be challenging and stressful, increasing the risk of mental health problems (Cage et al., 2021; Gall et al., 2000; Maymon & Hall, 2021). The contents in the syllabus must be learned in a short period of time (Oduwaiye et al., 2017). Additionally, there is pressure that exists among students for achieving good grades, making friends, and settling into university life (Tett et.al, 2017). Extensive academic load, family pressure, competition with peers, financial issues and time management are some of the stressor's students are exposed to (Bedewy & Gabriel, 2015; Byrd & McKinney, 2012; Ekpenyong et al., 2013; Freire et al., 2020; Karyotaki et al., 2020; Ketchen Lipson et al., 2015; Liu et al., 2018; Misra & Castillo, 2004; Mofatteh, 2021; Pedrelli et al., 2015; Reddy et al., 2018). These factors lead to students experiencing what is called academic stress. Academic stress can be understood as the type of stress experienced from feeling overloaded with academic work which is beyond the individuals' capacity (Khan et al., 2013; Wilks, 2008). It can also be referred to as any negative stimulus that include of social, interpersonal, intrapersonal, health-associated, environmental-associated factors that hinder the academic growth of the individual (Adom, et al., 2020).

Academic stress levels among university students are much greater than the general stress levels experienced by the general population (González-Ramírez et al, 2013; Geng & Midford's, 2015; Stallman, 2010) Among university students, first-year students in particular were significantly more stressed as compared to the students of other levels. Stress in first year is extremely common and can affect students' decisions as to whether to continue studying (Garcia-Ros et al., 2012; Harvey et al., 2006; Johnson, 1996; Reason et al., 2007; Tinto, 1999). The main source of high levels of stress was reported to be perceived academic overload. One of

the negative effects of academic stress has been indicated as decreased academic performance (Crego et al., 2016; Deng et al., 2022; Kotter et.al, 2017; Pascoe et al., 2019). Similarly, academic stress was found to lower motivation levels, impede academic performance and increase university dropout rates (Pascoe et al., 2019). Research has indicated negative implications on the mental health of the students due to experiencing academic stress (Li & Lin, 2003; Eisenberg et al., 2009; Green et al., 2021). Studies suggest that stress experienced at university might determine the diagnosis of mental illness (Pedrelli et al., 2015; Liu et al., 2018; Karyotaki et al., 2020). Coping strategies such as mindfulness meditation, cognitive behaviour therapy and other online coping tools have been shown as effective interventions in reducing stress of university students (Freire et al., 2020; Houston et al., 2017; Kang et al., 2009; Molla Jafar et al., 2015; Phang et al., 2015; Regehr et al., 2013; Yusufov et al., 2019).

In contrast, a number of studies (Alyami et al., 2017; Bello & Gumarao, 2016; Tus, 2020) report that academic stress does not correlate with academic performance. Meanwhile, academic performance has been found to be associated with academic motivation (Bolkan et al., 2014; Dogan, 2017; Fereidooni-Moghadam et al., 2017; Kori et al., 2016) Academic motivation is the student's will and level of interest in their subjects when their competence is determined against performance standards (Koyuncuoglu, 2020; Olowo et al., 2020; Serhan, 2019). Research indicates several links of academic motivation with academic engagement, academic achievement, persistence, and better study strategies (Martin et al., 2017; Paulsen & Feldman, 1999; Panitz, 1999; Porchea et al., 2010; Robbins et al., 2004; Rieger et al., 2022; Vanthournout et al., 2012). Motivation and time spent also have been found to have correlation. Motivation appears to be an important factor that manages and direct the academic time use (Koudela-Hamila et al., 2019; Moula, 2010). Lack of motivation has been shown as one of the main

reasons for underachievement (McCoah & Siegle, 2001; Nayak & Jahan, 2010; Scheel et al., 2009). Motivation and persistence are associated to one another. To persist through the academic workload, students require motivation (Allen, 1999; Vanthournout et al., 2012).

The present study examines how GI practiced over the course of a week affects (a) general stress, (b) academic stress, and (c) academic motivation. Academic motivation is reflected in performance within and persistence at a task drawing on novel but study-discipline-relevant information. With first-year psychology students as participants, we used four measures of academic motivation: (i) score in a quiz on using a statistical software that would be taught to students in full the following year, (ii) time spent viewing the video on which the quiz was based, (iii) time spent completing the quiz, and (iv) probability of voluntarily viewing a follow-up video with an associated quiz.

A randomised controlled trial design is used, with breathing relaxation exercise as the control condition. Breathing relaxation exercise involves focusing and being aware of one's breathing. We chose breathing as the exercise to be presented to the control group based on a previous study by Weydert et al. (2006), in which GI was also compared to a breathing relaxation condition over the course of a week. Our study utilised the GI audios that are freely available to stream from Inner Health Studio (www.innerhealthstudio.com). These resources are yet to be evaluated in relation to their effects on transitional/academic stress. In our study, in both conditions, interventions were delivered through a 5-10-minute audio – a different one each day for seven days. If the results from the current study are promising, then GI resources can be recommended as a relaxation tool for first-year students undergoing general stress, academic

stress, or issues with motivation. Since the audio resources are brief and easily accessible online, students will find it convenient to utilise them.

Our hypotheses are as follows:

Hypothesis 1 (general stress): Compared to participants in a control condition (breathing exercise), participants in the guided imagery condition will report lower levels of general stress post-intervention.

Hypothesis 1a (general stress: tentative): Compared to participants in the control condition, participants in the guided imagery condition will display a more negative slope on daily reports of general stress. This hypothesis is only tentative because we might have a substantial amount of missing data, and we cannot run a precise longitudinal analysis.

Hypothesis 2 (academic stress): Compared to participants in the control condition, participants in the guided imagery condition will report lower levels of academic stress post-intervention.

Hypothesis 3 (academic motivation): Compared to participants in the control condition, participants in the guided imagery condition will present with higher scores in their academic task-oriented quiz.

Hypothesis 3a (academic motivation: tentative): Compared to participants in the control condition, participants in the guided imagery condition will spend more time on viewing the video comprising part of the compulsory academic task. This hypothesis is only

tentative because times will reflect breaks participants take from the video as well as the amount of direct viewing time. Thus, variability in recorded times is likely to be substantial.

Hypothesis 3b (academic motivation: tentative): Compared to participants in the control condition, participants in the guided imagery condition will spend more time on the academic-oriented quiz. This hypothesis is only tentative because times will reflect breaks participants take from the quiz as well as the amount of direct time spent on the quiz. Thus, variability in recorded times is likely to be substantial.

Hypothesis 3c (academic motivation): Compared to participants in the control condition, participants in the guided imagery condition will be more likely to attempt a voluntary extension to the academic-oriented task.

Method

Participants

First-year students at the University of Adelaide's School of Psychology (N = 33; 15 in the treatment group; 18 in the control group; see Table 2 for descriptive statistics) participated in the study in return for course credit. Participants were recruited through the School's online research participation scheduling facility. The study advertisement advised participants not to take part if they suffered from chronic abdominal pain or breathing difficulties. These exclusion criteria were applied because, in a past study (Huth et al., 2004), two participants experienced discomfort when they focused on diaphragmatic breathing, and the authors concluded that this was likely linked to pre-existing abdominal pain or dyspnea (shortness of breath).

Sample size and power

A pre-registered a priori power analysis (https://osf.io/y6b7x) indicated that 64 participants per group would be needed to detect medium effect size of d = .5 for the difference between groups with a probability of .8. However, due to institutional constraints on the number of participation hours available per researcher, we sought to recruit 30 participants per group – the minimum sample size per group recommended for daily diary studies (Ohly et al., 2010). We did not reach this number due to time constraints, but, for all analyses (which feature between k = 2 and k = 4 estimated linear mixed model parameters) our sample size is above 3/k and above or near 10/k, which is in line with recommendations (Harrison et al., 2018).

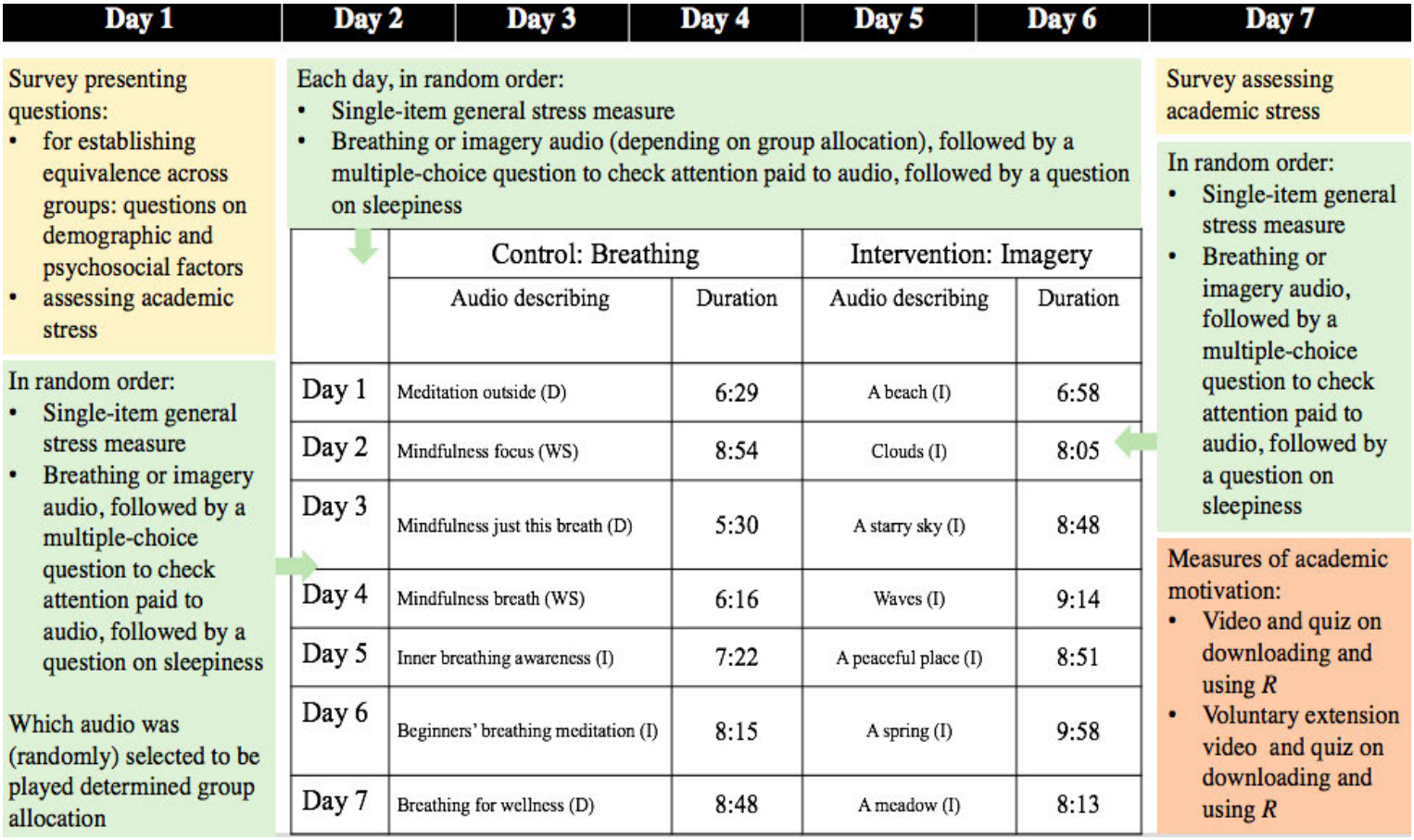
Procedure

Ethics approval was granted by the Human Research Ethics Sub-committee of the School of Psychology at the University of Adelaide (22/41).

Participation took place online over seven days. Each day, participation involved listening to an audio containing a guided imagery or breathing exercise. The audio was embedded in a Qualtrics survey containing single-item measures of general stress (one of the outcome variables) and mood (a distractor). It was randomly determined in each survey whether the stress and mood measures would be completed before or after the relaxation exercise. A single multiple-choice question assessing attention to the exercise was also included in the survey and was always completed after the exercise. A question on sleepiness during the exercise followed (see *Measures: Attention and Compliance below*). A different audio was presented each day, meaning that the question relating to attention to the audio also differed each day. On Days 1 and 7, the surveys contained additional measures. On Day 1, the additional measures related to academic stress, and demographic and psychosocial factors relevant to establishing baseline equivalence between groups. The assessed psychosocial factors were mental health (distress), personal wellbeing, and social support. On Day 7, the additional measures related to academic stress and academic motivation. Participation took approximately 125 minutes in total: 25 minutes on Day 1. 10 minutes on Days 2 to 6, and 40 minutes on Day 7. The steps involved in participation are summarised in Figure 1.

Figure 1

The procedure across the seven days



	Control: Breathing		Intervention: Imagery	
	Audio describing	Duration	Audio describing	Duration
Day 1	Meditation outside (D)	6:29	A beach (I)	6:58
Day 2	Mindfulness focus (WS)	8:54	Clouds (I)	8:05
Day 3	Mindfulness just this breath (D)	5:30	A starry sky (I)	8:48
Day 4	Mindfulness breath (WS)	6:16	Waves (I)	9:14
Day 5	Inner breathing awareness (I)	7:22	A peaceful place (I)	8:51
Day 6	Beginners' breathing meditation (I)	8:15	A spring (I)	9:58
Day 7	Breathing for wellness (D)	8:48	A meadow (I)	8:13

Note. D = Darmouth Wellness Centre; WS = Western Sydney; I = Inner Health Studio

As it can be seen in Figure 1, participants in both groups experienced a different audio each day, with the order of audios remaining fixed across days. All seven guided imagery audio files and two breathing relaxation audio files were purchased from Inner Health Studio (Inner Health Studio, n.d). The remaining breathing audios were downloaded free of charge from the Dartmouth Wellness Centre (Dartmouth Wellness Centre, n.d) and Western Sydney University (Western Sydney University, 2021).

In the advertisement for the study, no details were provided to participants regarding the existence of an intervention group and control group. The study was simply described as one interested in the relationship between relaxation, and stress and mood. All participants were directed to the survey for the Day 1, where, if they consented to participate, they completed demographic and baseline measures before being randomly assigned by Qualtrics to view a breathing or guided imagery exercise. After the completion of each Day 1 survey, the researcher received an email notification containing the questions presented to the participant. Based on this information, the researcher determined the group to which the participant had been allocated. The Day 1 survey asked students to provide their email address, and the researcher used this to set up scheduled survey emails for the next six days based on the group to which the participant was assigned.

On Days 2 to 7, participants received links to the day's survey via email every morning. An email was sent to the researcher each time a survey was completed, and, if the researcher did not receive this email, they sent the participant a reminder text message:

> Just a friendly reminder to login to Qualtrics and attempt today's relaxation and stress study. Please make sure you complete the assigned tasks before the end of today. We recommend using a desktop or laptop to complete the tasks and allowing 10 minutes for today's tasks. Your participation in the study is much appreciated. Thank you!

Participants who missed the Day 7 were sent additional reminder emails across three days. All participants were granted credit after receiving the Day 7 survey.

Data collection began on the 10th of May 2022. By the 25th of May, there were 14 participants in the breathing group but only 6 in the imagery group. Since two thirds of the participants were being assigned into the breathing group, researchers edited the settings to direct

a random two-thirds of future participants into the imagery group, effectively setting up blocked randomisation. The blocked randomisation in Qualtrics can be seen in Appendix 1.

Measures

Demographic factors (for establishing equivalence across groups)

The following demographic variables were measured using survey questions presented in the Day 1 survey: age, gender, ethnicity, language other than English spoken at home, religion, study load, domestic/international student, education, employment, living arrangement, income, rural/urban and relationship status. Appendix 2 shows the demographic questions that were given in the Day 1 survey.

Psychosocial factors (for establishing equivalence across groups)

Personal wellbeing. Personal wellbeing was assessed using the Personal Wellbeing Index (PWS), which consists of seven items assessing satisfaction with "standard of living", "health", "achieving in life", "relationships", "safety", "community-connectedness", and "future security". The internal consistency of the scale is between .70 and .85 and the intra-class correlation coefficient of good retest reliability is .84. Items were rated on from (0) "extremely dissatisfied" to (10) "extremely satisfied", and an example item is "How satisfied are you with health?" (Cummins et. al, 2002; International Wellbeing Group, 2013).

Social Support. Social support was measured using the Social Provisions Scale (SPS-5) which consists of five-items that assess social support. Scores on the scale have been found to correlate highly (.97) with scores on the 10-item version of the scale, as well as with reported sense of belongingness (Orpana et. al, 2019). In the same study, the SPS-5 had high internal consistency (.88) and its items formed one factor, as would be expected. Items are scored from (1) "not at all strongly disagree" to (5) "strongly agree", and an example item is "I have close relationships that provide me with a sense of emotional security and wellbeing".

Distress. Kessler Psychological Distress Scale is a widely used self-report scale that measures symptoms of anxiety, depression and psychological distress experienced during the past 30 days. It consists six items and each item is rated from (0) "none of the time" to (4) "all of the time". An example item is "during the past 30 days, how often did you feel nervous?". Kessler et al., (2010) found an internal consistency of 0.864. The confirmatory analysis suggests that the scale contains one -factor structure (Kawakami et al., 2020).

Academic stress (outcome variable)

Academic stress was measured using the perception of academic stress scale (PAS). It is an 18-item stress scale that assess the sources of academic stress in university students. Bedewy & Gabriel (2015) found an internal reliability consistency of 0.7. 89% of overall agreement was observed for the relevance of items in the scale, indicating evidence for content validity. Each item is rated from (0) "strong disagree" to (4) "strongly agree". An example item is "I am

confident that I will be a successful student". Some of the original questions in the scale were adjusted to Australian English to make it relevant to the participants (*See appendix 3)*.

General stress (outcome variable)

General stress was measured using a single item question. A brief scale that measures general stress. The question is as follows: "Stress means a situation in which a person feels tense, restless, nervous or anxious or is unable to sleep at night because his/her mind is troubled all the time. Do you feel this kind of stress these days?" The item was measured on 11-point likert scale, (0) being "not at all" and (10) referring "very much". It has satisfactory content and concurrent criterion validity. The construct validity was supported by its convergence with signs of health as well as associations to work traits (Elo et. al, 2003).

Mood (distractor variable)

A single item question was used as a distractor. The question was as follows: "How would you describe your mood at the moment"? The scale was rated (-5) "extremely negative" to (5) "extremely positive".

Academic motivation

Academic motivation was assessed using four measures: (i) score in the quiz, (ii) time spent viewing the video on which the quiz was based, and (iii) time spent completing the quiz, and (iv) likelihood of voluntarily viewing a follow-up video with an associated quiz.
The scores achieved on the main task quiz by both the groups was used as an indication of their level of academic motivation post intervention. Similarly, the amount of time participants spent

viewing the main video and the amount of time spent completing the quiz reflected their level of academic motivation post intervention. A timer was set on the academic task videos and quiz pages to check their academic motivation levels as well as to gauge attention and compliance in the study. The likelihood of voluntarily viewing a follow-up video with an associated quiz also indicated their level of academic motivation post intervention.

The two academic oriented tasks that were used for the study were created by the research member of the University of Adelaide who has extensive experience working with R. The videos were developed in accordance with the university guidelines for teaching purposes. The main task was compulsory, and it consisted of an introductory video to R and R studio. The main task was followed by multiple-choice quiz. The second task was voluntary, and it consisted of a video on creating graphs on R, which was also followed by multiple choice quiz. Once the answers to the multiple-choice quizzes were submitted, participants were provided with a downloadable pdf file with answers to all the questions. Students are required to use R Markdown and R Studio in later years of their study, which is why the tasks were based on working with R as it would be relevant and useful. Also, respecting the participation time, the research team decided to create tasks that are useful for future studies.

Before the end of the Day 7 survey, participants were asked if they had prior experience working with R and R studio. This question was important because if they had prior knowledge and experience using R and R studio, assessing academic motivation in connection with the tasks would have been difficult.

Attention and compliance

Attention paid to the audio. Every audio (in both conditions) was followed by one multiple-choice question. The question was based on the audio they listened to. An example can be seen in Table 1. Correct responses in the questions indicated that participants had paid attention during the GI or breathing exercise.

Table 1 shows example attention-check questions in the two conditions.

Control: Breathing	**Intervention: Guided imagery**
"You were asked to breathe in for the count of” • 0 • 99 • 4 • 20 • A slider question type on measuring sleepiness shown after the exercise:	"What scene were you asked to visualise?" • Beach • Forest • Clouds • Starry Sky • A slider question type on measuring sleepiness shown after the exercise:

Proportion of the sessions completed. If a participant missed a survey or returned their survey late – within 12 hours or less of their next completed survey – responses at that time point were considered missing. Up to 3 days were given to receive Day 7 survey. Table 3 in the Results shows that the rates of missing data (proportions of completed session) were equivalent across groups.

Sleepiness. Sleepiness was measured using a single item question which was "To what extent did you feel sleepy or drowsy during the exercise?". Participants were instructed to give an indication of their feeling of sleepiness from 0 to 10, (0) being "not at all" and (10) "being very much". A few practical tips were given to participants when indicated their sleepiness to be 3 or more.

Proportion of sessions in which participant left early. A timer was set on pages where the audio files were displayed to show how long participants spent on the page. The timer was set for 300 seconds (5 minutes) and participants were required to spend a minimum 5 minutes on this page before they could move on to the next page. The amount of time participant spent subtracted from the duration of the audio indicated how long participants spent. Further, suggesting the proportion of sessions in which participants left early.

Statistics and Data Analysis

The analysis for each hypothesis was pre-registered through the Open Science Framework: https://osf.io/y6b7x. To accommodate missing data, linear mixed effects models (conducted in the lme4 package (Bates et al., 2015) in R version 1.1-30 with participant ID as the random term were used in all analyses except where a Chi-square analysis was conducted (for Hypothesis 3c, with group as the predictor and whether participants engaged in the voluntary task as the outcome). For Hypotheses 1 and 2, the fixed effects were Group, Time (Hypothesis 1: pre-intervention vs. post-intervention; Hypothesis 1a: Day – 1 to 7), and the Group x Time interaction. For Hypotheses 3 to 3b, Group was the only fixed effect. For these models,

generalised linear models were also fitted to verify the conclusions from the linear mixed models. Notably, compared to the generalised linear models, the linear mixed effects models provided predicted values that were closer to the original values. This is despite the fact that the linear mixed effects models for Hypotheses 3 to 3b had to be fitted without checks for whether there were multiple observations per level of the random term. The outcome variables in the analyses were general stress for Hypothesis 1, steeper slope for general stress for Hypothesis 1a, academic stress for Hypothesis 2, quiz scores for Hypothesis 3, time spent viewing the main video for Hypothesis 3a and time spent on the quiz for 3b. The analysis script is provided in Appendix 4.

Results

Sample characteristics

A total of 48 responses were recorded for Day 1 survey. However, 15 responses out of the 48 were uncompleted. Two responses were doubled up, two participants faced technical difficulties and 11 participants consented to participate but did not proceed. At the end, the study was left with 33 completed responses. Sample characteristics are presented in Table 2 alongside tests of differences in characteristics between groups. As can be seen in the table, the groups did not significantly differ on any characteristics. However, the Imagery group reported marginally significantly more stress (p = .061) and tended to be recruited closer to exam preparation week (p = .065).

Table 2

Descriptive statistics and group differences with respect to sample characteristics

	M(SD) or *n*(percentage)		Group difference[1]
	Breathing (*n* = 18)	Imagery (*n* = 15)	
Age	19.611 (4.217)	18.467 (0.915)	*p* = .277 *d* = 0.375
Gender	Male: 4 (22.2%) Female: 14 (77.7%) Non-binary: 0	Male: 3 (20%) Female: 11 (73.3%) Non-binary: 1 (6.6%)	p = .825
Ethnicity[2]	E: 6 (33.3%) As: 4 (22.2%) I: 0 ME: 1 (5.5%) O: 6 (33.3%) NS: 1 (5.5%)	E: 7 (46.6%) As: 3 (20%) I: 1 (6.6%) ME: 0 O: 4 (26.6%) NS: 0	p = .927
Language other than English spoken at home	Yes: 6 (33.3%) No: 12 (66.6%)	Yes: 4 (26.6%) No: 11 (73.3%)	*p* = .722

Religion	Yes: 9 (50%) No: 8 (44.4%) Prefer not to say: 1 (5.5%)	Yes: 6 (46.1%) No: 6 (46.1%) Prefer not to say: 1 (7.6%)	$p = 1$
Study Load	Full-time: 18 (100%) Part-time: 0	Full-time: 15 (100%) Part-time: 0	$p = .602$ $V = .091$
Domestic/ International Student	Domestic: 16 (88.8%) International: 2 (11.1%)	Domestic: 14 (93.3%) International: 1 (6.6%)	$p = 1$
Education[3]	Some HS: 2 (11.1%) HS: 12 (66.6%) Voc: 1 (5.5%) HS and voc: 3 (16.6%)	Some HS: 0 HS: 15 (100%) Voc: 0 HS and voc: 0	$p = 1$
Employment	Full time: 1 (5.5%) Part time: 10 (55.5%) Contract/temp: 1 (5.5%) Looking for work: 2 (11.1%) Not looking: 3 (16.6%) Prefer not to say: 1 (5.5%)	Full time: 1(6.6%) Part time: 9 (60%) Contract/temp: 0 Looking for work: 3 (20%) Not looking: 2 (13.3%) Prefer not to say: 0	$p = 1$
Living Arrangement	Alone: 2 (11.1%) With family: 14 (77.7%) With partner: 2 (11.1%) With roommates: 0	Alone: 2 (13.3%) With family: 10 (66.6%) With partner: 2 (13.3%) With roommates: 1 (6.6%)	$p = .913$
Income (could raise $2000?)[4]	Easily 7 (38.8%) With sacrifices: 6 (33.3%) Drastic measures: 4 (22.2%) No: 1 (5.5%)	Easily: 4 (26.6%) With sacrifices: 8 (53.3%) Drastic measures: 3 (20%) No: 0	$p = .730$

Rural/Urban	Urban: 16 (88.8%) Rural: 2 (11.1%)	Urban: 14 (93.3%) Rural: 1 (6.6%)	$p = 1$
Relationship Status	Partnered: 3 (16.6%) Single 14 (77.7%) Prefer not to say: 1 (5.5%)	Partnered: 4 (26.6%) Single: 11 (73.3%) Prefer not to say: 0	$p = .825$
Days before exam preparation week at Day 1	25.611 (10.506)	18.933 (9.231)	$p = .061$• $d = 0.675$
First time working with R	Yes: 15 (100%)	Yes: 18 (100%)	$p = 1$
Academic stress	2.738 (0.487)	2.704 (0.528)	$p = .850$ $d = 0.067$
Personal Well-being index	6.659 (1.518)	6.610 (0.933)	$p = .91$ $d = 0.039$
Stress - single item	4.824 (2.270)	6.200 (1.781)	$p = .065$ • $d = 0.675$
Distress K6	2.731 (0.850)	2.833 (0.840)	$p = .733$ $d = 0.12$
Social Support	1.800 (0.636)	2.133 (0.574)	$p = .124$ $d = 0.55$

Note. [1]Independent samples t-tests were conducted for continuous variables, and Chi-square tests were conduclted for categorical variables. Fisher's exact tests were conducted instead of Chi-square tests for gender, education, language other than English spoken at home, religion, domestic/international student, education, employment, living arrangement, income, rural/urban, and relationship status.
[2]A = Aboriginal, E = European, As - Asian (Eastern), I - Indian, ME - Middle Eastern NA - North American, SA - South American, Af - African, O = Other, NS = Prefer not to say
[3]Some HS: Some high school, HS: High school, Voc: Vocational
• $.05 < p \leq .10$

Attention and Compliance

Descriptive statistics regarding attention and compliance in completing the interventions (breathing or imagery) and questionnaires is shown in Table 3. To a marginally significant degree (p=.075), the breathing group was more accurate in answering the attention check

questions presented after the audio exercises. As it can be seen, there were no significant group differences on other indicators of compliance and engagement: proportion of completed sessions, average delay in completing daily surveys, sleepiness or proportion of completed sessions in which participant left early.

Table 3

Descriptive statistics and group differences (independent samples t-tests) with respect to attention and compliance

	M(SD) or *n(*percentage)		Group difference[1]
	Breathing	Imagery	
Proportion of attention check questions correct	.857 (.174)	.950 (.115)	p = .075• d = 0.633
Proportion of completed sessions	.881 (.185)	.895 (.137)	p = .801 d = 0.088
Average delay in completing daily surveys (measured in days)	.936 (0.484)	1.043 (0.645)	p = .600 d = 0.188
Sleepiness	3.059 (1.596)	3.816 (2.098)	p = .262 d = 0.406
Proportion of completed sessions in which participant left early	.441 (.546)	.283 (.198)	p = .224 d = 0.427

• $.05 < p \leq .10$

Hypotheses 1-3b: Linear Mixed Effects Analyses

Results addressing Hypotheses 1 to 3b through linear mixed modelling are presented in Table 4, which also restates the hypotheses. Figures 2 and 3 present the associated descriptive

statistics. Figure 2 relates to the hypotheses involving general and academic stress (Hypotheses 1 to 2), and Figure 3 relates to the hypotheses regarding academic motivation (Hypotheses 3 to 3b).

In line with the first hypothesis that general stress will be lower in the Imagery group post-intervention, the interaction between Group and Time Period (Pre- vs. Post-Intervention) was significant ($p = 0.041$), and, as, Figure 2 indicates, in the expected direction. As Figure 2 further indicates, however, the baseline group difference in general stress (found to be marginally significant in the analysis of sample characteristics) contributed to the differences in general stress slope over time. Hypothesis 1a relating to differing trajectories in general stress across measured daily groups was also confirmed by a significant Group x Day interaction effect ($p < .001$) that, as Figure 2 indicates, partly reflected a baseline difference across groups. Notably, as Figure 2 shows, the interaction did reflect lower general stress in the Imagery group in later days; specifically, Day 5 onwards. This a preliminary indication that guided imagery reduces general stress more than a breathing intervention. Hypothesis 2 was not supported, in that no significant Group x Time Period (Pre- vs. Post-Intervention) was observed for academic stress.

As Table 2 and Figure 3 show, Hypotheses 3 to 3b were not supported in that there were no post-intervention group differences in the following indicators of academic motivation: scores on the task-oriented quiz ($p = .665$), time spent viewing the video ($p = .182$) and time spent taking the quiz ($p = .834$).

Table 4

Linear Mixed Effects (LME) and ANOVA conducted on Hypothesis 1-3

	Value	Sig.
Hypothesis 1: Compared to participants in a control condition (breathing exercise), participants in the guided imagery condition will report lower levels of general stress post-intervention	Intercept: 4.811 (0.524)	< .001***
	Period (Pre- vs. Post-Intervention): -0.902 (0.669)	0.178
	Group: 1.388 (0.767)	0.070
	Group x Period: 1.964 (0.964)	0.041*
Hypothesis 1a: Compared to participants in the control condition, participants in the guided imagery condition will display a more negative slope on daily reports of general stress.	Intercept: 4.860 (0.503)	< .001***
	Day: -0.117 (0.076)	0.125
	Group: 1.949 (0.743)	0.01**
	Group x Day: -0.438 (0.111)	<.001***
Hypothesis 2: Compared to participants in the control condition, participants in the guided imagery condition will report lower levels of academic stress post-intervention.	Intercept: 2.738 (0.105)	< .001***
	Period: 0.132 (0.089)	0.139
	Group: -0.034 (0.155)	0.827
	Group x Period: -0.165 (0.128)	0.199
Hypothesis 3: Compared to participants in the control condition, participants in the guided imagery condition will present with higher scores in their academic task-oriented quiz.	Intercept: 5.563 (0.583)	-
	Group: -0.363 (0.838)	.665
Hypothesis 3a: Compared to participants in the control condition, participants in the guided imagery condition will spend more time on viewing the video comprising part of the compulsory academic task.	Intercept:1132.8 (345.9)	-
	Group: -663.1 (497.3)	.182
	Intercept: 222.59 (47.09)	-

Hypothesis 3b: Compared to participants in the control condition, participants in the guided imagery condition will spend more time on the academic-oriented quiz.	Group: 14.21 (67.69)	.834

* .01 < p ≤ .05, ** .001 < p ≤ .01, *** p ≤ .001

Figure 2

Means and standard deviations of general stress and academic stress across days

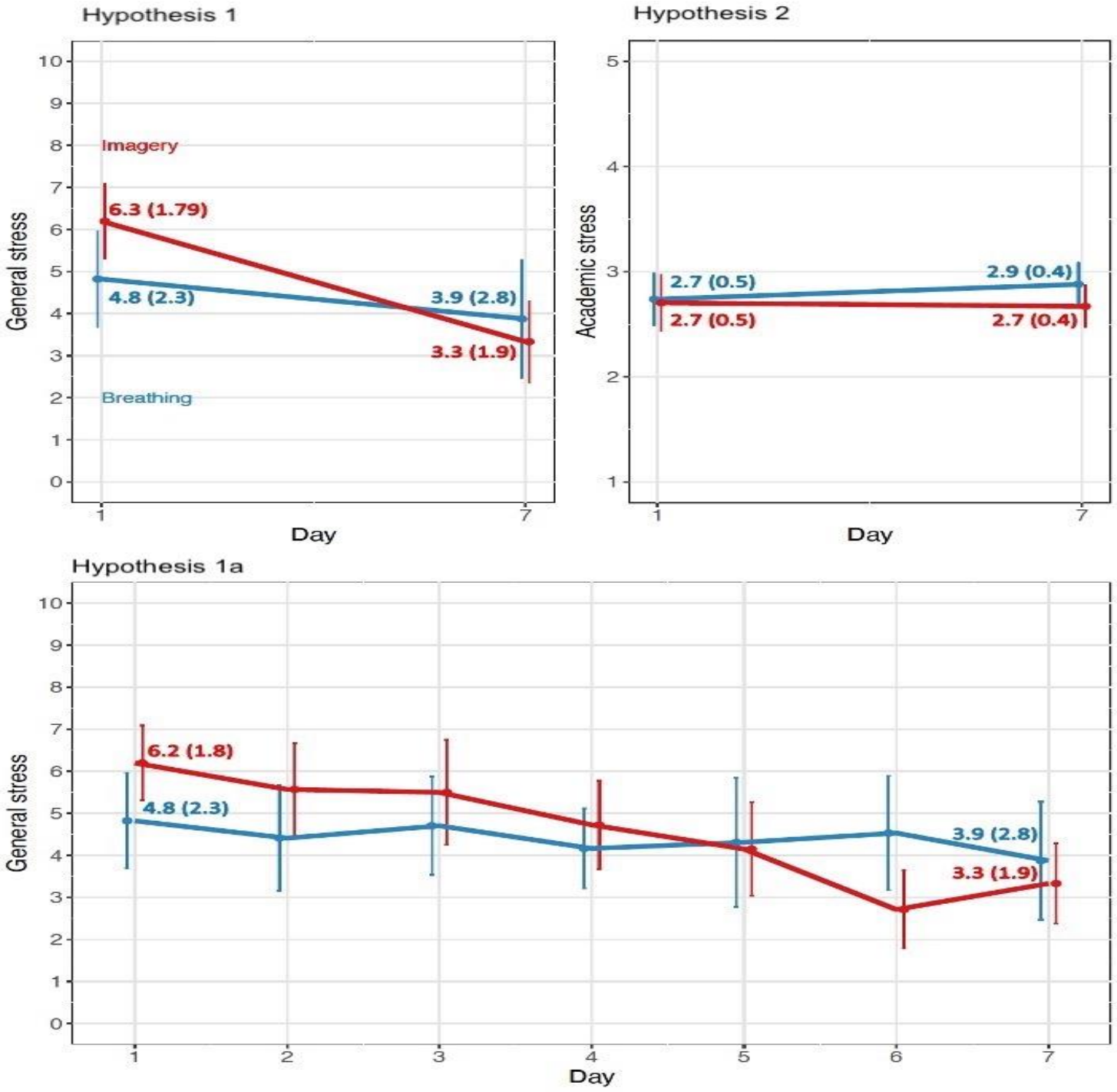
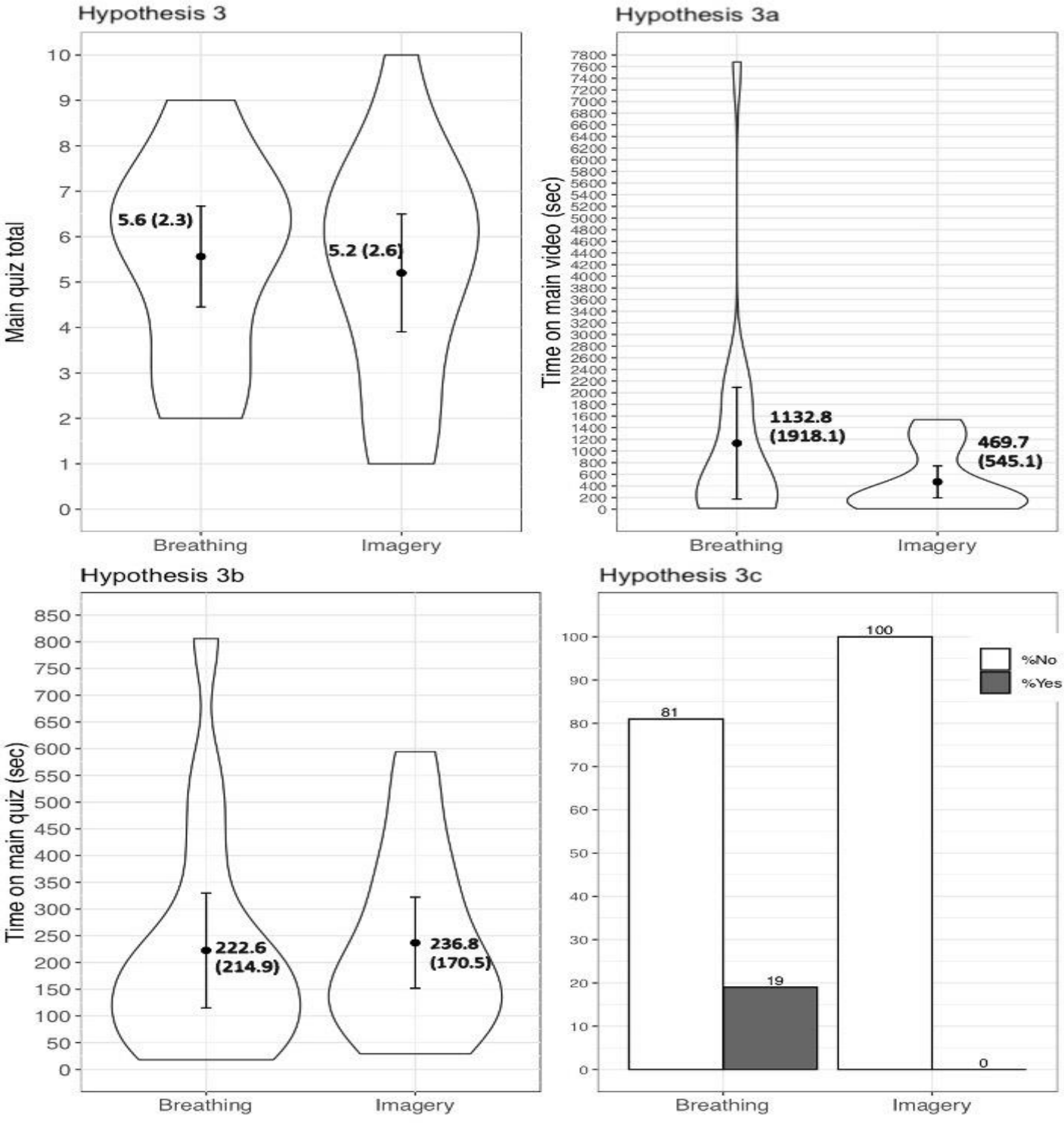


Figure 3

Means and standard deviations of total main quiz achieved, time spent on the main quiz, time spent on the main video and the proportion of participants took part in the voluntary task in both the conditions



Hypothesis 3d: Chi-square test

As Figure 3 also shows, no participants in the Imagery conduction attempted the voluntary task, and only two (19%) in the breathing group did so. A chi-square test indicated that this difference across groups was not statistically significant ($\chi^2(1, N = 33) = 1.34, p = .247$).

Discussion

The current study aimed to investigate the effectiveness of brief online guided imagery intervention in reducing general and academic stress over seven-day period. It also examined the effectiveness of this intervention in increasing academic motivation. Sustained practice of using GI for over seven days has been shown to reduce general stress. Further, a steeper negative slope in the imagery group was also observed, suggesting a preliminary indication of imagery reducing stress more than breathing. However, GI did not reduce academic stress, nor did it increase academic motivation.

GI's effects on general and academic stress

The findings show a significantly larger reduction in general stress following GI practice. This finding is in line with findings from past studies that examined effectiveness of GI in reducing stress levels in different populations (Bigham et al., 2014; Flynn et al., 2016; Jallo et al., 2014; Lee et al., 2013; Menzies et al., 2012). However, the findings are in contrast to a study conducted by Nilsson et al. (2015), where GI did not reduce stress or pain among children receiving vaccinations. A steeper negative slope in stress levels can be observed in the imagery, suggesting GI has reduced stress more. However, the baseline levels for stress in both the groups are different. Participants stress levels were different when they commenced the study. This is due to participants being recruited at different times of the semester and hence shown to have different levels of baseline stress levels. However, the findings do show a negative slope from Day 5 onwards, suggesting that imagery reduces stress more from Day 5 onwards.

The reduction of academic stress levels is one of the primary research gaps we wished to address. Interestingly, academic stress levels were fairly stable over the seven-day period and no

reduction was observed. The current study assessed academic stress more like a trait than as a state. The academic stress scale, used for the study, examines the study expectations', how students view themselves against their performance standards and expectations, their parents and teachers' expectations as well comparison against their peers (Bedewy & Gabriel, 2015). If the study assessed academic stress as a state, may be changes to the stress levels could have been observed.

GI's effects on academic motivation

The findings suggest that the sustained practice of using GI over seven-day period has not made any changes to their academic motivation levels. The scores achieved from the quiz was used as an indication of their level of motivation when answering the questions in the task. The quiz scores between both the conditions were found to be similar, denoting that GI has not increased participants' academic motivation. Having said that, the quiz scores achieved by both the groups are fairly low. This could be an indication of lack of interest in the task they were given, or the task might not have been engaging enough. Notably though, participants performed better than chance, suggesting the task was neither too hard nor too easy. However, task difficulty is not the same as academic motivation. Further, no differences were observed for the amount of time spent viewing the video across the two conditions. Similarly, no difference was found for the time spent completing the quiz. However, time is subject to variability due to people taking longer to watch the videos by re-watching them or taking breaks in between before they attempted the quiz. In regard to the participation in the voluntary task, only two participants attempted the task. With just two participants, the results remain inconclusive. Overall, it could be an indication that participants were not academically motivated enough to begin with, which

means there was not enough motivation to increase by the use of GI. Academic motivation generally comprises of intrinsic and extrinsic factors. Intrinsic motivation can be understood as internal motivation where one engages in activities because it is interesting and engaging (Amabile & Pratt, 2016; Di Domenico & Ryan, 2017; Lepper et al., 2005; Nawa & Yamagishi, 2021; Oudeyer, 2007; Ryan & Deci, 2000; Schiefele, 1991). Not being interested in the task given can be associated with student's intrinsic motivation. If participants do not find the task enjoyable then they lack intrinsic motivation, which might mean some level of academic motivation should be internal before GI can act as an intervention. Participants with high intrinsic motivation approaches the task, but participants with low intrinsic motivation avoids the task (Atkinson, 1974; McClelland, 1961; Kotera et al., 2021). Students who are less academically motivated, find it difficult to persist through their tasks and studies (Allen et al., 2008; Campbell, 1973; Gnambs & Hanfstingl, 2015). This might further explain why there was only two participants in the voluntary task.

In contrast, extrinsic motivation is where one engages in activities because they receive external rewards (Benabou & Tirole, 2003; Nawa & Yamagishi, 2021; Ryan & Deci, 2000). The scores achieved in the quiz can be associated with student's extrinsic motivation (Adamma et al., 2018; Stan, 2012). Perhaps, participants knowing that they will be assessed on the video they watched could be their extrinsic motivation. In other words, the scores could function as the participant's reward. Since the scores across the two groups are quite low, it might be an indication that participants were not driven by the fact that they would be assessed. This might indicate a lack of extrinsic motivation as well. The findings could be explained by both intrinsic and extrinsic motivational factors that affect academic motivation. However, these are possible

explanations only and because the sample is small it is difficult to make any definitive conclusions or recommendations.

Attention and compliance

Compliance and attention in both the conditions are similar except for the breathing group where participants have achieved slightly more correct responses for the attention check questions. One possible explanation for this is the duration of the imagery audios. Although the audio resources are brief, some participants might have experienced difficulty paying attention to them. Thus, less correct responses for the attention check questions in the imagery group. Another possible explanation is that GI might not be suitable for everyone. While many studies argue that GI works well for most people, it is a technique that requires the ability to imagine. Imagination is also depended on the individual's ability to enter an altered state of awareness. Additionally, one's hypnotic ability is also related to imagination. Being able to imagine or visualise is an ability in which there are individual differences (Bergmann et al., 2016; Cui et al., 2007; Lee et al., 2012; Kwekkeboom et al., 2008; Pearson et al., 2008). Some people have high hypnotic abilities which then help them absorb visuals more precisely, produce sophisticated images, recall dreams more frequently when awake and visualise with less eye movements (Fitzgerald & Langevin, 2014). When GI is tailored to personal preferences and requirements, it has been shown to give better experience for the individual (Carli et al., 2007; Olness, 2008). It is possible to increase GI's effectiveness by taking into account people's preferences for settings and whether they favour stimulation or relaxation (Fitzgerald & Langevin, 2014). Additionally, there are conditions like aphantasia and hyperphantasics that might affect the experience of using GI. People with aphantasia are unable to imagine mental images and hence guided imagery

might not work on them (Keogh & Pearson, 2018). According to the research, aphantasia has a prevalence of 3.9% in the general population of undergraduate students (Dance et al., 2022). On the other hand, people with hyperphantasics, experiences high vivid mental imagery (Zeman et al., 2020). Thus, there is a variability in imagining ability and it could affect how attentive or interested someone would be using GI.

Strengths and limitations

One of the main strengths of the study is the randomisation process that was set up in Qualtrics. Although the recruitment occurred at different times and randomisation has been impacted due to this, the research team was not involved in the process of the group allocation. A cause-effect relationship can be established from the randomised controlled trial. Additionally, the study followed careful graphing of analyses, so the unexpected trends were visible. Another strength of the study is that participants were not aware of the group they were assigned to. Participants were not aware of the existence of an intervention or control group. Instead, they were told that the study explores the effect of relaxation techniques on stress and mood. The study was a single-blind study, where only the researcher knew which group the participants were assigned to.

On the other hand, one of the major limitations of the study was small sample size. The study required (n = 128) of participants across the two conditions but we only had total of (n = 33) participants. Small sample size increases the margin of error and reduces the statistical power (Deziel, 2018; Eberly College of Science, n.d; Hackshaw, 2008) Larger sample size would have helped us to draw stronger conclusions about the effectiveness of the intervention and given

statistical power to the study Also, it would have helped the study give definitive recommendations for future research. Further, participants in the study are first year psychology students from the University of Adelaide, which limits the generalisability because the findings are only a representation of the students from one university.

Future research

The current study has a limited sample size; meaning the results obtained for general stress reduction might not be reliable and have a likelihood of type II error. Having said that, since the results are promising, a larger sample size as recommended by the a priori analysis of (n = 128) might be required to draw strong conclusions. Additionally, future research should consider using daily diary academic stress scale, where the measure contains a single item question asking how academically stressed, they feel over seven-day period (Moilanen et al., 2020). Single-item measures are especially useful when participation is required for several days. Single-item measures are less time consuming, feasible and easy to implement (Spector, 2022). Additionally, since the baseline stress levels were different, future study should recruit participants at two different time periods within the same semester. Participants should be recruited at the start of the semester, when they would have a lower academic load and thus be less stressed. This might help explore whether students might be more willing to persist through the novel tasks (both main task and voluntary task) when they are less stressed. Since research suggests several links between motivation, academic performance and academic stress, it would be interesting to see whether recruiting at different time periods would have any effect on the same. In other words, having two different periods of recruitment can help in examining how participants' academic motivation and performance are affected depending on their levels of

academic stress. Participants should also be recruited in the first week of the last quarter of the semester, which is closer to their examination period. This might mean students could have higher levels of academic stress and a change in stress level reduction could be observed from using the intervention. All participants should commence and finish the study on the same week, i.e., participants from the first recruitment group should start and finish at the same time. Similarly, participants from the second recruitment group should also commence and conclude at the same time. This ensures the baseline stress levels to be similar. The randomisation process will be more standardised across the two groups if all participants commence and finish the study in the same week. Future studies could further explore the effects time differences in recruiting has on the outcome variables in the study.

In regard to the voluntary task participation, a recommendation for future studies (with larger samples) is to investigate the relationship between the scores achieved on the main task and the willingness to take part in the voluntary task. This is because students who score higher find it easier to continue with their learning styles and approach because they experience academic achievement, suggesting internal motivation (Li & Pan, 2009; Saeed & Zyngier, 2012). Future studies could also consider assessing student's academic motivation on Day 1 and Day 7 through self-report measures. Time was one of the measures we used for academic motivation, however time is subject to variability. Similarly, both conditions received similar but low scores in the quiz. Perhaps, it is suggesting that future research should find alternate options to measure academic motivation. Self-report measures might give a better indication whether GI has increased their academic motivation on Day 7 since objective measures that were used in the current study were not able to assess any changes. It is also necessary to highlight that perhaps if the study had the required sample size, the results might have indicated an increase in academic

motivation post intervention. Thus, possibly another recommendation is to still keep the measures used from the current study but add a self-report measure as well. Nevertheless, it is to be restated that since the sample is small, definitive recommendations cannot be made.

Since there is a variability in imagining ability, it would be recommended to examine people's imagining ability prior to their commencement in the study. This would help predict the effectiveness of the intervention. A questionnaire assessing imagining ability such as the four-factor imagining scale (FFIS) could be administered post sign up. The scale examines the characteristics of the imaginative processes such as the regularity, emotional valence, intricacy and directedness of imagination (Zabelina & Condon, 2019). Another way to increase compliance is to make the audio exercises shorter; particularly, the imagery audio exercises as it was shown to have slightly lower levels of compliance and engagement.

Conclusion

While the study found a significant reduction of general stress in imagery group and the finding is consistent with the previous studies, it is important to reiterate that the current study lacks the recommended sample size, resulting in limited conclusions. Likewise, finding negative slope for the general stress levels in the imagery group is only a preliminary indication of a promising result. Non-significant results obtained for academic stress levels and academic motivation are also inconclusive because there are no evidences to suggest any positive impacts of the intervention. Administering a different academic stress scale, following the recommended sample size by the a priori analysis and changing the recruitment process are the main suggestions for future studies. In addition, exploring the relationship between the scores achieved

in the main task and the willingness to take part in the voluntary task could be examined. Academic stress has severe negative implications on the mental well-being of the university students. If future studies provide promising results for reduction in academic stress, then students could make use of the GI resources available.

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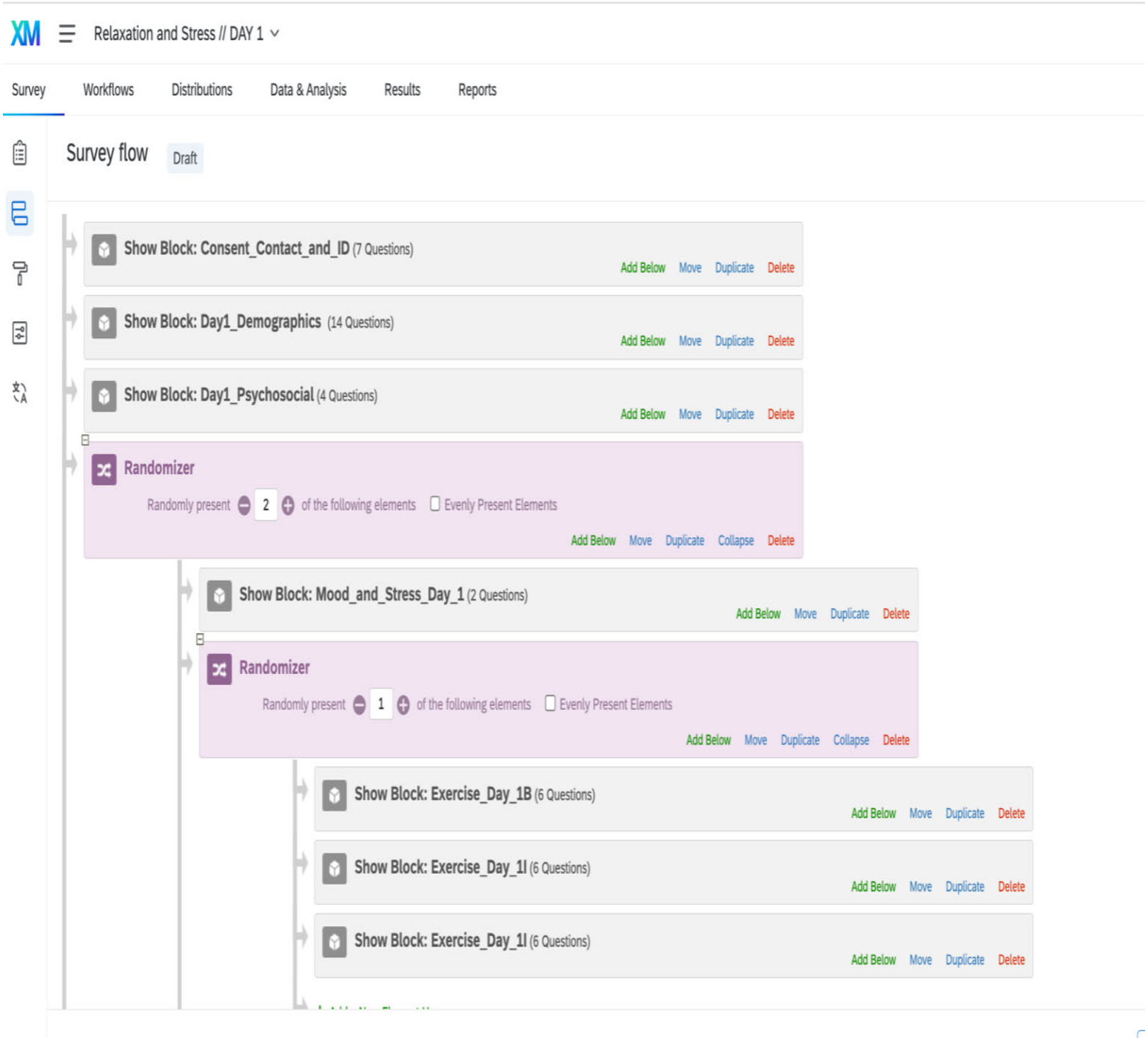
Appendix 1: Randomisation block



Appendix 2: Demographic variables

1. What is your age? Provide a whole number, rounding up to the nearest year.
2. What is your gender?
    a. Male
    b. Female
    c. Non-binary
    d. Prefer not to say
3. What is your ethnicity?
    a. Aboriginal
    b. European
    c. Asian – Eastern
    d. Indian
    e. Middle Eastern
    f. North American
    g. South American
    h. African
    i. Other
    j. Prefer not to say
4. Do you speak any language other than English at home?
    a. Yes
    b. No

    4a. Which language(s) other than English do you speak at home? Please tick all that apply.
        a. Arabic
        b. Cantonese
        c. Farsi
        d. German
        e. Greek
        f. Hindi
        g. Italian
        h. Korean
        i. Mandarin
        j. Punjabi
        k. Spanish
        l. Uiyghur
        m. Vietnamese
        n. Other
5. How would you describe your religion?
    a. Buddhist
    b. Christian
    c. Hindu
    d. Jewish
    e. Muslim
    f. Atheist

    g. Agnostic
    h. Other
    i. Prefer not to say
6. What is your study load?
    a. Full-time
    b. Part-time
7. Are you a domestic or international student?
    a. Domestic
    b. International
8. What levels of education have you completed leading up to your current degree? Tick all that apply.
    a. Some high school
    b. High school
    c. Vocational/TAFE
    d. Bachelor's degree
    e. Master's degree or above
    f. Other
9. What is your current employment status?
    a. Full-time
    b. Part-time
    c. Contract/ temporary
    d. Looking for work
    e. Not working and not looking for work
    f. Unable to work
    g. Other
    h. Prefer not to say
10. How would you describe your living arrangements?
    a. Living alone
    b. Living with family/parents
    c. Living with spouse/partner
    d. Living with roommates
    e. Other
    f. Prefer not to say
11. How easily could you raise $2,000 in an emergency?
    a. Easily
    b. With sacrifices
    c. Drastic measures would be needed
    d. I wouldn't be able to do it
12. Would you describe your place of residence as urban or rural?
    a. Urban
    b. Rural
13. What is your relationship status?
    a. Partnered
    b. Single
    c. Prefer not to say

Appendix 3: Perceived Academic Stress Scale Australian Version

Original Version	Australian Version
I think that my worry about examinations is weakness of character	I think that my worry about exams is a weakness of mine.
I believe that the amount of work assignment is too much	I believe that there is too much work required for assignments.
Am unable to catch up if getting behind the work	I am unable to catch up if I get behind on my work.
The examination questions are usually difficult	Exam questions are usually difficult.
Examination time is short to complete the answers	Exam times are too short to complete the answers.
Examination times are very stressful to me out	Exam times are very stressful to me.

Appendix 4: Statistical Analyses

Hypothesis 1

```
model1 <- lme4::lmer(Stress ~ Period + group + Period:group + (1|Student_ID),
data = data_long_Hyp1, REML = F)
summary(model1)
```

```
## Linear mixed model fit by maximum likelihood  ['lmerMod']
## Formula: Stress ~ Period + group + Period:group + (1 | Student_ID)
##    Data: data_long_Hyp1
##
##      AIC      BIC   logLik deviance df.resid
##    286.5    299.4   -137.3    274.5       57
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -1.8626 -0.6136 -0.0250  0.5673  2.1146
##
## Random effects:
##  Groups     Name        Variance Std.Dev.
##  Student_ID (Intercept) 1.074    1.036
##  Residual               3.615    1.901
## Number of obs: 63, groups:  Student_ID, 33
##
## Fixed effects:
##                         Estimate Std. Error t value
## (Intercept)               4.8113     0.5244   9.174
## PeriodPost               -0.9022     0.6693  -1.348
## groupImagery              1.3887     0.7666   1.812
## PeriodPost:groupImagery  -1.9644     0.9643  -2.037
##
## Correlation of Fixed Effects:
##             (Intr) PrdPst grpImg
## PeriodPost  -0.615
## groupImagry -0.684  0.421
## PrdPst:grpI  0.427 -0.694 -0.618
```

```
Anova(model1, type = 3)
```

```
## Analysis of Deviance Table (Type III Wald chisquare tests)
##
## Response: Stress
##                Chisq Df Pr(>Chisq)
## (Intercept)  84.1623  1    < 2e-16 ***
## Period        1.8174  1    0.17762
## group         3.2817  1    0.07006 .
## Period:group  4.1498  1    0.04164 *
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Hypothesis 1a

```
model1a <- lme4::lmer(Stress ~ Day + group + Day:group + (1|Student_ID), data
= data_long_Hyp2a, REML = F)
summary(model1a)
```

```
## Linear mixed model fit by maximum likelihood  ['lmerMod']
## Formula: Stress ~ Day + group + Day:group + (1 | Student_ID)
##    Data: data_long_Hyp2a
##
##      AIC      BIC   logLik deviance df.resid
##    849.7    869.6   -418.9    837.7      198
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.7310 -0.6355 -0.1084  0.7410  2.0605
##
## Random effects:
##  Groups     Name        Variance Std.Dev.
##  Student_ID (Intercept) 2.524    1.589
##  Residual               2.602    1.613
## Number of obs: 204, groups:  Student_ID, 33
##
## Fixed effects:
##                  Estimate Std. Error t value
## (Intercept)       4.86021    0.50259   9.670
## Day              -0.11708    0.07632  -1.534
## groupImagery      1.94881    0.74311   2.622
## Day:groupImagery -0.43758    0.11058  -3.957
##
## Correlation of Fixed Effects:
##             (Intr) Day    grpImg
## Day         -0.589
## groupImagry -0.676  0.398
## Dy:grpImgry  0.406 -0.690 -0.587
```

```
Anova(model1a, type = 3)
```

```
## Analysis of Deviance Table (Type III Wald chisquare tests)
##
## Response: Stress
##               Chisq Df Pr(>Chisq)
## (Intercept) 93.5143  1  < 2.2e-16 ***
## Day          2.3536  1   0.124994
## group        6.8775  1   0.008729 **
## Day:group   15.6576  1  7.591e-05 ***
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
model1a_rs <- lme4::lmer(Stress ~ Day + group + Day:group + (Day|Student_ID),
data = data_long_Hyp2a, REML = F)
summary(model1a_rs)
```

```
## Linear mixed model fit by maximum likelihood  ['lmerMod']
## Formula: Stress ~ Day + group + Day:group + (Day | Student_ID)
##    Data: data_long_Hyp2a
##
##      AIC      BIC   logLik deviance df.resid
##    846.5    873.1   -415.3    830.5      196
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.39640 -0.56762 -0.05922  0.64193  2.20681
##
## Random effects:
##  Groups     Name        Variance Std.Dev. Corr
##  Student_ID (Intercept) 2.75230  1.6590
##             Day         0.07503  0.2739   -0.37
##  Residual               2.22779  1.4926
## Number of obs: 204, groups:  Student_ID, 33
##
## Fixed effects:
##                   Estimate Std. Error t value
## (Intercept)       4.89082    0.50090   9.764
## Day              -0.12860    0.09705  -1.325
## groupImagery      1.91569    0.73964   2.590
## Day:groupImagery -0.42619    0.14114  -3.020
##
## Correlation of Fixed Effects:
##             (Intr) Day    grpImg
## Day         -0.603
## groupImagry -0.677  0.409
## Dy:grpImgry  0.415 -0.688 -0.599
```

```
Anova(model1a_rs, type = 3)
```

```
## Analysis of Deviance Table (Type III Wald chisquare tests)
##
## Response: Stress
##               Chisq Df Pr(>Chisq)
## (Intercept) 95.3373  1  < 2.2e-16 ***
## Day          1.7558  1   0.185146
## group        6.7082  1   0.009597 **
## Day:group    9.1184  1   0.002530 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Hypothesis 2

```
model2 <- lme4::lmer(Ac_Stress ~ Period + group + Period:group + (1|Student_ID), data = data_long_Hyp2, REML = F)
summary(model2)
```

```
## Linear mixed model fit by maximum likelihood  ['lmerMod']
## Formula: Ac_Stress ~ Period + group + Period:group + (1 | Student_ID)
##    Data: data_long_Hyp2
##
##      AIC      BIC   logLik deviance df.resid
##     71.1     84.1    -29.6     59.1       58
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.98432 -0.42778  0.03341  0.39569  2.06527
##
## Random effects:
##  Groups     Name        Variance Std.Dev.
##  Student_ID (Intercept) 0.13243  0.3639
##  Residual               0.06473  0.2544
## Number of obs: 64, groups:  Student_ID, 33
##
## Fixed effects:
##                          Estimate Std. Error t value
## (Intercept)               2.73765    0.10466  26.158
## PeriodPost                0.13193    0.08913   1.480
## groupImagery             -0.03395    0.15523  -0.219
## PeriodPost:groupImagery -0.16526    0.12874  -1.284
##
## Correlation of Fixed Effects:
##             (Intr) PrdPst grpImg
## PeriodPost  -0.386
## groupImagry -0.674  0.260
## PrdPst:grpI  0.267 -0.692 -0.396
```

```
Anova(model2, type = 3)
```

```
## Analysis of Deviance Table (Type III Wald chisquare tests)
##
## Response: Ac_Stress
##                Chisq Df Pr(>Chisq)
## (Intercept)  684.2376  1     <2e-16 ***
## Period         2.1910  1     0.1388
## group          0.0478  1     0.8269
## Period:group   1.6478  1     0.1993
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Hypothesis 3

```
model3 <- lme4::lmer(main_quiz_total ~ group + (1|Student_ID), data = data_me
rged, REML = F,
     control=lmerControl(check.nobs.vs.nlev = "ignore",
     check.nobs.vs.rankZ = "ignore",
     check.nobs.vs.nRE="ignore"))

## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkCon
v, :
## unable to evaluate scaled gradient

## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkCon
v, :
## Hessian is numerically singular: parameters are not uniquely determined

summary(model3)

## Linear mixed model fit by maximum likelihood  ['lmerMod']
## Formula: main_quiz_total ~ group + (1 | Student_ID)
##    Data: data_merged
## Control:
## lmerControl(check.nobs.vs.nlev = "ignore", check.nobs.vs.rankZ = "ignore",
##     check.nobs.vs.nRE = "ignore")
##
##      AIC      BIC   logLik deviance df.resid
##    148.4    154.2    -70.2    140.4       27
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -1.7485 -0.7832  0.1821  0.5985  1.9983
##
## Random effects:
##  Groups     Name        Variance Std.Dev.
##  Student_ID (Intercept) 0.3194   0.5652
##  Residual               5.1108   2.2607
## Number of obs: 31, groups:  Student_ID, 31
##
## Fixed effects:
##              Estimate Std. Error t value
## (Intercept)    5.5625     0.5826   9.548
## groupImagery  -0.3625     0.8375  -0.433
##
## Correlation of Fixed Effects:
##             (Intr)
## groupImagry -0.696
## optimizer (nloptwrap) convergence code: 0 (OK)
## unable to evaluate scaled gradient
##  Hessian is numerically singular: parameters are not uniquely determined
```

```
Anova(model3)

## Analysis of Deviance Table (Type II Wald chisquare tests)
##
## Response: main_quiz_total
##        Chisq Df Pr(>Chisq)
## group 0.1873  1     0.6651

rbind(psych::describe(predict(model3)), psych::describe(data_merged$main_quiz
_total))

##     vars  n mean   sd median trimmed  mad  min   max range  skew kurtosis
se
## X1     1 31 5.39 0.23   5.36     5.4 0.26 4.95  5.76  0.81 -0.20    -1.01
0.04
## X11    1 31 5.39 2.38   6.00     5.4 1.48 1.00 10.00  9.00 -0.22    -0.84
0.43

VarCorr(model3)

##  Groups     Name        Std.Dev.
##  Student_ID (Intercept) 0.56518
##  Residual               2.26071

model3_glm <- glm(main_quiz_total ~ group, family=poisson(link = "log"), data
= data_merged)
summary(model3_glm)

##
## Call:
## glm(formula = main_quiz_total ~ group, family = poisson(link = "log"),
##     data = data_merged)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -2.2589  -0.8733   0.1831   0.5857   1.8651
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)   1.71605    0.10600  16.189   <2e-16 ***
## groupImagery -0.06739    0.15510  -0.434    0.664
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for poisson family taken to be 1)
##
##     Null deviance: 35.728  on 30  degrees of freedom
## Residual deviance: 35.539  on 29  degrees of freedom
##   (2 observations deleted due to missingness)
## AIC: 145.79
```

```
##
## Number of Fisher Scoring iterations: 4
```

```
rbind(psych::describe(predict(model3_glm)), psych::describe(data_merged$main_
quiz_total))
```

```
##     vars  n mean   sd median trimmed  mad  min   max range  skew kurtosis
se
## X1     1 31 1.68 0.03   1.72    1.68 0.00 1.65  1.72  0.07 -0.06    -2.06
0.01
## X11    1 31 5.39 2.38   6.00    5.40 1.48 1.00 10.00  9.00 -0.22    -0.84
0.43
```

Hypothesis 3a

```
model3a <- lme4::lmer(time_main_vid ~ group + (1|Student_ID), data = data_mer
ged, REML = F,
     control=lmerControl(check.nobs.vs.nlev = "ignore",
     check.nobs.vs.rankZ = "ignore",
     check.nobs.vs.nRE="ignore"))
summary(model3a)
```

```
## Linear mixed model fit by maximum likelihood  ['lmerMod']
## Formula: time_main_vid ~ group + (1 | Student_ID)
##    Data: data_merged
## Control:
## lmerControl(check.nobs.vs.nlev = "ignore", check.nobs.vs.rankZ = "ignore",
##     check.nobs.vs.nRE = "ignore")
##
##      AIC      BIC   logLik deviance df.resid
##    544.4    550.1   -268.2    536.4       27
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -0.5717 -0.3872 -0.1859  0.2542  3.3456
##
## Random effects:
##  Groups     Name        Variance Std.Dev.
##  Student_ID (Intercept) 957177   978.4
##  Residual               957177   978.4
## Number of obs: 31, groups:  Student_ID, 31
##
## Fixed effects:
##              Estimate Std. Error t value
## (Intercept)    1132.8      345.9   3.275
## groupImagery   -663.1      497.3  -1.333
##
## Correlation of Fixed Effects:
##             (Intr)
## groupImagry -0.696
```

```
Anova(model3a)

## Analysis of Deviance Table (Type II Wald chisquare tests)
##
## Response: time_main_vid
##        Chisq Df Pr(>Chisq)
## group 1.7782  1     0.1824

rbind(psych::describe(predict(model3a)), psych::describe(data_merged$time_mai
n_vid))

##     vars  n   mean      sd median trimmed    mad    min     max   range sk
ew
## X1     1 31 811.98  779.75 619.30  667.45 466.42 239.31 4406.03 4166.72 3.
18
## X11    1 31 811.98 1446.25 205.74  524.49 275.43   8.88 7679.22 7670.34 3.
47
##     kurtosis     se
## X1     11.74 140.05
## X11    13.50 259.75
```

The model is not doing a good job of estimaing the median, but is doing okay with the trimmed median

```
VarCorr(model3a)

##  Groups     Name        Std.Dev.
##  Student_ID (Intercept) 978.35
##  Residual               978.35

model3a_glm <- glm(time_main_vid ~ group, data = data_merged)
summary(model3a_glm)

##
## Call:
## glm(formula = time_main_vid ~ group, data = data_merged)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1118.7   -757.7   -363.7    497.5   6546.4
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)    1132.8      357.6   3.168   0.0036 **
## groupImagery   -663.1      514.1  -1.290   0.2073
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for gaussian family taken to be 2046378)
##
##     Null deviance: 62749054  on 30  degrees of freedom
```

```
## Residual deviance: 59344955  on 29  degrees of freedom
##   (2 observations deleted due to missingness)
## AIC: 542.39
##
## Number of Fisher Scoring iterations: 2
```

```
rbind(psych::describe(predict(model3a_glm)), psych::describe(data_merged$time
_main_vid))
```

```
##     vars  n   mean      sd  median trimmed    mad    min     max   range
skew
## X1     1 31 811.98  336.85 1132.84  814.55   0.00 469.74 1132.84  663.10 -
0.06
## X11    1 31 811.98 1446.25  205.74  524.49 275.43   8.88 7679.22 7670.34
3.47
##     kurtosis     se
## X1     -2.06  60.50
## X11    13.50 259.75
```

Run t-test

```
independentSamplesTTest(time_main_vid ~ group,
  data = data_merged,
  var.equal = FALSE,
  one.sided = FALSE,
  conf.level = 0.95)
```

```
## Warning in independentSamplesTTest(time_main_vid ~ group, data = data_merg
ed, :
## 2 case(s) removed due to missingness
```

```
##
##    Welch's independent samples t-test
##
## Outcome variable:   time_main_vid
## Grouping variable:  group
##
## Descriptive statistics:
##             Breathing Imagery
##    mean      1132.836 469.740
##    std dev.  1918.063 545.140
##
## Hypotheses:
##    null:        population means equal for both groups
##    alternative: different population means in each group
##
## Test results:
##    t-statistic:  1.327
##    degrees of freedom:  17.557
##    p-value:  0.202
##
```

```
## Other information:
##    two-sided 95% confidence interval:[-388.738, 1714.929]
##    estimated effect size (Cohen's d):  0.47
```

Hypothesis 3b

```
model3b <- lme4::lmer(time_main_quiz ~ group + (1|Student_ID), data = data_me
rged, REML = F,
     control=lmerControl(check.nobs.vs.nlev = "ignore",
     check.nobs.vs.rankZ = "ignore",
     check.nobs.vs.nRE="ignore"))
summary(model3b)
```

```
## Linear mixed model fit by maximum likelihood  ['lmerMod']
## Formula: time_main_quiz ~ group + (1 | Student_ID)
##    Data: data_merged
## Control:
## lmerControl(check.nobs.vs.nlev = "ignore", check.nobs.vs.rankZ = "ignore",
##     check.nobs.vs.nRE = "ignore")
##
##      AIC      BIC   logLik deviance df.resid
##    420.7    426.5   -206.4    412.7       27
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -0.7822 -0.4715 -0.2069  0.3653  2.1991
##
## Random effects:
##  Groups     Name        Variance Std.Dev.
##  Student_ID (Intercept) 17603    132.7
##  Residual               17870    133.7
## Number of obs: 31, groups:  Student_ID, 31
##
## Fixed effects:
##              Estimate Std. Error t value
## (Intercept)    222.59      47.09   4.727
## groupImagery    14.21      67.69   0.210
##
## Correlation of Fixed Effects:
##             (Intr)
## groupImagry -0.696
```

```
Anova(model3b)
```

```
## Analysis of Deviance Table (Type II Wald chisquare tests)
##
## Response: time_main_quiz
##        Chisq Df Pr(>Chisq)
## group 0.0441  1     0.8337
```

```
rbind(psych::describe(predict(model3b)), psych::describe(data_merged$time_mai
n_quiz))

##     vars  n   mean     sd median trimmed    mad    min    max  range skew
## X1     1 31 229.47  95.28 198.80  216.90  73.36 121.06 512.17 391.10 1.17
## X11    1 31 229.47 191.59 174.64  203.62 157.19  17.99 806.14 788.14 1.20
##     kurtosis    se
## X1      0.71 17.11
## X11     0.82 34.41

VarCorr(model3b)

##  Groups     Name        Std.Dev.
##  Student_ID (Intercept) 132.68
##  Residual               133.68

model3b_glm <- glm(time_main_quiz ~ group, data = data_merged)
summary(model3b_glm)

##
## Call:
## glm(formula = time_main_quiz ~ group, data = data_merged)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -207.57  -125.11   -54.89    96.93   583.54
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    222.59      48.68   4.572 8.31e-05 ***
## groupImagery    14.21      69.99   0.203    0.841
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for gaussian family taken to be 37919.94)
##
##     Null deviance: 1101241  on 30  degrees of freedom
## Residual deviance: 1099678  on 29  degrees of freedom
##   (2 observations deleted due to missingness)
## AIC: 418.75
##
## Number of Fisher Scoring iterations: 2

rbind(psych::describe(predict(model3b_glm)), psych::describe(data_merged$time
_main_quiz))

##     vars  n   mean     sd median trimmed    mad    min    max  range skew
## X1     1 31 229.47   7.22 222.59  229.41   0.00 222.59 236.80  14.21 0.06
## X11    1 31 229.47 191.59 174.64  203.62 157.19  17.99 806.14 788.14 1.20
##     kurtosis    se
```

```
## X1     -2.06  1.30
## X11     0.82 34.41
```

Run t-test

```
independentSamplesTTest(time_main_quiz ~ group,
  data = data_merged,
  var.equal = FALSE,
  one.sided = FALSE,
  conf.level = 0.95)
```

```
## Warning in independentSamplesTTest(time_main_quiz ~ group, data = data_mer
ged, :
## 2 case(s) removed due to missingness
```

```
##
##    Welch's independent samples t-test
##
## Outcome variable:   time_main_quiz
## Grouping variable:  group
##
## Descriptive statistics:
##             Breathing Imagery
##    mean       222.593 236.802
##    std dev.   214.877 170.523
##
## Hypotheses:
##    null:        population means equal for both groups
##    alternative: different population means in each group
##
## Test results:
##    t-statistic:  -0.205
##    degrees of freedom:  28.259
##    p-value:  0.839
##
## Other information:
##    two-sided 95% confidence interval:  [-156.427, 128.009]
##    estimated effect size (Cohen's d):  0.073
```

Hypothesis 3c
Chi-square analysis

```
lsr::associationTest(~ group + VolunteeredYN, data = data_merged)
```

```
## Warning in lsr::associationTest(~group + VolunteeredYN, data = data_merged
): 2
## case(s) removed due to missingness
```

```
## Warning in lsr::associationTest(~group + VolunteeredYN, data = data_merged
):
## Expected frequencies too small: chi-squared approximation may be incorrect

##
##      Chi-square test of categorical association
##
## Variables:   group, VolunteeredYN
##
## Hypotheses:
##    null:        variables are independent of one another
##    alternative: some contingency exists between variables
##
## Observed contingency table:
##            VolunteeredYN
## group        0  1
##   Breathing 13  3
##   Imagery   15  0
##
## Expected contingency table under the null hypothesis:
##            VolunteeredYN
## group          0    1
##   Breathing 14.5 1.55
##   Imagery   13.5 1.45
##
## Test results:
##    X-squared statistic:  1.338
##    degrees of freedom:  1
##    p-value:  0.247
##
## Other information:
##    estimated effect size (Cramer's v):  0.208
##    Yates' continuity correction has been applied
##    warning: expected frequencies too small, results may be inaccurate
```

Fisher test

May not be needed in final analysis

```
fisher.test(data_merged$group, data_merged$VolunteeredYN)

##
## Fisher's Exact Test for Count Data
##
## data:  data_merged$group and data_merged$VolunteeredYN
## p-value = 0.2258
## alternative hypothesis: true odds ratio is not equal to 1
## 95 percent confidence interval:
##  0.00000 2.48557
## sample estimates:
```

```
## odds ratio
##          0
```