Investigation of the Effect of Stress Mindset on the Relationship between Perceived Stress and Mental Health in Students

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Abstract

Stress management issues are a major component affecting students' mental health. Recently, a successful approach has been developed to help students effectively manage their stress perception: changing their mindset towards stress through an intervention (Keech et al., 2021). According to Crum et al. (2013), *stress mindset* is a set of beliefs one holds about the consequences of experiencing stress. To accelerate research in this area, this study aimed to (a) test whether stress mindset moderates the association between perceived stress and mental health outcomes; (b) evaluate the efficacy of an extended version of the imagery-based intervention by Keech et al. (2021) in changing stress mindset and (c) examine the effect of the intervention on mental health outcomes, compared to a control group, and comparing baseline vs. one-week follow-up measurement.

A preregistered randomised controlled trial design was used for the investigation. Students from the Dutch University of Twente (N = 82) filled out an online survey twice over a period of one week, assessing their stress mindset, perceived stress level, and depressive and anxiety symptoms. In the first session, students received the intervention or control condition stimuli, consisting of videos. After three days, students in the intervention condition completed another mental imagery task to boost the effect.

A moderated linear regression analysis revealed that stress mindset moderates the relationship between perceived stress and mental health. Mixed model ANOVAs revealed a significant difference in stress mindset among intervention group participants immediately post intervention, at one-week follow-up, and in comparison to the control group. The additional mental imagery task was successful in preserving the intervention's impact. There were also robust effects of the intervention on depressive symptoms, although not on anxiety.

The findings suggest that the employed intervention is a potential approach for altering students' stress mindset and improving their well-being. Future research could focus on conducting intensive longitudinal designs to further investigate the stimulation of stress mindset. Developing interventions for different populations and various types of stress could also be a topic worth investigating in future research projects.

Keywords: perceived stress, stress mindset, depression, anxiety, intervention, mental imagery, students

1. Introduction

The impact of stress on all areas of health is a growing global issue. *Stress* is experienced as tension when an external event seems to exceed our ability to cope because all resources have been exhausted (Lazarus & Launier, 1978; Lovallo, 2016). According to Marks (2021), stress can have detrimental effects on health as it can lead to serious mental health issues such as depression and anxiety, as well as obesity, heart attacks and strokes. One at-risk group particularly affected by rising levels of stress are students, given the demands placed on young adults during their studies (Peer et al., 2015). In a recent study, Barbayannis et al. (2022) discovered that students reported an exacerbation in perceived stress in relation to the COVID-19 pandemic. The concept of *perceived stress* refers to a person's feelings or thoughts about how much stress is experienced at a certain time or throughout a given period (Phillips, 2013). Additionally, Barbayannis et al. (2022) found that when the perceived stress level of their participants increased, their mental health status decreased. *Mental health* is “a state of well-being in which individuals realise their potential, can cope with the normal stressors of life, can work productively and fruitfully, and are able to make a contribution to the community” (World Health Organization, 2022, para. 1). Hence, to meet the demands of their studies and reach their full potential, students must be able to manage their stress perception so that their mental well-being does not suffer as a result. In light of the consequences of the COVID-19 pandemic, it seems more important than ever to investigate the link between perceived stress and mental health to expand the potential for effective interventions. Therefore, priority should be given to current research on interventions to improve students' stress management and thereby protect their mental health.

A growing body of evidence shows that stress management problems are a major component influencing students’ mental well-being. A study by Liu et al. (2019) revealed that high perceived stress levels among students are closely associated with a higher likelihood of mental health problems and suicide attempts. The severity of the problem is further demonstrated by a cross-sectional study, carried out by the Dutch University of Twente in 2019 (Kelders et al., 2019). They discovered that the level of perceived stress and symptoms of depression and/or anxiety are prevalent and high among their students and that only about a fifth did not suffer from at least mild depression or anxiety symptoms. Moreover, they found that a sizable portion of 75% of students experiencing symptoms goes untreated (Kelders et al., 2019). This concerning finding is not distinctive to the Dutch university as similar results are found worldwide. In a cross-national sample of first-year students from 24 universities in 9 countries, Karyotaki et al. (2020) discovered a significant dose-response relationship between perceived stress and increased risk of mental disorders. Similar findings were obtained in a study conducted by Beiter et al. (2015), who observed an increasing trend of severe mental health symptoms in a student sample from the United States. Given the existing body of evidence, researchers should certainly aim to develop strategies to make studying less stressful, it seems equally vital to find ways in which students can foster their stress resilience, as stress's effects do not have to be entirely harmful (Crum et al., 2013). This idea is supported by multiple studies discovering that having a positive mindset toward stress can protect from its negative consequences (Crum et al., 2013; Huebschmann & Sheets, 2020; Jiang et al., 2019; Keech et al., 2021).

The mindset toward stress determines the evaluation of its consequences. According to Crum et al., (2013), *stress mindset* is a set of beliefs about the consequences of experiencing stress. They argue that stress mindset is not an appraisal of stress in the sense of determining whether a stressor is more or less stressful, instead, they claim that stress mindset is an evaluation of the "*nature of the stress itself"* (Crum et al., 2013, p. 718) as either enhancing or debilitating. Individuals who believe stress has a generally positive influence on their health, well-being, and productivity, have – according to Crum et al. (2013) – a *stress-is-enhancing mindset*, whereas those who believe stress is detrimental to their health, well-being and productivity have a *stress-is-debilitating mindset*. An example: An upcoming exam is perceived by a student as a stressful event, regardless of his/her stress mindset. However, someone with a stronger stress-is-enhancing mindset will believe that stress leads to positive outcomes (i.e. studying more efficiently, staying focused during the exam, and growing from the challenge). In contrast, according to Klussman et al. (2021), students with a stronger stress-is-debilitating mindset are likely to believe that exam stress leads to negative outcomes (i.e. losing concentration, procrastinating, and making mistakes).

Stress mindset affects stress perception and stress-related health outcomes. According to Crum et al., (2013) the mindset toward stress, rather than the actual level of stress, influences how much stress is perceived. This finding is further supported by the study of Park et al. (2018), who discovered that adolescents who adopted a stronger stress-is-enhancing mindset were less likely to report stress when confronted with adverse life events – such as a serious illness in the family or parents fighting more than usual – than those who endorsed a stress-is-debilitating mindset. Moreover, in a study by Keller et al. (2005), it was investigated whether people with high-stress levels were more likely to die in the next five years. Their hypothesis was confirmed, but only in cases where the individuals had a stress-is-debilitating mindset. This study provides evidence that the decisive factor in longer life expectancy is not stress level, but how people perceive stress. Therefore, stress mindset appears to operate as a moderator between perceived stress and health outcomes.

Having a stress-is-enhancing mindset comes with several advantages. Growing evidence from multiple studies shows that people endorsing a positive stress mindset report better mental health and fewer symptoms of depression and anxiety (Huebschmann & Sheets, 2020; Keech et al., 2021). Moreover, in some studies, the stress-is-enhancing mindset even acted as a buffer against the harmful effects of stress on depression, by activating more problem-focused behaviours and reducing arousal levels (Grünenwald et al., 2022; Jenkins et al., 2021; Jiang et al., 2019; Keech et al., 2018). Furthermore, researchers looking at the relationship between stress mindset, health, and performance discovered that people with a positive stress mentality had better coping skills, higher self-reported physical health and well-being, and performed better academically while being under stress (Casper et al., 2017; Keech et al., 2018). All in all, the investigation of stress mindset has shed considerable light on one of the potential explanatory factors for a person's self-reported mental and physiological health status.

To investigate stress mindset, Crum and colleagues (2013) developed a Stress Mindset Measure (SMM). The scale measures stress mindset as fixed-enhancing and fixed-debilitating. Keech et al. (2018) criticise this conceptualisation of measuring a fixed stress mindset as in the study by Crum et al. (2013), the scores indicated that people tend to see stress as debilitating by default. Furthermore, Keech et al. (2018) argue that a change in one's stress mindset would require a complete paradigm shift in the conceptualisation of stress in individuals. Thereupon, Keech et al. (2018) suggest that stress mindset should not be viewed as fixed, but rather seen from a nuanced point of view, such as stress "can be" beneficial. Following their new insights, Keech and colleagues (2018) developed a new assessment tool, which is based on the SMM: the Stress Control Mindset Measure (SCMM). According to this approach, Keech et al. (2018) recommend developing interventions that convey a holistic view of stress. The study by Liu et al. (2017) supports this idea, finding that participants who watched videos that conveyed a balanced view of stress had significantly lower heart rates and diastolic blood pressure levels than participants who watched videos with a fixed view. In addition, they found that people who watched videos with an unbalanced framing subsequently responded less efficiently to stressors. Lui et al. (2017) interpreted their findings by suggesting that unbalanced framing of stress may have led to unrealistic expectations, thus hindering the development of adaptive responses to stress. To sum up, a non-dichotomous definition and measurement of stress not only contributes to a more accurate assessment of stress perception but also improves stress management.

Stress management can be improved by using interventions targeted to change peoples' stress mindset. In a study by Crum et al. (2013), they found that employees' stress mindset was malleable using an intervention of three short video clips. The outcome was that participants who watched videos with stress-is-enhancing messages not only adopted a stress-is-enhancing mentality, but also self-reported improved work performance and mental health as a result (Crum et al., 2013). Similar findings were made in an intervention conducted by Keech et al. (2021). The researchers launched their intervention by having the experimental group watch an informational video about the negative and positive consequences of stress, followed by an imagery exercise. In this exercise, they were asked to consider the possible good outcomes of stress in their life, as well as what they could do to experience these consequences (Keech et al., 2021). The results showed that the participants in the experimental group developed a stronger stress-is-enhancing mindset and especially individuals with high perceived stress levels benefited most from the intervention. However, the effect of the intervention declined over time and in a two-week follow-up survey no significant effect on health- and performance-related outcomes were found. In order to achieve long-term benefits, Keech and colleagues (2021) propose increasing the dose of extra imagery sessions during the trial. To summarise, interventions intended to alter students' stress mindset led to improved stress management, although contradictory findings were observed of its effect on mental health.

The goal of this research project is to identify a potential solution to the problem of unduly stressed students who suffer from mental health issues as a result. As a response, this study examines whether an intervention can change students’ stress mindset to improve their mental well-being. While Crum et al. (2013) observed post intervention an improvement in employees' mental health, Keech et al. (2021) did not find this effect in their student sample. Therefore, the present study aims to bridge the gap between these contradictory findings of the impact of stress mindset on mental health. This is accomplished by investigating the role of stress mindset in moderating the relationship between perceived stress and mental health, using an expanded version of the intervention by Keech et al. (2021). Their intervention proved to be successful in changing students' stress mindset, however, a diminished effect was observed over time. Therefore, in this study, an additional mental imagery exercise is added to reinforce the effect of the intervention. It is assumed that the boosting effect will not only maintain the students' stress mindset, but also positively influence their mental health, as it was found in the study by Crum et al. (2013).

The research questions that need to be answered are: (1) Is there a relationship between students' perceived stress levels and their mental health outcomes? (2) Does stress mindset moderate this relationship? (3) Is students' stress mindset modifiable through an intervention? (4) Do students who developed a stronger stress-is-enhancing mindset also have better mental health after the intervention?

Based on the reviewed literature, it is expected that higher perceived stress levels will be associated with worse mental health status (H1). Next, it is assumed that stress mindset will act as a moderator on the relationship between perceived stress and mental health (H2). Furthermore, it is expected that post intervention, students from the intervention group will have a stronger stress-is-enhancing mindset than at baseline (H3) and in comparison to the control group (H4). Lastly, it is hypothesised that post intervention, students from the intervention group will have better mental health than at baseline (H5) and in comparison to the control group (H6).

2. Methods

2.1 Participants

A total of 82 participants filled in the questionnaire in its entirety, of which 35 took part in the intervention condition and 47 in the control condition. For the intervention condition, a number of seven (20%) of the respondents were male, 27 (77%) were female and one (3%) person was non-binary/third gender, with ages ranging from 18 to 28 (M = 20.43, SD = 2.13). Furthermore, 11 (31%) of the respondents were Dutch, 22 (63%) were German and two (6%) people came from another country. For the control condition, a number of 11 (23%) of the respondents were male, and 36 (77%) were female, with ages ranging from 18 to 24 (M = 21, SD = 1.72). Furthermore, nine (19%) of the respondents were Dutch, 33 (70%) were German and five (11%) came from another country.

Participants were students, recruited from the University of Twente in the Netherlands through online advertisement, including a university participant pool (sona system). Eligibility criteria were being proficient in English, older than 18 years and current registration as an undergraduate student at the University of Twente. Students received sona credits as a token of appreciation for their participation.

A priori power analysis was conducted using GPower v3.1 for a mixed model ANOVA estimating repeated measures, within-between interactions. The effect size was set to detect a medium effect (f = .25), with power set to .8 and α = .05. The total minimum sample size required was n = 48 (24 participants in each condition). To allow for 20% attrition, the target sample size was a minimum of 60 participants.

2.2 Design and Procedure

The University of Twente Ethics Committee BMS/ Domain Humanities and Social Science approved the study (Requestnr. 221173). Data was collected in November 2022. The study was conducted entirely online, using Qualtrics Software and comprised a baseline and a follow-up session, which were separated by one week. In all sessions, participants received study information (see Appendix A) and provided informed consent (see Appendix B).

The intervention group had to complete three sessions, and the control group two. In the first session, a baseline measurement of the following study variables was taken: perceived stress level, stress mindset and depression and anxiety symptoms. This was followed by either the intervention or the control condition material. In addition, stress mindset was measured immediately after the intervention in both groups. Three days later, only those in the intervention group were required to complete another intervention activity. In the last session, participants of both groups completed a follow-up survey, including the same study variables as at baseline. Of the 89 participants, 82 (92 %) completed all sessions. No unintended consequences, harms, or adverse events were reported in the course of the study.

The study adopted a parallel two-group mixed (within-between) double-blind randomised controlled design. The study method and intervention materials were based on the work of Keech et al. (2021), who published their materials on the Open Science Framework: https://osf.io/en7q8/. The current study incorporated their videos and stress mindset assessment tool (SCMM). Besides Keech et al.'s video material, another video clip was added which contains another imagery task. In that video, participants in the intervention group were first reminded about the positive consequences of stress and then asked to advise another student on how to deal with stress more effectively by focusing on its positive aspects. This exercise was added to enhance participants' information processing and to avoid the diminishment of the intervention's effect over time. To ensure that participants watched the videos, a timer was put on the videos so that participants could only continue with the questionnaire at the time when the video was supposed to be over. In addition, participants had to answer an attention task question about the narrator's voice ("The narrator's voice was: male/female/no voice at all").

At the end of each session, participants were thanked for their participation and provided with the researchers contact details for asking questions or receiving further information about the project. In addition to that, in session one, all students were informed about the following steps and when to complete the next part of the study. This was also done for the students in the intervention group in session two.

2.2.1 Intervention Condition

In the first session, participants in the intervention group watched a series of videos and completed two imagery exercises, followed by writing down their thoughts. The first video provided them with an introduction to the activities. Second, they watched a video that informed them about the positive and negative consequences of stress (balanced view). Next, they practised a mental imagery task, “tangy lemon” (Holmes & Mathews, 2005), to get familiar with the exercise. Right after that participants were instructed to imagine potential positive consequences of the stress in their lives and the things they can do to experience positive consequences. Finally, students were instructed to write down their thoughts in a section below the video to enhance their information processing.

In the second session, three days later, participants in the intervention group were provided with a video, reminding them about the positive consequences of stress (see Appendix C for the video script). After that, they were asked to imagine themselves in a conversation with a fellow student who experiences high levels of stress and suffers from its negative consequences. Participants were asked to provide the student with advice on how his/her stress can also benefit him/her. Following this exercise, participants were asked to write down their imaginations in the space provided to boost the effectiveness of the intervention.

2.2.2 Control Condition

Participants in the control condition completed the “tangy lemon” mental imagery task equally to the intervention group.

2.2.3 Randomisation

Simple randomisation was used, randomly allocating each participant to one of the two groups. The randomisation was conducted employing Qualtrics randomisation features which used a Mersenne Twister pseudo-random number generator.

2.3 Measures

Stress mindset was measured at baseline, immediate post-intervention, and at the one-week follow-up. All other variables were measured at baseline and in the follow-up session.

2.3.1 Stress Mindset

Stress mindset was measured using the 15-item Stress Control Mindset Measure (SCMM; Keech et al., 2018). The items of this scale were based on the conceptualization of stress mindset by Crum et al. (2013) that consisted of four domains: performance and productivity, learning and growth, health and vitality and a general domain. The instrument measures stress mindset on a continuous scale, where a higher value means that a stronger stress-is-enhancing mindset prevails (min. 15, max. 90). Participants rate the extent to which they agree with a statement about stress (i.e., “You can use stress to boost your performance and productivity”) on a six-point Likert scale (1 = strongly disagree and 6 = strongly agree). Items 1, 4, 6, 10, 11, 12, 13, and 14 were negatively worded and scores needed to be reversed (i.e. “You are unable to use stress to enhance your performance and productivity”).

In the study by Keech et al. (2021) they found that in a student sample the complete scale exhibited excellent internal consistency (Cronbach’s α = .90) and the four subscales exhibited good internal consistency (performance and productivity α = .82; learning and growth α = .85; health and vitality α = .70; general domain α = .64).

Furthermore, Keech et al. (2021) found good test–retest reliability: baseline to immediate post-intervention, $r = 0.91$, $p < .001$; immediate post-intervention to follow-up $r = 0.92$, $p < .001$; baseline to follow-up, $r = 0.88$, $p < .001$. As the study showed consistent and predictive validity in the previous study with a similar sample population (students) this assessment tool was evaluated as an appropriate choice for the current research project.

2.3.2 Perceived Stress

To assess students’ perceived stress levels at baseline and follow-up, the 10-item Perceived Stress Scale (PSS-10; Cohen & Williamson, 1988) was used. In the first session, participants answered about how often they had felt or thought a certain way during the last month (e.g., “In the last month, how often have you felt nervous or stressed?”) on a scale from 0 (never) to 4 (very often). Higher levels of perceived stress were indicated by higher scores (max. 40).

In the follow-up session, the sentences were adapted to what they had felt or thought during the previous week to get an indication of how the intervention had affected their perceived stress levels (e.g., “In the last week, how often have you felt that you were unable to control the important things in your life?”).

In previous research, it has been summarised that the PSS-10 shows adequate internal consistency, test-retest reliability, and validity across different populations (Cohen et al., 1983; Liu et al., 2020; Mitchell et al., 2008). As the PSS-10 has been shown to highly correlate with variables such as depression, anxiety and life events (Cohen et al., 1983; Lee, 2012) it was a suitable instrument for the research study at hand.

2.3.3 Depressive Symptoms

Depression and anxiety symptoms were acquired from the students to assess their mental health. Depression was measured with the brief Patient Health Questionnaire (PHQ-9; Kroenke et al., 2001). This scale consists of nine questions that are scored on a scale from ‘Not at all’ (0) to

‘Nearly every day’ (3). Total scores are divided into four categories: ‘No depression’ (0-4), ‘Mild depression’ (5-9), ‘Moderate depression (10-14), ‘Moderately severe depression (15-19) and ‘Severe depression’ (20-27).

The PHQ-9 has been verified in several student samples (Adewuya et al., 2006; Zhang et al., 2013), shows good test-retest reliability (Adewuya et al., 2006; Kroenke et al., 2001) and correlates with other scales for depression and anxiety (Cameron et al., 2008; Zhang et al., 2013), making it a well-suited instrument for the study at hand.

2.3.4 Anxiety Symptoms

The brief measure for Generalised Anxiety Disorder (GAD-7) was used to measure anxiety (Spitzer et al., 2006). This scale is made up of seven questions that are rated on a range from ‘Not at all’ (0) to ‘Nearly every day’ (3). The total scores are divided into four groups: ‘Minimal anxiety’ (0-4), ‘Mild anxiety’ (5-9), ‘Moderate anxiety (10-14) and ‘Severe anxiety’ (15-21).

The GAD-7 has been utilised in several research studies on university students (Choueiry et al., 2016; Han et al., 2013), the test-retest reliability of the scale has been proven to be good (Spitzer et al., 2006) and previous studies have shown that it correlates with other variables such as depression and resilience (Löwe et al., 2008; Spitzer et al., 2006). Therefore, the GAD-7 was an appropriate tool for the study at hand.

2.4 Statistical Analysis

To analyse the data, the program R-Studio version 2002.07.9+576 was used. The complete R-code can be found in Appendix D. First, two linear models were created with perceived stress and stress mindset as independent variables and the mental health variables (depressive symptoms and anxiety symptoms) as dependent variables. This was done for pre- and post-measurements. To evaluate if the models can explain the data accurately, assumption checks were conducted.

After that, moderated linear regression analyses were performed to examine stress mindset as a moderator of the relationships between perceived stress and mental health outcomes. This, again, was done for both measurement points (pre- and post-intervention). In order to do so, the scores of perceived stress and stress mindset were adjusted to be mean-centred. For each regression model, perceived stress, stress mindset, and perceived stress × stress mindset interaction term were entered as predictor variables, with one of the mental health variables as the dependent variable. The linear regression models were tested to see if they meet the assumptions.

The effect of the intervention on stress mindset was evaluated using a 2 × 3 mixed model Analysis of Variance (ANOVA). Group was the between-subjects independent variable; time (pre-intervention, immediately post intervention, one-week follow-up) was the within-subjects variable and stress mindset was the moderating variable. Within-group changes in outcome across time intervals were compared, as were between-group differences in outcome at each time point. The ANOVA model was tested to see if it met the assumptions.

The effect of the intervention on the stress-related outcomes was evaluated using a series of 2 × 2 mixed model ANOVAs. Group was the between-participants independent variable; time (pre-intervention, immediately post intervention, one-week follow-up) was the within-participants variable; and perceived stress and mental health outcomes were separate dependent variables. Within-group differences in the outcome between time points, and between-group differences in the outcome at each time point were compared. The ANOVA models were tested to see if they meet the assumptions.

3. Results

Before starting with the analysis, the data set was scanned for missing data. Collected data from seven individuals, all from the intervention group, had to be eliminated ($n = 82$) based on various reasons. Two of the participants dropped out of the survey after not completing the first part of the study. Two other students did not complete the study in its entirety, missing the second imaginary task. The remaining three people did not finish the follow-up questionnaire of the study. The data set was also reviewed for suspicious responses, such as speedy response times, repetitive patterns of selected answers and the attention task being answered incorrectly. However, no further exclusion of data was required due to suspicious responses.

To start with the data analysis, firstly, the data sets' descriptive information was elaborated on and presented in Table 1. What is noticeable, the intervention group had at baseline a higher mean and minimum score on the stress mindset scale compared to the control group. A paired *t*-test revealed that the groups significantly differed in stress mindset scores and perceived stress level at baseline ($p < .05$). Strikingly, the intervention group's scores on stress mindset improved between baseline, immediate post-intervention and follow-up, whereas the control group's scores did not change particularly. Concerning the means of reported depression and anxiety symptoms, these decreased in both groups over the test period, although somewhat more in the intervention group. To get to the bottom of the initial cues of the results, the correlations of the individual variables were examined for significant relationships. For this purpose, the established hypotheses were tested.

Table 1

Estimated Marginal Means, Standard Errors, Minimum and Maximum Scores, and Confidence Intervals of Study Variables by Time and Group (n = 82)

	Control Group				Intervention Group				
Questionnaires	*M (SE)*	Min.	Max.	95% CI	*M (SE)*	Min.	Max.	95% CI	*p*-value
1. SCMM, Baseline	3.30 (0.12)	28	78	[3.07, 3.54]	3.64 (0.11)	38	77	[3.41, 3.87]	*
2. SCMM, immediate post-intervention	3.35 (0.12)	27	77	[3.11, 3.59]	4.20 (0.08)	47	75	[4.03, 4.37]	
3. SCMM, Follow-up	3.29 (0.12)	24	77	[3.04, 3.53]	4.20 (0.10)	33	76	[3.98, 4.42]	
4. PSS-10, Baseline	21.32 (0.97)	9	33	[19.4, 23.3]	17.94 (1.04)	7	28	[15.8, 20.1]	*
5. PSS-10, Follow-up	20.04 (1.02)	7	35	[18.0, 22.1]	16.60 (1.17)	6	37	[14.2, 19.0]	
6. PHQ-9, Baseline	9.96 (.80)	0	23	[8.34, 11.6]	8.00 (.67)	1	18	[6.63, 9.37]	.08
7. PHQ-9, Follow-up	8.98 (.81)	1	21	[7.35, 10.6]	5.77 (.59)	1	13	[4.56, 6.98]	
8. GAD-7, Baseline	9.25 (.81)	0	21	[7.63, 10.9]	7.80 (.83)	1	18	[6.12, 9.48]	.22
9. GAD-7, Follow-up	8.27 (.74)	0	18	[6.79, 9.76]	5.54 (.80)	0	18	[3.92, 7.17]	

Note. M = Estimated Marginal Mean; *SE* = Standard Error; Min. = Minimum Score; Max. = Maximum Score; 95% CI = 95% Confidence Interval; *p*-value was assessed by paired t-tests to compare baseline differences between groups; * $p < .05$; Baseline = Pre-Intervention; Follow-up = One-week Post-Intervention; SCMM = Stress Control Mindset Measure (Min. 15, Max. 90); PSS-10 = Perceived Stress Scale (Min. 0, Max. 40); PHQ-9 = Patient Health Questionnaire-9 (Min. 0, Max. 27); GAD-7 = General Anxiety Disorder-7 (Min. 0, Max. 21); Participants lost to attrition (n = 7) are not included in the estimates.

Prior testing the hypotheses, the scales were evaluated for internal consistency to ensure that the items of each survey measure the same construct and thus provide valid results. In the sample studied, the complete SCMM for assessing stress mindset had excellent internal consistency at all measurement points (Cronbach's α = .90 at baseline; Cronbach's α = .93 immediately after the intervention; and Cronbach's α = .94 at the one-week follow-up). The four subscales of the SCMM repeatedly showed good internal consistency (baseline: performance and productivity α = .84, learning and growth α = .82, health and vitality α = .71, general domain α = .62; immediate post-intervention: performance and productivity α = .85, learning and growth α = .80, health and vitality α = .73, general domain α = .61; follow-up: performance and productivity α = .86, learning and growth α = .85, health and vitality α = .73; general domain α = .60).

The PSS-10 measuring students' perceived stress levels had good internal consistency (Cronbach's α = .87 at baseline; Cronbach's α = .91 at one-week follow-up), as did the PHQ-9 measuring depressive symptoms (Cronbach's α = .82 at baseline; Cronbach's α = .84 at one-week follow-up). Cronbach's alpha for the GAD-7 to assess anxiety symptoms was α = .89 at baseline and α = .90 at one-week follow-up, demonstrating good internal consistency. As all scales had excellent or good internal consistency, this was a solid predictor for obtaining accurate results.

3.1 Direct Effects

The first hypothesis (H1) assumed that higher perceived stress levels are associated with worse mental health status. To test this hypothesis, two linear models were set up, with perceived stress level as the independent variable and either symptoms of depression or symptoms of anxiety as the dependent variable. This was done for both measurement points, i.e., baseline and one-week follow-up.

Before executing the analysis, the models were checked to ensure that they met four assumptions and thus provide reliable outputs. The models with the dependent variable 'depressive symptoms' met all four assumptions at baseline and one-week follow-up; the relationship between the variables was linear; the residuals were independent of each other; the residuals had equal variance (homoscedasticity); and the residuals were normally distributed. The models with the dependent variable 'anxiety symptoms' did not meet all assumptions, as the assumption of normal distribution of the residuals was violated at baseline and follow-up. Therefore, a non-parametric test was conducted. Spearman's rank correlation was computed to assess the relationship between perceived stress and anxiety symptoms at baseline and follow-up. A positive correlation was found between the two variables (baseline: $r(80) = .66$; follow-up: $r(80) = .74$) and the results provided evidence that the two variables were related to each other (baseline: $p < .001$; follow-up: $p < .001$). Based on the results of the parametric and non-parametric tests, it was concluded that the results of the models were valid and reliable. Therefore, the analysis was carried out.

The results of the linear regression analysis showed a significant effect of perceived stress on depressive symptoms ($b = 0.58$, $t(79) = .08$, $p = .001$, $R^2 = .45$) at baseline and at follow-up ($b = 0.49$, $t(79) = 7.07$, $p = .001$, $R^2 = .46$). When looking at the effect of perceived stress on anxiety, a significant effect was found at baseline ($b = 0.76$, $t(79) = 7.55$, $p = .001$, $R^2 = .44$) and at follow-up (*b* = 0.74, $t(79) = 8.82$, $p = .001$, $R^2 = .53$). Hence, these findings confirm the hypothesis that the perceived stress level significantly affected the students' depression and anxiety status.

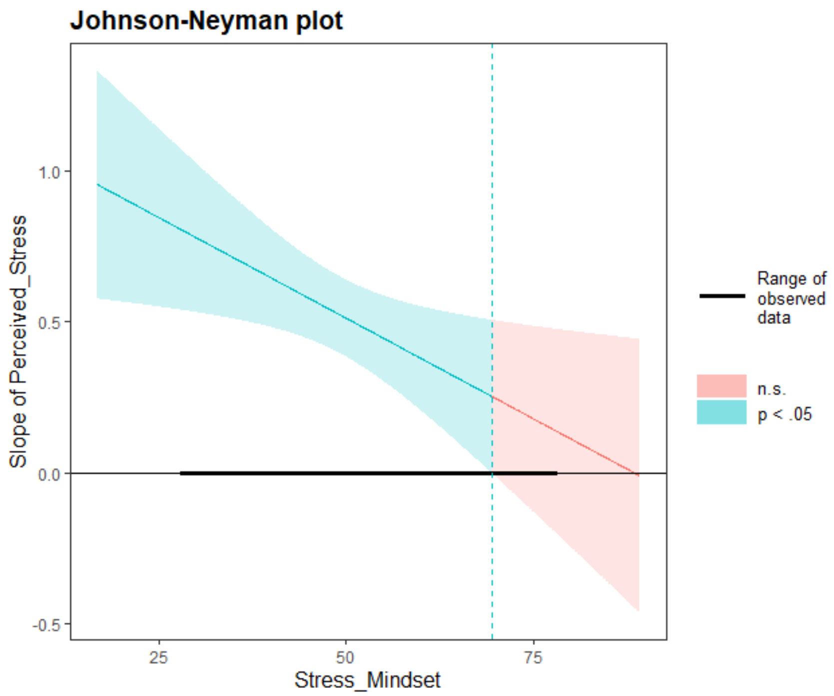
3.2 Interaction Effects

Next, it was assumed that stress mindset acts as a moderator of the relationship between perceived stress and mental health (H2). To investigate the moderating relationship, two linear regression models were tested at both measurement points (baseline and one-week follow-up). The regression model was based on either depressive or anxiety symptoms as the dependent variable, perceived stress as the independent variable, and stress mindset as the moderating variable. Again, before conducting the analysis, the models were first examined to see if they met all four assumptions. All models met the assumptions of a linear relationship between the variables, independence and equal variance. However, the distribution of the residuals was only normal in the models with 'depressive symptoms' as the dependent variable. As the models including 'anxiety scores' did not meet all assumptions, a non-parametric test, Friedman's test, was performed. The Friedman's test revealed that the participants had significantly different median scores for the examined variables (perceived stress, stress mindset and anxiety symptoms) at baseline ($\chi^2(2, n = 82) = 84.98$, $p < .001$) and at one-week follow-up ($\chi^2(2, n = 82) = 64.70$, $p < .001$). Using the outcomes of the parametric and non-parametric tests, it was determined that the model's outputs were valid and reliable. As a result, the analysis was carried out.

When controlling for depressive symptoms at baseline, the results of the linear regression analysis showed a significant interaction effect of perceived stress and stress mindset ($b = -.22$, $t(78) = -2.43$, $p = .017$, $R^2 = .49$). This was also the case at one-week follow up ($b = -.17$, $t(78) = -2.42$, $p = .018$, $R^2 = .50$). An exploration of the significant interaction effect with the Johnson-Neyman technique identified that perceived stress only had an effect on depressive symptoms when stress mindset scores were below 70 at baseline and below 72 at follow-up (see Figure 1 and 2). Moreover, the outcome of the analysis demonstrated that stress mindset had a moderating influence in 93% of the students at baseline and in 89% of the students at follow-up.

Figure 1

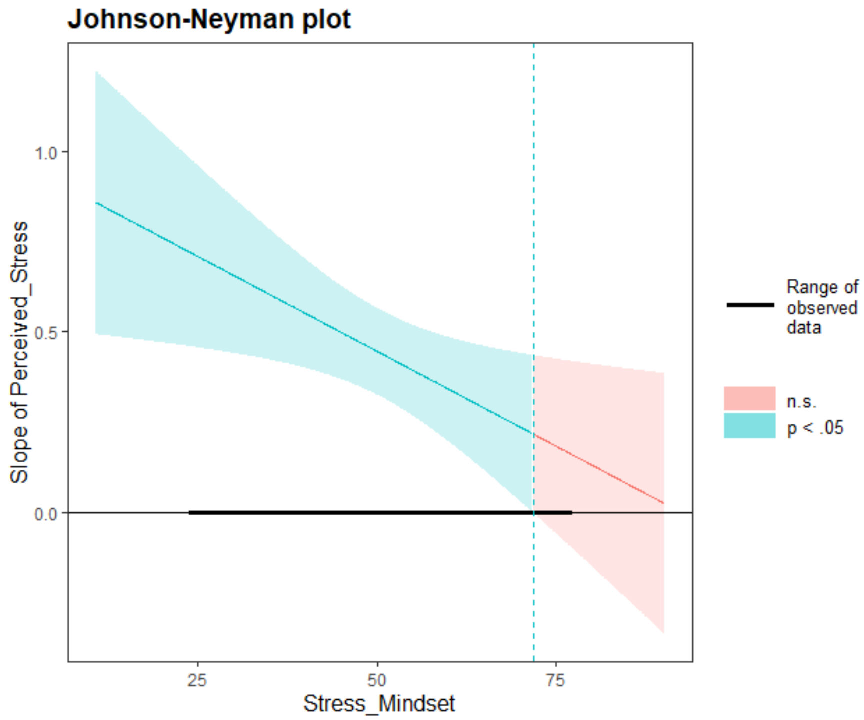
Johnson-Neyman Plot for the Significant Interaction Effect of Perceived Stress and Stress Mindset on Depressive Symptoms at Baseline



Note. X-axis = stress mindset scores pre-intervention; Y-axis = perceived stress scores pre-intervention; n.s. = not significant.

Figure 2

Johnson-Neyman Plot for the Significant Interaction Effect of Perceived Stress and Stress Mindset on Depressive Symptoms at One-Week Follow-Up

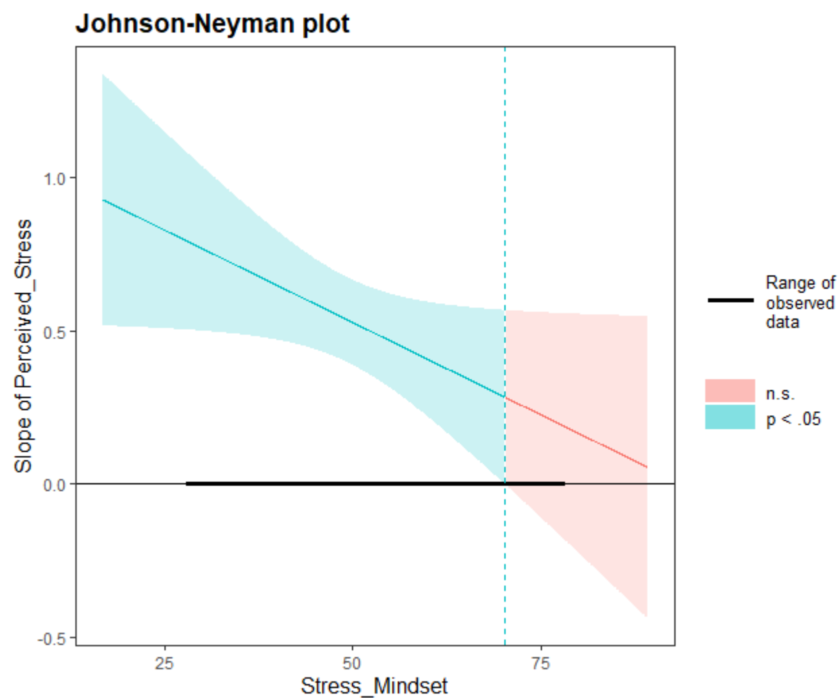


Note. X-axis = stress mindset scores post-intervention; *Y*-axis = perceived stress scores post-intervention; n.s. = not significant.

Looking at the interaction effect of perceived stress and stress mindset on anxiety symptoms, a significant effect was found at baseline (b = -.28, t(78) = -2.02, p = .047, R^2 = .47) but not at one-week follow-up (b = -.11, t(78) = -1.28, p = .204, R^2 = .54). An examination of the significant interaction effect at baseline with the Johnson-Neyman technique identified that perceived stress had a significant effect on anxiety symptoms when stress mindset scores were below 70 (see Figure 3). Moreover, the analysis demonstrated that stress mindset had a moderating influence on 93% of the students.

Figure 3

Johnson-Neyman Plot for the Significant Interaction Effect of Perceived Stress and Stress Mindset on Anxiety Symptoms at Baseline



Note. *X*-axis = stress mindset scores pre-intervention; *Y*-axis = perceived stress scores pre-intervention; n.s. = not significant.

In summary, the hypothesis that stress mindset acts as a moderator on the relationship between perceived stress and mental health was confirmed for depressive symptoms but had to be, at least partially, rejected for anxiety symptoms.

3.3 Stress Mindset

Students in the intervention group were expected to have a stronger stress-is-enhancing mindset post intervention compared to at baseline (H3) and in comparison to the control group (H4). This hypothesis was tested using a 2 × 3 mixed model ANOVA, with stress mindset scores as the dependent variable, group as the between-subjects independent variable, and time (pre-intervention, immediate post-intervention, one-week follow-up) as the within-subjects variable.

To obtain valid results, the model was first checked for compliance with eight assumptions (van den Berg, 2021). (1) The dependent variable is measured on a continuous basis. (2) The within-subject variable consists of at least two variables. (3) The between-subject factor consists of at least two categories. (4) There are no outliers in the model when assessing the boxplot. (5) The dependent variable is approximately normally distributed for each group at each measurement point. Assumption five is verified using a histogram. (6) There is homogeneity of covariance across all possible pairs of within-subject conditions and subgroups of the independent variables. This assumption is tested using Box's test of equality of covariance matrices. (7) There is homogeneity of variances across all possible pairs of within-subject conditions and subgroups of the independent variables. This assumption is checked by using Levene's test. (8) The variances of the differences between all possible pairs of within-subject conditions of the independent variable are equal. Mauchly's sphericity test is used to verify this assumption.

The model met the assumptions one, two, three, five and six. The fourth assumption was violated, due to three outliers in the model (see boxplot in Figure 5). The seventh assumption of homogeneity of variances was met for all measurement points, except for 'immediate post-intervention', as assessed by Levene's test ($p < .05$). Lastly, Mauchly's test of sphericity indicated that the assumption of sphericity was violated as well ($p = .005$).

Consequently, the correction method of Greenhouse-Geisser was applied to the calculation of the ANOVA table to ensure that the output was reliable. In addition, the non-parametric Kruskal-Wallis rank sum test was administered. Based on its output the null hypothesis was rejected since the equal distribution of stress mindset scores per measurement point across all groups was not given, ($\chi^2(1,\ n = 246) = 46.165$, $p < .001$). After checking the assumptions and performing corrections and non-parametric tests, it could be ensured that the results of the models were reliable and valid, which is why the ANOVA was carried out.

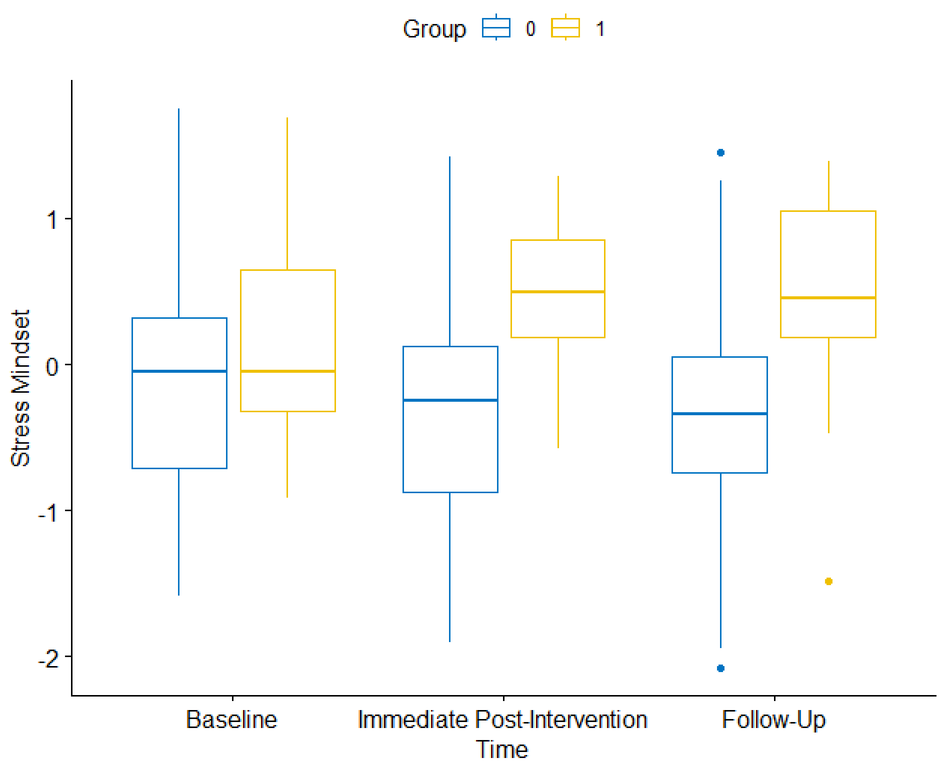
When performing the analysis, a mixed model ANOVA revealed a statistically significant two-way interaction effect between the independent variables 'group' and 'time' on the dependent variable 'stress mindset', $F(2, 160)= 20.33$, $p < .001$. This result indicates that changes in stress mindset scores across time points were different between groups and therefore supports hypothesis four.

Furthermore, to probe the interaction effect, simple main effects were examined. When taking a closer look at the intervention group, stress mindset scores were found to increase significantly from pre-intervention to immediate post-intervention ($p < .001$). These scores did not change significantly between immediate post-intervention and one-week follow-up ($p = 1$). The effect size of the intervention remained large and was significantly larger than at baseline ($p = .004$). Hence, the intervention group displayed a stronger stress-is-enhancing mindset after the intervention than before, supporting hypothesis three.

Beyond that, the examination of the simple main effects revealed that there was a significant difference between the intervention and control group at baseline ($p = .045$). This will be taken into account when interpreting the results. Unexpectedly, the control group's stress mindset scores also changed significantly during the test period, both, from baseline to immediate post-intervention ($p < .001$), and from baseline to the one-week follow-up ($p = .002$). However, stress mindset scores were significantly higher in the intervention group compared to the control group immediately post intervention ($p < .001$) and at follow-up ($p < .001$). The changes in stress mindset between the groups during the test period are shown in Figure 4. The boxplot clearly indicates that the intervention group developed a higher stress mindset score than the control group, supporting hypothesis four.

Figure 4

Boxplot of Interaction Effect of Time and Group on Stress Mindset



Note. Group 0 = control group; Group 1 = intervention group.

3.4 Mental Health

Students from the intervention group were expected to show better mental health post intervention compared to at baseline (H5) and the control group (H6). In order to evaluate mental health data/scores two two-way mixed ANOVA models were set up. One with 'depressive symptoms' as the dependent variable and another one with 'anxiety symptoms' as the dependent variable. In both models 'time' was set as the within-subjects variable and 'group' as the between-subjects independent variable.

To obtain valid results, the models were first checked for compliance with the following assumptions (van den Berg, 2021). (1) The dependent variable is measured on a continuous basis. (2) The within-subject variable consists of at least two variables. (3) The between-subject factor consists of at least two categories. (4) There are no outliers in the model when assessing the boxplot. (5) The dependent variable is approximately normally distributed for each group at each measurement point. Assumption five is verified using a histogram. (6) There is homogeneity of covariance across all possible pairs of within-subject conditions and subgroups of the independent variables. This assumption is tested using Box's test of equality of covariance matrices. (7) There is homogeneity of variances across all possible pairs of within-subject conditions and subgroups of the independent variables. This assumption is checked by using Levene's test. (8) The variances of the differences between all possible pairs of within-subject conditions of the independent variable are equal. Mauchly's sphericity test is used to verify this assumption.

Both models met the assumption one, two, three and six. The fourth assumption was violated due to three outliers in each model (see boxplot in Figures 6 and 7). Furthermore, the fifth assumption of the dependent variable being approximately normally distributed for each group at each measurement point was violated in the model that included 'anxiety symptoms'. The seventh assumption, homogeneity of variances, was violated for the measurement point 'follow-up' in the model that included 'depressive symptoms', as assessed by Levene's test ($p < .05$). Lastly, the assumption of sphericity was violated in both models, as Mauchly's test of sphericity indicated, $p = .005$.

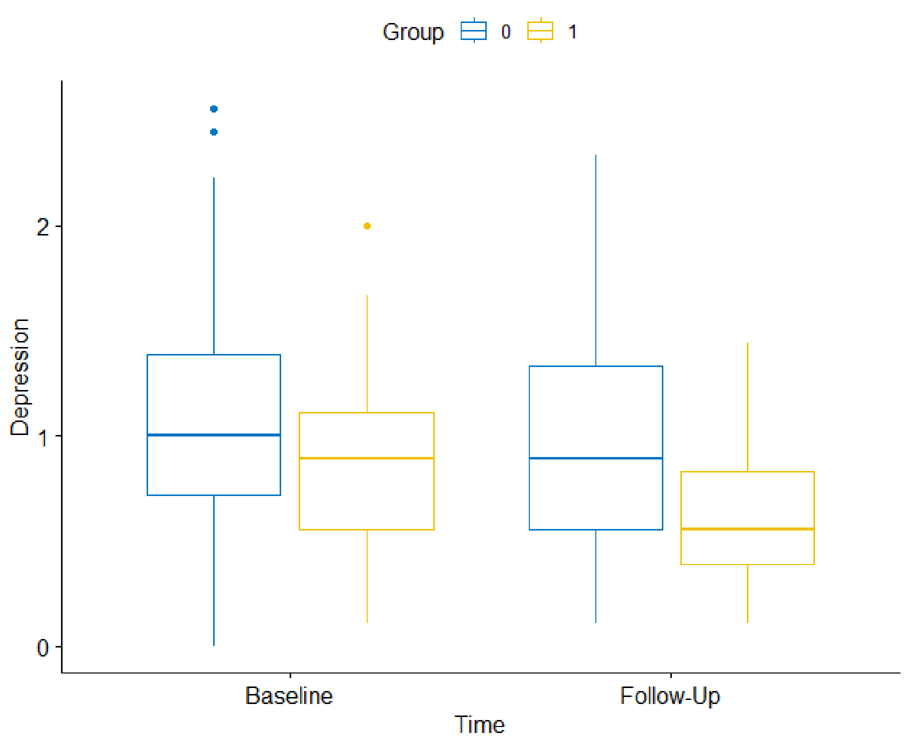
Consequently, the correction method of Greenhouse-Geisser was applied to the calculation of the ANOVA tables to ensure the reliability of the outputs. In addition, the non-parametric Kruskal-Wallis rank sum test was performed for each model. Based on the results of this test, the null hypotheses on depression scores per measurement point being distributed equally for all groups ($\chi^2(1, n = 164) = 8.84$, $p = .002$), and anxiety scores per measurement point being distributed equally for all groups ($\chi^2(1, n = 164) = 6.71$, $p = .009$) was rejected. After checking the assumptions and performing corrections and non-parametric tests, it could be ensured that the results of the models were reliable and valid, which is why the ANOVA was carried out.

When performing the analysis, the output of the ANOVA table revealed a statistically significant two-way interaction between the independent variables 'group' and 'time' on the dependent variable 'depressive symptoms', $F(1, 80) = 3.18$, $p = .004$. The result indicated that changes in reported depressive symptoms across time points were not equivalent between groups and therefore supported hypothesis six. Furthermore, to probe the significant interaction effect, simple main effects were examined.

Further examination of the intervention group demonstrated that depression scores decreased significantly from pre-intervention to one-week follow-up ($p < .001$). Hence, the intervention group had lower depression scores after the intervention, supporting hypothesis five. Beyond that, the examination of the simple effects revealed that there was no significant difference between the intervention and the control group at baseline ($p = .078$). Unexpectedly, the control group's depression scores also changed significantly during the test period, from baseline to one-week follow-up ($p = .041$). However, depression scores were significantly lower in the intervention group compared to the control group at follow-up ($p = .004$). The changes in depressive symptoms between the groups during the test period are shown in Figure 5 and clearly indicate that the intervention group developed lower depression scores than the control group, further supporting hypothesis six.

Figure 5

Boxplot of Interaction Effect of Time and Group on Depressive Symptoms



Note. Group 0 = control group; Group 1 = intervention group.

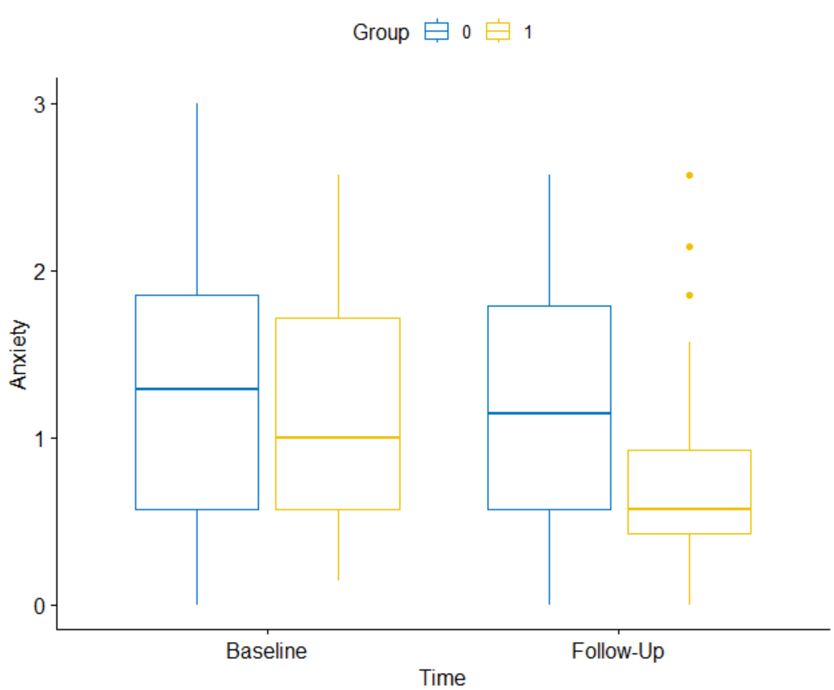
Turning to the second ANOVA table with anxiety symptoms as the dependent variable, the outcome revealed a statistically non-significant two-way interaction between the independent variables ‘group’ and ‘time’ on the dependent variable ‘anxiety symptoms’, $F(1, 80)= 2.04$, $p = .157$. This result indicates that changes in reported anxiety symptoms across time points were not significantly different between groups and therefore rejected hypothesis six. To probe the non-significant interaction effect, simple effects were examined.

When taking a closer look at the simple effects, they revealed that there was no significant difference in anxiety scores between the intervention and control group at baseline (p = .220). Furthermore, the control group's anxiety scores did not change significantly during the test period, from baseline to one-week follow-up (p = .088). The reported changes in anxiety symptoms between the groups during the test period are shown in Figure 6. The boxplot indicates that the intervention group developed a lower anxiety score than the control group throughout the tested period.

To conclude, the interaction effect of time and group on anxiety was not significant, although the boxplots indicated a shift toward lower scores. Hence, the hypothesis that post intervention, students from the intervention group would have better mental health than at baseline (H5) and in comparison to the control group (H6) can only be accepted for depressive symptoms but needs to be rejected for anxiety symptoms.

Figure 6

Boxplot of Interaction Effect of Time and Group on Anxiety Symptoms



Note. Group 0 = control group; Group 1 = intervention group.

To summarise the findings, the hypothesis on higher perceived stress levels being associated with worse mental health status (H1) was accepted, as well as that stress mindset moderating this relationship (H2). Next, the hypotheses on students from the intervention group having a stronger stress-is-enhancing mindset post intervention vs. baseline (H3) and in comparison to the control group (H4) also were accepted. Lastly, the hypothesis that post intervention, students from the intervention group have better mental health than at baseline (H5) and in comparison to the control group (H6) was only partially accepted. The hypothesis was only true for depressive symptoms and not for anxiety symptoms.

4. Discussion

The goal of this research project was to identify a potential solution to the problem of unduly stressed students who consequently suffer from mental health issues. As a response, this study developed and tested an intervention targeted at changing students' stress mindset in order to improve their mental well-being. The purpose of this research study was to find a bridge between the contradictory findings of the impact of stress mindset on mental health. While Crum et al. (2013) observed post intervention an improvement in employees' mental health, Keech et al. (2021) did not find this effect in their student sample. Therefore, the role stress mindset plays in moderating the relationship between perceived stress and mental health was investigated, using an extended version of the intervention by Keech et al. (2021), incorporating an additional mental imagery task. The present study demonstrates an intervention that effectively changed students' stress mindset into a stronger stress-is-enhancing mindset immediately post intervention and at a one-week follow-up evaluation. Moreover, these changes in stress mindset positively correlated with improvements in students' well-being. These findings add value to previous research on stress mindset by demonstrating that maintaining a stress-is-enhancng mindset can have a positive impact on one's mental health.

Before going into the major findings of this study, the scores of the present sample are evaluated by comparing them with norm groups. This allows for a deeper insight into the characteristics of the sample under study. When comparing the reported mean scores on the PSS-10 to a norm group of American citizens between the ages of 18 and 29 (Cohen, 1994), it becomes evident that the current sample perceived higher stress levels than the norm group at all measurement points and across both groups. The norm group reported an average level of perceived stress of $M = 14.2$, whereas in the present sample, the intervention group achieved the lowest mean score measured of $M = 16.60$ at follow-up (see Table 1).

For the SCMM, no normative data has been collected yet. The research conducted by Keech et al. (2021) is the only study that has utilised the SCMM on a similar population (Australian students), thus the estimated marginal means of the two studies will be compared. First of all, the control groups of both studies showed similar means in stress mindset scores at baseline, around *M* = 2.29. However, the intervention groups differed at baseline, as the current study had a higher mean (*M* = 3.35 vs. *M* = 3.64). At immediate post-intervention, both studies observed an increase in the mean of stress mindset scores in their intervention groups (around *M* = 4.24). About the mean of the control group, in the study by Keech et al. (2021), the mean remained approximately the same immediately post-intervention and at follow-up (*M* = 3.28), whereas in the current study stress mindset scores first increased immediately post-intervention (*M* = 3.35) and then decreased again at follow-up (*M* = 3.29). The major difference between the two studies is the intervention group's follow-up score. In the study by Keech et al. (2021), the mean on stress mindset scores declined over time (*M* = 4.02), however in the current study, it remained constant (*M* = 4.20). This finding supports the idea that the added mental imagery task had a boosting impact on students' stress-is-enhancing mindset.

Furthermore, when looking at the PHQ-9 scores at baseline and at follow-up, a comparison with a norm group of 344 German university students (Kocalevent et al., 2013) revealed that the current sample reported more depressive symptoms than the norm group at all measurement points and across both groups. The norm group reported an average level of depressive symptoms of *M* = 2.5, whereas the intervention group achieved a score of *M* = 5.77 at follow-up, which was the lowest score measured.

When the analysed sample's average level of anxiety symptoms is compared to that of a norm group of 14-24-year-old Germans (Löwe et al. 2008), it becomes clear that the sample reported throughout the study more symptoms than the norm group. The norm group had an average level of *M* = 2.76, whereas the intervention group achieved the lowest score in anxiety symptoms across both groups at follow-up, *M* = 5.54.

Overall, it is evident that the current sample scored higher in comparison to norm groups in terms of perceived stress and mental health symptoms. These findings are in line with the previous study carried out by the Dutch University of Twente in 2019 (Kelders et al., 2019). They discovered that the level of perceived stress and symptoms of depression and anxiety are prevalent and high among their students. According to the present results, this situation has not changed by now and students are still suffering from stress-related health outcomes.

Four key findings can be identified in the research study at hand. First, the results support the hypothesis that perceived stress significantly correlates with depressive and anxiety symptoms at baseline and follow-up. The results are consistent with the growing body of evidence showing that high levels of perceived stress have negative effects on students’ mental well-being. For example, Barbayannis et al. (2022) discovered a significant negative correlation between stress perception and mental health in their student sample. These findings go along with Liu et al. (2019), who found an association between students' perceived stress levels and the likelihood of mental health problems and suicide attempts. All in all, the results of this study support the hypothesis that perceived stress levels influence students' mental health status.

Second, the results of the present study provide supporting evidence for the hypothesis that stress mindset acts as a moderator on the relationship between perceived stress and mental health. At baseline, the moderating influence of stress mindset was significant for both, depressive and anxiety symptoms. Moreover, stress mindset had a moderating influence on about 90% of the students, making it a highly relevant factor in understanding the relationship between perceived stress and mental health. This finding is consistent with the work of Huebschmann and Sheets (2020) who observed a consistent pattern of higher perceived stress levels and a rising number of self-reported mental health issues in a sample of students.

At follow-up, the influence of stress mindset on the relationship between perceived stress and mental health was only significant for depressive symptoms. The missing effect for anxiety symptoms may be explained by the idea that the moderating effect is less powerful when a stronger stress-is-enhancing mindset is present. Since the analysis showed that the mean of stress mindset scores increased for both groups from baseline to follow-up, the enhancement may have led to a reduction in the moderation effect. This interpretation is in line with the findings of a longitudinal study of pregnant women by Taouk et al. (2021). Their study revealed that the moderating effect of stress mindset on the relationship between perceived stress and anxiety symptoms was strongest when stress was viewed as debilitating. Moreover, the effect grew weaker as the stress mindset became more positive, and was no longer significant when stress was evaluated as enhancing (Taouk et al., 2021). Noticeably, Taouk et al., (2021) used the same mental health questionnaires (PHQ-9, GAD-7) as the current study did, making the results well comparable. Thus, the same concepts of anxiety and depression were measured in both studies, which supports the idea that the same effect occurred.

Another possible explanation for the differing findings for depression and anxiety at follow-up is the occurrence of outliers. As it was the case that outliers were found when controlling for anxiety at follow-up (see Figure 6), it may be the case that they increased the variability in the data, which consequently led to the consequence of decreased statistical power.

The third finding of this research project is that the applied intervention successfully modified students' stress mindset into a stronger stress-is-enhancing mindset. This result is consistent with previous outcomes of interventions that were targeted to change stress mindset. Just as in the mental imagery-based intervention by Keech et al. (2021), a significant change in students' stress mindset was found immediately post intervention, at follow-up, and comparing intervention vs. control group. Likewise, the intervention by Crum et al. (2013), who used short video clips to persuade their participants of a stress-is-enhancing mindset, demonstrated a significant effect on employees' stress mindset. Remarkably, the aforementioned interventions used the same method of providing participants with short video clips and/or simple tasks to improve their stress mindset, and all were able to achieve a significant effect. Therefore, the most compelling explanation for the present set of findings is that a simple video-based intervention, such as the one used in this study, is highly effective in improving students’ stress mindset.

However, the data analysis also showed that the intervention group and the control group differed significantly in their stress mindset from the beginning. As the individuals were randomly allocated to one of two conditions to eliminate systematic disparities across condition groups this happened due to random variation. Apart from this, it was also the case that the groups were not equal in size, as seven participants dropped out of the intervention group. One reason for their withdrawal might be that the closing video in the first session caused them to leave the study early. As the video was followed by a conclusion page with information on how to proceed further, they might have missed it and therefore did not participate in further parts of the study. In future research, this could be prevented by only choosing one clear closing option.

Another striking finding in the data analysis was that the control group also showed a significant improvement in stress mindset over the course of the study. The potential occurrence of a *placebo effect*, an improvement observed in individuals despite receiving an actual treatment (Margo, 1999), could explain this outcome. Since the information presented to the participants in the control condition was not meant to impact their stress mindset, knowing that they were taking part in a research study might have caused some changes in their perception.

Another potential explanation could be the presence of confounding variables that the researcher did not control for. One confounding variable could have been academic stress. According to Schafer (1996), the most distressing daily problems described by college students were linked to academics, such as writing term papers and taking part in examinations. Since academic stress fluctuates when, for example, an exam period starts or ends, these stressors are not constantly present and therefore may have impacted the study's findings. Therefore, future research should evaluate the current academic load as an extra baseline measure to rule out confounding variables that cause unexpected changes, as factors like these will always play a role in student populations.

Lastly, in accordance with prior expectations, in the intervention group, a substantial improvement in the reported mental health problems was found, comparing baseline to follow-up, as well as in comparison to the control group. However, the effect was only significant for depressive symptoms, not for anxiety. Therefore, the hypothesis that changing students' stress mindset into a stronger stress-is-enhancing mindset has beneficial effects on their mental health could only be accepted partially. Compared to the predecessor intervention by Keech et al. (2021), who did not find an effect on any of the stress-related health outcomes, the current intervention achieved a successful impact on mental health.

There are several possible interpretations of the missing effect of the intervention on anxiety symptoms. One interpretation is that the presence of outliers in the data set led to decreased statistical power and therefore no effect was found. Another explanation for the differing findings for depression and anxiety symptoms may be that they are not always mutually inclusive. According to Sherrell (2022), the two mental health conditions frequently overlap; nonetheless, there are fundamental differences between anxiety and depression that must be addressed differently. It can therefore be assumed that the intervention addressed depressive symptoms rather than anxiety symptoms.

Another possibility for the hypothesis's limited acceptance is that anxiety was defined and measured differently compared to similar research studies that found an effect. Crum et al. (2018), for example, used the Mood and Anxiety Symptom Questionnaire (Watson et al., 1995) and the Healthy Days Measures (Center for Disease Control and Prevention, 2000) to assess participants' psychological health. These tools are not only measuring depressive and anxiety symptoms but also the quality of life. Therefore, the results of the intervention on mental health are not comparable as the studies did not measure the same concepts. Furthermore, the samples of both studies differed, as Crum et al. (2018) examined employees who were affected by downsizing at their workplace. It can be assumed that the employees experienced different stressors than students, which may have affected their mental health differently and thus made the two groups less comparable. In addition, the groups differed in their age range, as the participants in the study by Crum et al. (2013) had an average age of $M = 38.49$ vs. $M = 20.67$ in the present study. Taking this into account, it is conceivable that the impact of age may have contributed to the disparities in the two studies' findings regarding mental health. According to Blanchard-Fields et al. (2007), different age groups approach obstacles in different ways. For example, the researchers discovered that older adults were more effective in problem-solving than younger adults, whereas younger adults used less avoidant–denial strategies than older adults (Blanchard-Fields et al., 2007). Therefore, it can be assumed that depending on how the two age groups handled obstacles, the intervention's effects on mental health may have differed.

Taken together, the results suggest that, when controlling for mental health symptoms, having a stronger stress-is-enhancing mindset can be protective against the development of depression in students who suffer under high amounts of stress. Hence, the present study reached its goal of creating an intervention that can successfully protect students from certain negative consequences of perceived stress, like depressive symptoms. Moreover, the intervention was able to produce an impact that its predecessor, developed by Keech et al. (2021), was unable to achieve. Keech et al. (2021) did not find a significant effect of the intervention on students' self-reported psychological well-being; the present study, however, has proven that eliciting a stress-is-enhancing mindset is accompanied by corresponding positive changes in students' reported psychological symptoms.

The main reason behind finding a significant effect on students' mental health may be the expansion of the intervention, by adding another mental imagery task. The introduction of this task solved one limitation encountered by Keech et al. (2021). They found that the delay from immediate post-intervention to follow-up resulted in a substantial decrease in the intervention's effect on stress mindset. In the current study, however, the effect was found to be maintained. The results strongly imply that the additional task reminded the students of the benefits of stress just in time. The timely reminder then again led to the students developing a stronger stress-is-enhancing mindset, which positively affected their mental health. The effect of the additional mental imagery task is a major strength of this study and future studies should focus on understanding the amount of time and reinforcements needed to generate stable changes in stress beliefs.

Adding to the strengths of this study, pre- and post-tests provide deeper insights into the effects of the intervention, making it a well-chosen study design. Not only the comparison with the control group but also the option to compare individual participants during the course of the study made it possible to examine how a simple intervention can prevent students from getting overwhelmed by their feelings of stress and ending up depressed. Besides that, the study used valid and reliable measurement tools. In the follow-up session, the formulations were adjusted to assess only the period since the intervention, to acquire a better picture of the intervention's effect. All scales had either a good or an excellent Cronbach's alpha, indicating that the assessment instruments had strong internal consistency, which validated the study results. Taken together, these features strengthen the study's validity and reduce bias in the results.

In addition to that, the study took advantage of the most recent insights about the stress mindset. The novel measurement instrument SCMM, developed by Keech et al. (2018), was used to assess stress mentality. This tool guaranteed that a stress-is-debilitating mindset did not emerge by default, as it did in the study of Crum et al. (2013), and therefore more accurate results could be obtained. Furthermore, in developing the intervention, the recommendations of Keech et al. (2018) and Liu et al. (2017) were integrated to employ a balanced rather than a rigid view of stress mindset. This decision ensured that a change in stress mindset would not lead to a complete paradigm shift in individuals' conceptualisation of stress (Keech et al., 2018) and the development of unrealistic expectations that may prevent them from adaptive responses to stress (Liu et al., 2017).

Besides its many strengths, this study also has its limitations. One limitation is that the stress exposure of the participants was not controlled, thus it varied over time. This restriction implies that the effects on stress mindset and mental health outcomes cannot be entirely attributed to the intervention and that other confounding variables may have played into the results. This may also explain the significant changes in stress mindset and mental health in the control group over time, even though they did not receive any of the intervention material. A possible solution to this problem is inducing stress in the laboratory, as Crum et al. (2013) did. When looking at the results of Keech et al. (2021), they reported finding effects only in participants who were highly stressed at the baseline of the study. Therefore, it is advisable to first screen participants for their baseline level of perceived stress and ensure that a large enough sample is recruited to examine the impact of the intervention on those who are likely to benefit most.

Another limitation of this study is that the sample size of 82 participants appears to be small to make generalisations about the entire population beyond students from the University of Twente. An even larger participant pool in a replication of this study could provide more certainty of the effect of the intervention on stress mindset and mental health.

The aspect that the study's data came from self-reported online questionnaires adds to the limitation of this research study. According to Tourangeau and Yan (2007), people have a tendency to downplay socially unacceptable attitudes and behaviours while exaggerating positive attributes, a phenomenon known as *social desirability bias*. As the responses collected were all self-reported, there is a possibility that participants were prone to this bias. Furthermore, researchers argue that social desirability response bias is frequently motivated by a desire to prevent embarrassment and the consequences of sharing sensitive information (Tourangeau and Yan 2007). Since participants in this research study were required to reveal personal information, such as their email addresses, they may have thought that their answers could be traced back to them, discouraging them from giving honest responses. Additionally, as the study was conducted online, the researchers had no control over the environment in which the participants engaged in during the intervention. Even though an attention task was placed in the survey, it is impossible to say with certainty if all of the participants watched the videos fully and thoroughly. Hence, recommendations for future research include avoiding the collection of personal information to prevent social desirability bias and delivering the intervention in a controlled setting to guarantee attentive participation.

The results of this research project may be of importance to the general public as human society faces increasing amounts of stress, not least due to the COVID-19 pandemic or other stressors such as the climate change or economic recession. This study demonstrates that students' mental health can benefit significantly from the positive consequences of a relatively simple intervention. Knowing the impacts of one's stress mindset on mental well-being may help students in changing their perspectives and thereby improve their mental health. More research on the association between stress mindset and mental health is needed to create the groundwork for practical implications. Future research should therefore be focused on replicating the methods used in this study in order to verify its findings across various demographic groups. Because the study did not examine long-term consequences, future research should look into how long individuals maintain the stress-is-enhancing perspective over time. A long-term study, for instance, may provide the required study design to determine the degree of mindset change, as well as the time period after which further reinforcements may be required to achieve a stable stress-is-enhancing mindset throughout time.

Another suggestion for future research is to collect various sets of participants based on their perceived stress levels and investigate the effect of the intervention on the different groups. Stress mindset may then be evaluated more accurately for varying intensities ranging from low to high. To increase the validity further, it is also encouraged to incorporate a controlled stressor, as Crum et al. (2013) did in their study, to ensure that stress exposure does not change due to confounding variables. One may then be able to determine more precisely what role stress mindset plays in the relationship between perceived stress and mental health.

Another path for future research could be to investigate the effect of the interventions in various populations and with people experiencing different types of stress. Ideas for future directions could be to look into the effect of the intervention on people having short-term and long-term stress, but also more specific stressors, such as psychosocial stress due to a prolonged illness or a natural catastrophe. As in different life events, the amount and type of stress experienced may vary, the mindset one holds towards stress may have a different influence on the stress response and may change less quickly under specific circumstances. Because different stressors may have different effects on an individual's mental health, there may also be a difference in willingness to modify one's stress mindset. In addition, some stressors may be induced by external threats, such as financial hardship, and may be more difficult to overcome by shifting stress mindset. Therefore, while changing stress mindset to improve mental health may be effective for students and employees, this may differ for other types of populations and stress.

This study provides evidence of the assumption that stress mindset plays an influencing role in the relationship between perceived stress and students’ mental health outcomes. The current intervention contributes to the growing body of evidence showing that ones’ stress mindset is not stable but rather can be changed through an intervention. As a result, this work contributes to research into stress mindset and expands the potential for effective interventions. Moreover, this research project offers a direct solution to improve students' stress management in order to enhance their mental well-being.

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Appendix A

Information Sheet

Welcome to this research study!
Participating involves completing an initial survey and taking part in a mental imagery task. In completing this task, you will be asked to watch a video that guides you through imagining scenarios vividly in your mind and answer some questions afterwards. After one week you will be asked to complete a short follow-up survey.

The aim of the current study is to understand the influence of beliefs about the nature of stress on stress-related psychological health outcomes. This research is conducted by Jennifer Töws in fulfilment of the requirements of the bachelor's program of psychology at the University of Twente under the supervision of Dr Anne van Dongen.

We welcome your participation if you are an undergraduate student of the University of Twente, at least 18 years old and proficient in English.

By participating in this study you will get the benefit of earning credit points in the sona system. Furthermore, your participation will provide valuable information to our understanding of the factors influencing the effect of stress on mental health.

It is unlikely that there are any risks greater than daily living involved with participating in this project. The research project has been reviewed and approved by the BMS Committee. However, if you feel any discomfort as a result of taking part in this survey, you can contact De Luisterlijn (+31(0)88 0767 000), which offers a free telephone counselling service, or you can contact the student psychologist at the University of Twente (+31(0)53 489 2035).

Your participation in this project is completely voluntary and you may cease participation at any time. If you agree to participate, you can withdraw from participation at any time during the project without comment or penalty.

However, once your responses have been analysed and we have de-identified them, you will be unable to withdraw. Your decision to participate will in no way impact your current or future relationship with the University of Twente.

The information and responses you provide will be treated confidentially and will be accessible only to members of the research team. Your responses to the questionnaire will form part of a large data response set, which will initially be stored by Qualtrics. Research data from Qualtrics will be downloaded and stored securely on the University of Twente Google Drive or OneDrive allocation. Data will be password-protected and accessible only to members of the research team. As required by the University of Twente, all research data (survey responses and analysis) will be retained in a password-protected electronic file for a minimum period of five years before being destroyed.

Participants will be given the opportunity to express consent to be contacted for the follow-up survey via email. These contact details will be deleted following the conclusion of the follow-up survey. Students' identity codes in the sona system will be used to match surveys. Participants' data will not be identifiable in any publication or reporting. In the interest of researcher transparency, a strictly de-identified version of the research data will be prepared and made available on the online open data repository Open Science Framework (https://osf.io/).

Research results will be reported in an academic thesis, and may also be disseminated via journal articles and/or conference presentations
Please contact the research team members if you have any questions or require further information about the project.

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No automatic feedback will be given to you about the results of this study. However, if you participate and wish to receive a summary of the research results once the study has been completed, you can email the research team members.

The University of Twente conducts research in accordance with the National Statement on Ethical Conduct in Human Research. If you do have any concerns or complaints about the ethical conduct of the project you may contact the Manager, Research Ethics on ethicscommittee-bms@utwente.nl. This project has received ethical approval from the University of Twente Human Research Ethics Committee BMS/Domain Humanities and Social Science.

Appendix B

Consent Form

1. I have read and understood the participant information sheet. I know that I may ask for more information about the project as it goes on.
2. I understand that this study contains an initial survey, watching videos, taking part in a mental imagery task and a survey to be completed in one week.
3. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.
4. I understand that my participation will be included in a large data set and immediately de-identified.
5. I understand that personal information collected about me that can identify me, such as [e.g. my email address or my identity code], will not be shared beyond the study team and immediately be de-identified once the data collection has been completed.
6. I understand that information I provided will be used for the academic thesis, and may also be disseminated via journal articles and/or conference presentations. I understand that a strictly de-identified version of the research data may be published on the online open data repository Open Science Framework (https://osf.io/).
7. I understand that all information will be treated in the strictest confidence and used for research purposes only. I understand that I will not be personally identified on any reports from this project.
8. I assign and waive all claims to patents, commercial exploitation, property or any material or products which may form part of or arise from this study.
9. I understand that this research will comply with the National Health and Medical Research Council's National Statement on Ethical Conduct in Research Involving Humans and with the privacy politics of the University of Twente.
10. I understand that this study has been approved by the University of Twente Human Research Ethics Committee and that if I have any questions I can contact them via ethicscommittee-bms@utwente.nl.

Do you agree with the above-mentioned information?

- Yes
- No

Appendix C

Script of Second Imagery Task

Welcome to the second part of the study!

For the next couple of minutes, I am going to guide you through a video.

First, I will remind you about some information about stress.

After that, we will do a mental imagery exercise. In this exercise, I will ask you to visualise a scene in your mind.

Before we start, I would like you to make yourself comfortable, and to make sure you are free from any distractions. When you are comfortable and ready to begin, please continue to play this video.

As you have already learned from the last videos, stress not only has negative consequences but also can be beneficial for us. Let me remind you of some of the positive sides of stress.

Stress can help us mobilise resources so that we can meet our demands, it can make us more alert, and give us the energy to complete a task.

Stress can also motivate us to seek out new ideas, new experiences, and new perspectives.

In fact, times of stress often lead to significant personal growth, reflection and improvement.

Research also supports that stress can have a positive influence on our health and vitality. For example, experiencing stress followed by periods of recovery can help the body to adapt to stress and make it more resilient.

Research also supports that recognising these positive consequences of stress is associated with a range of benefits such as better psychological well-being, better physical well-being, improved mood, and higher performance.

Recognising these positive consequences of stress can be beneficial for us.

In the previous imagery task, I asked you to note down the things you considered as the possible good outcomes of stress in YOUR life as well as what YOU could do to experience these positive consequences.

Have you already noticed any positive effects of stress?

Now we will go on to the next imagery exercise. You will find that it might help to close your eyes when doing your imagery.

While it might take you some time, or be challenging to come up with these things, that is alright, please just do your best, and try to imagine them as vividly as possible.

I want you to think about having a conversation with a fellow student who is complaining about his high stress level. He tells you that during the current exam period, he is so stressed that he is more irritable, exhausted, and less open to learning. During one exam, he could not even remember any of the study material because of the stress. He believes that stress should be avoided as much as possible.

Now it is up to you to explain to him that the consequences of stress do not have to be entirely negative but also can be beneficial for us. After learning more about the positive sides of stress, what advice would you give the student to view stress from a different perspective?

Try to imagine the situation as vividly as possible.

I will let you know when the time is over...

Alright, now that you have finished your imagery, please note down a few sentences summarising the advice you would give to the other student. Please use the space below. You should aim to make your writing as detailed as possible. Writing down your images helps you to remember them more vividly. Spend about 2-3 minutes noting down your thoughts.

Thank you for completing the exercise. When you find yourself experiencing stress, please remember your goal and the advice you would give to another student.

Please now proceed to the next page.

Appendix D

R Code

```
#Codes Bachelor Thesis on Stress Mindsets
library(haven)
library(CTT)
library(psych)
library(foreign)
library(tidyverse)
library(janitor)
library(broom)
library(vtree)
library (openxlsx)
library(car)
library(readxl)
library(writexl)
library (modelr)
library (ltm)
library(ggplot2)
library(Hmisc)
library(reshape)
library(ez)
library(dplyr)

###############PRE_ANALYSIS##################################################

setwd("C:/Users/Jennifer/Documents/Uni/University Twente/Bachelor Thesis/Data Sets")

data <- read_excel("Stress Mindsets_Pre_November 20, 2022_04.11._v1.1.xlsx")

#delete unnecessary columns
data$StartDate  <- NULL
data$EndDate  <- NULL
data$Status  <- NULL
data$IPAddress  <- NULL
data$Progress  <- NULL
data$`Duration (in seconds)` <- NULL
data$Finished  <- NULL
data$RecordedDate  <- NULL
data$ResponseId  <- NULL
data$RecipientLastName  <- NULL
data$RecipientFirstName <- NULL
data$RecipientEmail  <- NULL
data$ExternalReference  <- NULL
```

```
data$LocationLatitude  <- NULL
data$LocationLongitude  <- NULL
data$DistributionChannel  <- NULL
data$UserLanguage  <- NULL
data$Informed_consent<- NULL
data$`Q30_First Click`<- NULL
data$`Q30_Click Count`<- NULL
data$`Q30_Last Click`<- NULL
data$`Q30_Page Submit`<- NULL

#delete unnecessary row
data1 <- data [-c (1),]

#delete unnecessary columns
data1<- data1[, -c(48:55)]
data1<- data1[, -c(106:127)]
data1<- data1[, -5]

#from list to numeric
data2 <- as.data.frame(apply(data1, 2, as.numeric))
summary(data2)

#count Gender
vtree(data2, "Gender")

#count Group
vtree(data2, "Group")

#count Nationality
vtree(data2, "Nation")

#count gender by group
vtree(data2, c("Group", "Gender"),
    fillcolor = c( Group = "#e7d4e8", Gender = "#99d8c9"),
    horiz = FALSE)

#count Nationality by group
vtree(data2, c("Group", "Nation"),
    fillcolor = c( Group = "#e7d4e8", Nation = "#99d8c9"),
    horiz = FALSE)

#count Age by group
vtree(data2, c("Group", "Age"),
    fillcolor = c( group = "#e7d4e8", Age = "#99d8c9"),
```

```
    horiz = FALSE)

#Group 0 = Control Group
#Group 1 = Intervention Group

#age mean sd per group 0
data2 %>% filter (Group == 0) %>% summarise (mean = mean (Age), sd = sd (Age))

#age mean sd per group 1
data2 %>% filter (Group == 1) %>% summarise (mean = mean (Age), sd = sd (Age))

#Preparation of the Data Set

##################SPP_PRE##################################################

#combine SPP_pre
data2[is.na(data2)] <- 0
SPP_pre <- data2[,c(5:14, 63:72)]
SPP_pre[SPP_pre == 0] <- NA

#NA into 0
SPP_pre[is.na(SPP_pre)] <- 0

#combine two answers of questionnaire into one
SPP_pre_combined <- SPP_pre[,1:10] + SPP_pre[,11:20]

#subtract 1 because scale ranges from 0 to 4
SPP_pre_combined <- SPP_pre_combined - 1


#reverse items that are negatively formulated
reverse_cols = c("SPP_C_pre_4", "SPP_C_pre_5", "SPP_C_pre_7", "SPP_C_pre_8")
SPP_pre_combined[ , reverse_cols] = 4 - SPP_pre_combined[ , reverse_cols]

#Add scale of SPP_pre to data2
data2$all_SPP_pre <- rowMeans(SPP_pre_combined)
data2$Perceived_Stress <- rowSums(SPP_pre_combined)

#Cronbach's alpha for SPP_pre
psych::alpha(SPP_pre_combined)
#alpha= 0.87

#########################SCMM_PRE#########################################
```

```
#combine SCMM_pre
data2[is.na(data2)] <- 0
SCMM_pre <- data2[,c(15:29, 73:87)]
SCMM_pre[SCMM_pre == 0] <- NA

#NA into 0
SCMM_pre[is.na(SCMM_pre)] <- 0

#combine two answers of questionnaire into one
SCMM_pre_combined <- SCMM_pre[,1:15] + SCMM_pre[,16:30]

#reverse items that are negatively formulated
reverse_cols = c("SCMM_C_pre_1", "SCMM_C_pre_4", "SCMM_C_pre_6",
"SCMM_C_pre_10",
        "SCMM_C_pre_11", "SCMM_C_pre_12", "SCMM_C_pre_13", "SCMM_C_pre_14")
SCMM_pre_combined[ , reverse_cols] = 7 - SCMM_pre_combined[ , reverse_cols]

#Add scale of SCMM_pre to data2
data2$all_SCMM_pre <- rowMeans(SCMM_pre_combined)
data2$Stress_Mindset <- rowSums(SCMM_pre_combined)

#Cronbach's alpha for SCMM_pre
psych::alpha(SCMM_pre_combined)
#alpha= 0.93

##########################PHQ9_PRE########################################

#combine PHQ9_pre
data2[is.na(data2)] <- 0
PHQ9_pre <- data2[,c(30:38, 88:96)]
PHQ9_pre[PHQ9_pre == 0] <- NA

#NA into 0
PHQ9_pre[is.na(PHQ9_pre)] <- 0

#combine two answers of questionnaire into one
PHQ9_pre_combined <- PHQ9_pre[,1:9] + PHQ9_pre[,10:18]

#subtract 1 because scale ranges from 0 to 4
PHQ9_pre_combined <- PHQ9_pre_combined - 1

#Add scale of PHQ9_pre to data2
data2$all_PHQ9_pre <- rowMeans(PHQ9_pre_combined)
data2$all_PHQ9_pre_sum <- rowSums(PHQ9_pre_combined)
```

```
#Cronbach's alpha for PHQ9_pre
psych::alpha(PHQ9_pre_combined)
#alpha= 0.82
####################GAD7_PRE###########################################

#combine GAD7_pre
data2[is.na(data2)] <- 0
GAD7_pre <- data2[,c(40:46, 98:104)]
GAD7_pre[GAD7_pre == 0] <- NA

#NA into 0
GAD7_pre[is.na(GAD7_pre)] <- 0

#combine two answers of questionnaire into one
GAD7_pre_combined <- GAD7_pre[,1:7] + GAD7_pre[,8:14]

#subtract 1 because scale ranges from 0 to 4
GAD7_pre_combined <- GAD7_pre_combined - 1

#Add scale of GAD7_pre to data2
data2$all_GAD7_pre <- rowMeans(GAD7_pre_combined)
data2$all_GAD7_pre_sum <- rowSums(GAD7_pre_combined)

#Cronbach's alpha for GAD7_pre
psych::alpha(GAD7_pre_combined)
#alpha= 0.89


####################SCMM_immed-post#####################################

#combine SCMM_immed-post
data2[is.na(data2)] <- 0
SCMM_immed_post <- data2[,c(48:62, 105:119)]
SCMM_immed_post[SCMM_immed_post == 0] <- NA

#NA into 0
SCMM_immed_post[is.na(SCMM_immed_post)] <- 0

#combine two answers of questionnaire into one
SCMM_immed_post_combined <- SCMM_immed_post[,1:15] + SCMM_immed_post[,16:30]

#reverse items that are negatively formulated
reverse_cols = c(1,4,6,10:14)
```

```
SCMM_immed_post_combined[ , reverse_cols] = 7 - SCMM_immed_post_combined[ ,
reverse_cols]

#Add scale of SCMM_immed_post to data2
data2$all_SCMM_immed_post <- rowMeans(SCMM_immed_post_combined)
data2$all_SCMM_immed_post_sum <- rowSums(SCMM_immed_post_combined)

#Cronbach's alpha for SCMM_immed_post
psych::alpha(SCMM_immed_post_combined)
#alpha= 0.93

#descriptive data per group

data2 %>% filter (Group == 1) %>% summarise (mean = mean (all_SPP_pre_sum),
                                  sd = sd (all_SPP_pre_sum),
                                  min = min (all_SPP_pre_sum),
                                  max = max(all_SPP_pre_sum))

data2 %>% filter (Group == 0) %>% summarise (mean = mean (all_SPP_pre_sum),
                                  sd = sd (all_SPP_pre_sum),
                                  min = min (all_SPP_pre_sum),
                                  max = max(all_SPP_pre_sum))

data2 %>% filter (Group == 1) %>% summarise (mean = mean (all_SCMM_pre_sum),
                                  sd = sd (all_SCMM_pre_sum),
                                  min = min (all_SCMM_pre_sum),
                                  max = max(all_SCMM_pre_sum))
data2 %>% filter (Group == 0) %>% summarise (mean = mean (all_SCMM_pre_sum),
                                  sd = sd (all_SCMM_pre_sum),
                                  min = min (all_SCMM_pre_sum),
                                  max = max(all_SCMM_pre_sum))

data2 %>% filter (Group == 1) %>% summarise (mean = mean (all_PHQ9_pre_sum),
                                  sd = sd (all_PHQ9_pre_sum),
                                  min = min (all_PHQ9_pre_sum),
                                  max = max(all_PHQ9_pre_sum))
data2 %>% filter (Group == 0) %>% summarise (mean = mean (all_PHQ9_pre_sum),
                                  sd = sd (all_PHQ9_pre_sum),
                                  min = min (all_PHQ9_pre_sum),
                                  max = max(all_PHQ9_pre_sum))

data2 %>% filter (Group == 1) %>% summarise (mean = mean (all_GAD7_pre_sum),
                                  sd = sd (all_GAD7_pre_sum),
                                  min = min (all_GAD7_pre_sum),
```

```
                                          max = max(all_GAD7_pre_sum))
data2 %>% filter (Group == 0) %>% summarise (mean = mean (all_GAD7_pre_sum),
                                          sd = sd (all_GAD7_pre_sum),
                                          min = min (all_GAD7_pre_sum),
                                          max = max(all_GAD7_pre_sum))

data2 %>% filter (Group == 1) %>% summarise (mean = mean (all_SCMM_immed_post_sum),
                                          sd = sd (all_SCMM_immed_post_sum),
                                          min = min (all_SCMM_immed_post_sum),
                                          max = max(all_SCMM_immed_post_sum))
data2 %>% filter (Group == 0) %>% summarise (mean = mean (all_SCMM_immed_post_sum),
                                          sd = sd (all_SCMM_immed_post_sum),
                                          min = min (all_SCMM_immed_post_sum),
                                          max = max(all_SCMM_immed_post_sum))

#calculating SE
data2 %>%
  group_by(Group) %>%
  summarise(se_all_SPP_pre_sum=plotrix::std.error(all_SPP_pre_sum))
data2 %>%
  group_by(Group) %>%
  summarise(se_all_SCMM_pre_sum=plotrix::std.error(all_SCMM_pre_sum))
data2 %>%
  group_by(Group) %>%
  summarise(se_all_SCMM_immed_post_sum=plotrix::std.error(all_SCMM_immed_post_sum))
data2 %>%
  group_by(Group) %>%
  summarise(se_all_PHQ9_pre_sum=plotrix::std.error(all_PHQ9_pre_sum))
data2 %>%
  group_by(Group) %>%
  summarise(se_all_GAD7_SCMM_pre_sum=plotrix::std.error(all_GAD7_pre_sum))

#calculating CI
require(dplyr)
alpha <- 0.05

data2 %>%
  group_by(Group) %>%
  summarise(mean = mean(all_SPP_pre_sum),
            lower = mean(all_SPP_pre_sum) - qt(1- alpha/2, (n() -
1))*sd(all_SPP_pre_sum)/sqrt(n()),
            upper = mean(all_SPP_pre_sum) + qt(1- alpha/2, (n() -
1))*sd(all_SPP_pre_sum)/sqrt(n()))
data2 %>%
```

```
  group_by(Group) %>%
  summarise(mean = mean(all_SCMM_pre_sum),
            lower = mean(all_SCMM_pre_sum) - qt(1- alpha/2, (n() -
1))*sd(all_SCMM_pre_sum)/sqrt(n()),
            upper = mean(all_SCMM_pre_sum) + qt(1- alpha/2, (n() -
1))*sd(all_SCMM_pre_sum)/sqrt(n()))
data2 %>%
  group_by(Group) %>%
  summarise(mean = mean(all_SCMM_immed_post_sum),
            lower = mean(all_SCMM_immed_post_sum) - qt(1- alpha/2, (n() -
1))*sd(all_SCMM_immed_post_sum)/sqrt(n()),
            upper = mean(all_SCMM_immed_post_sum) + qt(1- alpha/2, (n() -
1))*sd(all_SCMM_immed_post_sum)/sqrt(n()))
data2 %>%
  group_by(Group) %>%
  summarise(mean = mean(all_PHQ9_pre_sum),
            lower = mean(all_PHQ9_pre_sum) - qt(1- alpha/2, (n() -
1))*sd(all_PHQ9_pre_sum)/sqrt(n()),
            upper = mean(all_PHQ9_pre_sum) + qt(1- alpha/2, (n() -
1))*sd(all_PHQ9_pre_sum)/sqrt(n()))
data2 %>%
  group_by(Group) %>%
  summarise(mean = mean(all_GAD7_pre_sum),
            lower = mean(all_GAD7_pre_sum) - qt(1- alpha/2, (n() -
1))*sd(all_GAD7_pre_sum)/sqrt(n()),
            upper = mean(all_GAD7_pre_sum) + qt(1- alpha/2, (n() -
1))*sd(all_GAD7_pre_sum)/sqrt(n()))


#########################Hypotheses 1&2 testing############################

#H1: depression or anxiety ~ perceived stress + stress mindset
#H2:Formula: depression or anxiety ~ perceived stress * stress mindset

#centre variables
data2$all_SPP_pre_centered <- data2$all_SPP_pre - mean(data2$all_SPP_pre)
data2$all_SCMM_pre_centered <- data2$all_SCMM_pre - mean(data2$all_SCMM_pre)
data2$all_SCMM_immed_post_centered <- data2$all_SCMM_immed_post -
mean(data2$all_SCMM_immed_post)


# direct effect perceived stress and stress mindset on depression
model1 <- lm(all_PHQ9_pre ~ all_SPP_pre_centered + all_SCMM_pre_centered, data=data2)
model1 %>%  tidy()
```

```
summary (model1)

# direct effect perceived stress and stress mindset on anxiety
model2 <- lm(all_GAD7_pre ~ all_SPP_pre_centered + all_SCMM_pre_centered, data=data2)
model2 %>%  tidy()
summary (model2)

#interaction effect on depression
model3 <- lm(all_PHQ9_pre ~ all_SPP_pre_centered*all_SCMM_pre_centered,data=data2)
model3 %>% tidy
summary (model3)

#interaction effect on anxiety
model4 <- lm(all_GAD7_pre ~ all_SPP_pre_centered*all_SCMM_pre_centered,data=data2)
model4 %>% tidy
summary (model4)

#interaction effect on depression - not standardised
model3.1 <- lm(all_PHQ9_pre_sum ~ Perceived_Stress*Stress_Mindset,data=data2)
model3.1 %>% tidy
summary (model3.1)

#interaction effect on anxiety - not standardized
model4.1 <- lm(all_GAD7_pre_sum ~ Perceived_Stress*Stress_Mindset,data=data2)
model4.1 %>% tidy
summary (model4.1)

interactions::johnson_neyman(model3.1, pred = Perceived_Stress, modx = Stress_Mindset, alpha
= .05)
interactions::johnson_neyman(model4.1, pred = Perceived_Stress, modx = Stress_Mindset, alpha
= .05)

library("writexl")
write_xlsx(data2, "C:/Users/Jennifer/Documents/Uni/University Twente/Bachelor Thesis/Data
Sets//data2.xlsx")


##################ASSUMPTION CHECK######################################

#preparation for assumption
data2 <- data2 %>%
  add_residuals(model1)
data2 <- data2 %>%
  add_predictions(model1)
```

```
data2 <- data2 %>%
  add_residuals(model2)
data2 <- data2 %>%
  add_predictions(model2)

data2 <- data2 %>%
  add_residuals(model3)
data2 <- data2 %>%
  add_predictions(model3)

data2 <- data2 %>%
  add_residuals(model4)
data2 <- data2 %>%
  add_predictions(model4)

#1. Linear relationships --> not violated no funnel no curve
with(data2,plot(all_SPP_pre_centered,all_PHQ9_pre))
with(data2,plot(all_SPP_pre_centered[all_SCMM_pre],all_PHQ9_pre[all_SCMM_pre]))

with(data2,plot(all_SPP_pre_centered,all_GAD7_pre))
with(data2,plot(all_SPP_pre_centered[all_SCMM_pre],all_GAD7_pre[all_SCMM_pre]))

#2. No multicollinearity = independence --> not violated
car::vif(model1)
#vif < 5 = good, vif > 10 = bad

car::vif(model2)
#vif < 5 = good, vif > 10 = bad

car::vif(model3)
#vif < 5 = good, vif > 10 = bad

car::vif(model4)
#vif < 5 = good, vif > 10 = bad

#3.Normality of residuals depression models --> not violated but slightly skewed to the right
hist(resid(model1))
shapiro.test(resid(model1))
data2 %>%
  ggplot(aes(x = resid)) +
  geom_histogram()

hist(resid(model3))
```

```
shapiro.test(resid(model3))
data2 %>%
  ggplot(aes(x = resid)) +
  geom_histogram()

#Normality of residuals anxiety models --> violated
hist(resid(model2))
shapiro.test(resid(model2))
data2 %>%
  ggplot(aes(x = resid)) +
  geom_histogram()

hist(resid(model4))
shapiro.test(resid(model4))
data2 %>%
  ggplot(aes(x = resid)) +
  geom_histogram()

#non-parametric tests for anxiety model
#Spearman's rho ---> correlation of
library(Hmisc)
rcorr(data2$all_GAD7_pre, data2$all_SPP_pre_centered, type = "spearman")
cor.test (data2$all_GAD7_pre, data2$all_SPP_pre_centered,method = "spearman", exact =
FALSE)
library(Kendall)
Kendall(data2$all_GAD7_pre, data2$all_SPP_pre_centered)

#4. equal variance --> not violated
data2 %>%
  ggplot(aes(x = pred, y = resid)) +
  geom_point()

data2 %>%
  ggplot(aes(x = all_SPP_pre_centered, y = resid)) +
  geom_point()

#Non-parametric test/ Friedman's test
datawide <- data2 [ , c ("id", "all_SCMM_pre_centered", "all_SPP_pre_centered",
"all_GAD7_pre")]

datalong = melt(datawide, id = c("id"),
                measured= c ("all_SCMM_pre_centered", "all_SPP_pre_centered",
"all_GAD7_pre"))
```

```
#useful column names#
colnames(datalong) = c ("id", "Measure", "Score")

#rename levels and reorder
datalong$Measure = factor (datalong$Measure,
                    levels = c ("all_SCMM_pre_centered", "all_SPP_pre_centered",
"all_GAD7_pre"))


datawide %>%
  pivot_longer(cols = -id, names_to = "Measure", values_to = "Score")

datalong %>%
  friedman.test(Score ~ Measure | id, data = .)


######################Post ANALYSIS########################################

data3 <- read_excel("Stress Mindsets_Post_November 20, 2022_04.11._v1.1.xlsx")

#delete unnecessary columns
data3$StartDate  <- NULL
data3$EndDate  <- NULL
data3$Status  <- NULL
data3$IPAddress  <- NULL
data3$Progress  <- NULL
data3$`Duration (in seconds)` <- NULL
data3$Finished  <- NULL
data3$RecordedDate  <- NULL
data3$ResponseId  <- NULL
data3$RecipientLastName  <- NULL
data3$RecipientFirstName <- NULL
data3$RecipientEmail  <- NULL
data3$ExternalReference  <- NULL
data3$LocationLatitude  <- NULL
data3$LocationLongitude  <- NULL
data3$DistributionChannel  <- NULL

#delete unnecessary row
data4 <- data3 [-c (1),]

#from list to numeric
data5 <- as.data.frame(apply(data4, 2, as.numeric))
summary(data5)
```

```
#SUMMARY OF DESCRIPTIVE DATA


#Preparation of the Data Set

######SPP_POST#####

#combine SPP_post
data5[is.na(data5)] <- 0
SPP_post <- data5[,c(5:14)]
SPP_post[SPP_post == 0] <- NA

#NA into 0
SPP_post[is.na(SPP_post)] <- 0

#subtract 1 because scale ranges from 0 to 4
SPP_post <- SPP_post - 1

#reverse items that are negatively formulated
reverse_cols = c("SPP_both_post_4", "SPP_both_post_5", "SPP_both_post_7",
"SPP_both_post_8")
SPP_post[ , reverse_cols] = 4 - SPP_post[ , reverse_cols]

#Add scale of SPP_post to data5
data5$all_SPP_post <- rowMeans(SPP_post)
data5$Perceived_Stress <- rowSums(SPP_post)

#Cronbach's alpha for SPP_pre
psych::alpha(SPP_post)
#alpha= 0.91

###############SCMM_POST################################################

#combine SCMM_pre
data5[is.na(data5)] <- 0
SCMM_post <- data5[,c(15:29)]
SCMM_post[SCMM_post == 0] <- NA

#NA into 0
SCMM_post[is.na(SCMM_post)] <- 0

#reverse items that are negatively formulated
```

```
reverse_cols = c("SCMM_both_post_1", "SCMM_both_post_4", "SCMM_both_post_6",
"SCMM_both_post_10",
            "SCMM_both_post_11", "SCMM_both_post_12", "SCMM_both_post_13",
"SCMM_both_post_14")
SCMM_post[ , reverse_cols] = 7 - SCMM_post[ , reverse_cols]

#Add scale of SCMM_post to data5
data5$all_SCMM_post <- rowMeans(SCMM_post)
data5$Stress_Mindset <- rowSums(SCMM_post)

#Cronbach's alpha for SCMM_pre
psych::alpha(SCMM_post)
#alpha= 0.94

###############PHQ9_POST##################################################

#combine PHQ9_post
data5[is.na(data5)] <- 0
PHQ9_post <- data5[,c(30:38)]
PHQ9_post[PHQ9_post == 0] <- NA

#NA into 0
PHQ9_post[is.na(PHQ9_post)] <- 0

#subtract 1 because scale ranges from 0 to 4
PHQ9_post <- PHQ9_post - 1

#Add scale of PHQ9_post to data5
data5$all_PHQ9_post <- rowMeans(PHQ9_post)
data5$all_PHQ9_post_sum <- rowSums(PHQ9_post)

#Cronbach's alpha for PHQ9_pre
psych::alpha(PHQ9_post)
#alpha= 0.84

############GAD7_POST#####################################################

#combine GAD7_post
data5[is.na(data5)] <- 0
GAD7_post <- data5[,c(40:46)]
GAD7_post[GAD7_post == 0] <- NA

#NA into 0
GAD7_post[is.na(GAD7_post)] <- 0
```

```
#subtract 1 because scale ranges from 0 to 4
GAD7_post <- GAD7_post - 1

#Add scale of GAD7_post to data5
data5$all_GAD7_post <- rowMeans(GAD7_post)
data5$all_GAD7_post_sum <- rowSums(GAD7_post)

#Cronbach's alpha for GAD7_pre
psych::alpha(GAD7_post)
#alpha= 0.90


#############descriptive data per group#########################################

data5 %>% filter (Group == 1) %>% summarise (mean = mean (all_SPP_post_sum),
                                sd = sd (all_SPP_post_sum),
                                min = min (all_SPP_post_sum),
                                max = max(all_SPP_post_sum))
data5 %>% filter (Group == 0) %>% summarise (mean = mean (all_SPP_post_sum),
                                sd = sd (all_SPP_post_sum),
                                min = min (all_SPP_post_sum),
                                max = max(all_SPP_post_sum))

data5 %>% filter (Group == 1) %>% summarise (mean = mean (all_SCMM_post_sum),
                                sd = sd (all_SCMM_post_sum),
                                min = min (all_SCMM_post_sum),
                                max = max(all_SCMM_post_sum))
data5 %>% filter (Group == 0) %>% summarise (mean = mean (all_SCMM_post_sum),
                                sd = sd (all_SCMM_post_sum),
                                min = min (all_SCMM_post_sum),
                                max = max(all_SCMM_post_sum))

data5 %>% filter (Group == 1) %>% summarise (mean = mean (all_PHQ9_post_sum),
                                sd = sd (all_PHQ9_post_sum),
                                min = min (all_PHQ9_post_sum),
                                max = max(all_PHQ9_post_sum))
data5 %>% filter (Group == 0) %>% summarise (mean = mean (all_PHQ9_post_sum),
                                sd = sd (all_PHQ9_post_sum),
                                min = min (all_PHQ9_post_sum),
                                max = max(all_PHQ9_post_sum))

data5 %>% filter (Group == 1) %>% summarise (mean = mean (all_GAD7_post_sum),
                                sd = sd (all_GAD7_post_sum),
```

```
                                    min = min (all_GAD7_post_sum),
                                    max = max(all_GAD7_post_sum))
data5 %>% filter (Group == 0) %>% summarise (mean = mean (all_GAD7_post_sum),
                                    sd = sd (all_GAD7_post_sum),
                                    min = min (all_GAD7_post_sum),
                                    max = max(all_GAD7_post_sum))
#calculating SE
data5 %>%
  group_by(Group) %>%
  summarise(se_all_SPP_post_sum=plotrix::std.error(all_SPP_post_sum))
data5 %>%
  group_by(Group) %>%
  summarise(se_all_SCMM_post_sum=plotrix::std.error(all_SCMM_post_sum))
data5 %>%
  group_by(Group) %>%
  summarise(se_all_PHQ9_post_sum=plotrix::std.error(all_PHQ9_post_sum))
data5 %>%
  group_by(Group) %>%
  summarise(se_all_GAD7_SCMM_post_sum=plotrix::std.error(all_GAD7_post_sum))

#calculating CI
alpha <- 0.05

data5 %>%
  group_by(Group) %>%
  summarise(mean = mean(all_SPP_post_sum),
            lower = mean(all_SPP_post_sum) - qt(1- alpha/2, (n() -
1))*sd(all_SPP_post_sum)/sqrt(n()),
            upper = mean(all_SPP_post_sum) + qt(1- alpha/2, (n() -
1))*sd(all_SPP_post_sum)/sqrt(n()))
data5 %>%
  group_by(Group) %>%
  summarise(mean = mean(all_SCMM_post_sum),
            lower = mean(all_SCMM_post_sum) - qt(1- alpha/2, (n() -
1))*sd(all_SCMM_post_sum)/sqrt(n()),
            upper = mean(all_SCMM_post_sum) + qt(1- alpha/2, (n() -
1))*sd(all_SCMM_post_sum)/sqrt(n()))
data5 %>%
  group_by(Group) %>%
  summarise(mean = mean(all_PHQ9_post_sum),
            lower = mean(all_PHQ9_post_sum) - qt(1- alpha/2, (n() -
1))*sd(all_PHQ9_post_sum)/sqrt(n()),
            upper = mean(all_PHQ9_post_sum) + qt(1- alpha/2, (n() -
1))*sd(all_PHQ9_post_sum)/sqrt(n()))
```

```
data5 %>%
  group_by(Group) %>%
  summarise(mean = mean(all_GAD7_post_sum),
            lower = mean(all_GAD7_post_sum) - qt(1- alpha/2, (n() -
1))*sd(all_GAD7_post_sum)/sqrt(n()),
            upper = mean(all_GAD7_post_sum) + qt(1- alpha/2, (n() -
1))*sd(all_GAD7_post_sum)/sqrt(n()))

#Hypotheses 1&2 testing POST Intervention
#H1: depression or anxiety ~ perceived stress + stress mindset
#H2:Formula: depression or anxiety ~ perceived stress * stress mindset


#centre variables
data5$all_SPP_post_centered <- data5$all_SPP_post - mean(data5$all_SPP_post)
data5$all_SCMM_post_centered <- data5$all_SCMM_post - mean(data5$all_SCMM_post)

# direct effect perceived stress and stress mindset on depression
model5 <- lm(all_PHQ9_post ~ all_SPP_post_centered + all_SCMM_post_centered, data=data5)
model5 %>%  tidy()
summary (model5)

# direct effect perceived stress and stress mindset on anxiety
model6 <- lm(all_GAD7_post ~ all_SPP_post_centered + all_SCMM_post_centered,
data=data5)
model6 %>%  tidy()
summary (model6)

#interaction effect on depression
model7 <- lm(all_PHQ9_post ~ all_SPP_post_centered*all_SCMM_post_centered,data=data5)
model7 %>% tidy
summary (model7)

#interaction effect on anxiety
model8 <- lm(all_GAD7_post ~ all_SPP_post_centered *all_SCMM_post_centered,data=data5)
model8 %>% tidy
summary (model8)

#interaction effect on depression - not standardised
model 7.1 <- lm(all_PHQ9_post_sum ~ Perceived_Stress*Stress_Mindset,data=data5)
model 7.1 %>% tidy
summary (model 7.1)

#interaction effect on anxiety - not standardised
```

```
model 8.1 <- lm(all_GAD7_post_sum ~ all_SPP_post_sum*all_SCMM_post_sum,data=data5)
model 8.1 %>% tidy
summary (model 8.1)

interactions::johnson_neyman(model 7.1, pred = Perceived_Stress, modx = Stress_Mindset,
alpha = .05)
interactions::johnson_neyman(model 8.1, pred = all_SPP_post_sum, modx =
all_SCMM_post_sum, alpha = .05)

library("readxl")
write_xlsx(data5, "C:/Users/Jennifer/Documents/Uni/University Twente/Bachelor Thesis/Data
Sets//data5.xlsx")

#perceived stress only had an effect on depression when Stress Mindset was lower than 70 at
baseline and lower than 72 at follow-up.

#########################ASSUMPTION CHECK###############################

#preparation for assumption

data5 <- data5 %>%
  add_residuals(model5)
data5 <- data5 %>%
  add_predictions(model5)

data5 <- data5 %>%
  add_residuals(model6)
data5 <- data5 %>%
  add_predictions(model6)

data5 <- data5 %>%
  add_residuals(model7)
data5 <- data5 %>%
  add_predictions(model7)

data5 <- data5 %>%
  add_residuals(model8)
data5 <- data5 %>%
  add_predictions(model8)

#1. Linear relationships --> not violated no funnel no curve
with(data5,plot(all_SPP_post_centered,all_PHQ9_post))
with(data5,plot(all_SPP_post_centered[all_SCMM_post],all_PHQ9_post[all_SCMM_post]))
```

```
with(data5,plot(all_SPP_post_centered,all_GAD7_post))
with(data5,plot(all_SPP_post_centered[all_SCMM_post],all_GAD7_post[all_SCMM_post]))


#2. No multicollinearity = independence --> not violated
car::vif(model5)
#vif < 5 = good, vif > 10 = bad

car::vif(model6)
#vif < 5 = good, vif > 10 = bad

car::vif(model7)
#vif < 5 = good, vif > 10 = bad

car::vif(model8)
#vif < 5 = good, vif > 10 = bad


#3. Normality of residuals depression models --> not violated but slightly skewed to the right

hist(resid(model5))
shapiro.test(resid(model5))
data5 %>%
  ggplot(aes(x = resid)) +
  geom_histogram()

hist(resid(model7))
shapiro.test(resid(model7))
data5 %>%
  ggplot(aes(x = resid)) +
  geom_histogram()

#Normality of residuals anxiety models --> violated
hist(resid(model6))
shapiro.test(resid(model6))
data5 %>%
  ggplot(aes(x = resid)) +
  geom_histogram()

hist(resid(model8))
shapiro.test(resid(model8))
data5 %>%
  ggplot(aes(x = resid)) +
  geom_histogram()
```

```
#non-parametric tests for anxiety model
#Spearman's rho ---> correlation of
library(Hmisc)
rcorr(data5$all_GAD7_post, data5$all_SPP_post_centered, type = "spearman")
cor.test (data5$all_GAD7_post, data5$all_SPP_post_centered,method = "spearman", exact =
FALSE)
library(Kendall)
Kendall(data5$all_GAD7_post, data5$all_SPP_post_centered)

#4. equal variance --> not violated
data5 %>%
  ggplot(aes(x = pred, y = resid)) +
  geom_point()

data5 %>%
  ggplot(aes(x = all_SPP_post_centered, y = resid)) +
  geom_point()


#Non-parametric test/ Friedman's test
datawide1 <- data5 [ , c ("all_SCMM_post_centered", "all_SPP_post_centered",
"all_GAD7_post")]
datawind 1['id']= data2['id']

datalong1 = melt(datawind 1, id = c("id"),
                measured= c ("all_SCMM_post_centered", "all_SPP_post_centered",
"all_GAD7_post"))
#useful column names#
colnames(datalong1) = c ("id", "Measure", "Score")
#rename levels and reorder
datalong1$Measure = factor (datalong1$Measure,
                          levels = c ("all_SCMM_post_centered", "all_SPP_post_centered",
"all_GAD7_post"))
datawind 1 %>%
  pivot_longer(cols = -id, names_to = "Measure", values_to = "Score")

datalong1 %>%
  friedman.test(Score ~ Measure | id, data = .)



###############################ANOVA############################################
```

```
#####Preparation of data set "stresslong"###

####mixed Anova#####
data_stress <- data2 [ , c ("id", "Group", "all_SCMM_pre_centered",
"all_SCMM_immed_post_centered")]
data_stress['all_SCMM_post_centered']= data5['all_SCMM_post_centered']
stress long = melt(data_stress, id = c("id", "Group"),
        measured= c ("all_SCMM_pre_centered", "all_SCMM_immed_post_centered",
"all_SCMM_post_centered"))

#useful column names#
colnames(stresslong) = c ("id", "Group", "Time", "Stress Mindset")

#rename levels and reorder
stress long$Time = factor (stress long$Time,
            levels = c ("all_SCMM_pre_centered",  "all_SCMM_immed_post_centered",
"all_SCMM_post_centered"),
            labels = c("Baseline","Immediate Post-Intervention", "Follow-Up"))
#####Conduction of ANOVA Analysis####
library(tidyverse)
library(ggpubr)
library(rstatix)
library(datarium)

stress long <- stress long %>%
  convert_as_factor(id, Time, Group)
set.seed(123)
stresslong %>% sample_n_by(Group, Time, size = 1)

stresslong %>% sample_n_by(Group, size = 1)

#summary statistics of the score variable: mean and sd
stresslong %>%
  group_by(Time, Group) %>%
  get_summary_stats(Stress_Mindset, type = "mean_sd")

#Visualisation, box plots
bxp <- ggboxplot(
  stresslong, x = "Time", y = "Stress Mindset",
  colour = "Group", palette = "jco"
)
bxp

##########################Check Assumptions###################################
```

```
#1.Identify outliers --> three outliers found (excluded from dataset?)
stresslong %>%
  group_by(Time, Group) %>%
  identify_outliers(Score)

#2.Normality
stresslong %>%
  group_by(Time, Group) %>%
  shapiro_test(Score)

gg qq plot(stresslong, "Score", ggtheme = theme_bw()) +
  facet_grid(Time ~ Group)
# We can assume normality of the data as all points fall approximately along the reference line,
for each cell.

#3.Homogneity of variance --> violated
stresslong %>%
  group_by(Time) %>%
  levene_test(Score ~ Group)
#There was homogeneity of variances for all cells (p > 0.05), except for the condition time:t2
#(p = 0.0034), as assessed by Levene's test of homogeneity of variance.

#4.Homogeneity of covariances
box_m(stresslong[, "Score", drop = FALSE], stresslong$Group)
#There was homogeneity of covariances, as assessed by Box's test of equality of covariance
matrices (p > 0.001).

#5.Assumption of sphericity --> Mauchlys test
ezANOVA(data = stresslong,
        dv = Score,
        wid = id,
        within = Time,
        between = Group,
        detailed = TRUE,
        type = 3)
# when performing the Mauchly's test of sphericity,
#it indicates that the assumption of sphericity is violated (p = 0.005).
#Hence, the correction method of Greenhouse–Geisser is applied to the
#calculation of the ANOVA table to reasure, that the output is reliable.

#6. Non-parametric test
stresslong %>%
  kruskal.test(Score ~ Group, data = .)
```

```
##
## Kruskal-Wallis rank sum test
##
## data:Score by Group
## Kruskal-Wallis chi-squared = 46.165, df = 1, p-value <
## 0.00000000001087
stresslong$Score %>% length()
## [1] 246
stresslong$Group %>% length()
## [1] 246

#Outcome:
#The null-hypothesis that stress mindset scores per measurement point are distributed equally
#for all groups was tested using a Kruskal-Wallis test with an (alpha)
#of 0.05. Results showed that the null-hypothesis could be rejected,
# X^2(1,N = 246) = 46.165, p < .001.


###################################ANALYSIS################################

# Two-way mixed ANOVA test
res.aov <- anova_test(
  data = stresslong, dv = Score, wid = id,
  between = Group, within = Time
)
get_anova_table(res.aov)

#Output:
# From the output above, it can be seen that, there is a statistically significant two-way
#interactions between group and time on stress mindset score, F(1.78, 142.41) = 20.33, p < 0.001.

###Post-hoc tests####
#Simple main effect
# 1. Effect of group at each time point
one.way <- stresslong %>%
  group_by(Time) %>%
  anova_test(dv = Score, wid = id, between = Group) %>%
  get_anova_table() %>%
  adjust_pvalue(method = "bonferroni")
one.way

#Simple pairwise comparisons
# Pairwise comparisons between group levels
pwc <- stresslong %>%
```

```
  group_by(Time) %>%
  pairwise_t_test(Score ~ Group, p.adjust.method = "bonferroni")
pwc

##Output (noch umändern):
#Considering the Bonferroni adjusted p-value (p.adj), it can be seen that the simple main effect of
#group was significant at t2 (p = 0.018) and t3 (p < 0.0001) but not at t1 (p = 1).Pairwise
comparisons
#show that the mean anxiety score was significantly different in grp1 vs grp3 comparison at t2 (p
= 0.0063);
#in grp1 vs grp3 (p < 0.0001) and in grp2 vs grp3 (p = 0.0013) at t3.


# 2. Effect of time at each level of intervention group
one.way2 <- stresslong %>%
  group_by(Group) %>%
  anova_test(dv = Score, wid = id, within = Time) %>%
  get_anova_table() %>%
  adjust_pvalue(method = "bonferroni")
one.way2
# Pairwise comparisons between time points at each group levels
# Paired t-test is used because we have repeated measures by time
pwc2 <- stresslong %>%
  group_by(Group) %>%
  pairwise_t_test(
    Score ~ Time, paired = TRUE,
    p.adjust.method = "bonferroni")%>%
  select(-df, -statistic, -p)
pwc2

stresslong %>%
  pairwise_t_test(
    Score ~ Time, paired = TRUE,
    p.adjust.method = "bonferroni"
  )
#OUtput (muss noch geändert werden):
#There was a statistically significant effect of time on anxiety score for each of
#the three groups. Using pairwise paired t-test comparisons, it can be seen that for grp1 and grp2,
#the mean anxiety score was not statistically significantly different between t1 and t2 time points.
#The pairwise comparisons t1 vs t3 and t2 vs t3 were statistically significantly different for all
groups.


##################################Depression_ANOVA###########################
```

```
#####Preparation of data set depressionlong"####################################

####mixed Anova#####
data_depression <- data2 [ , c ("id", "Group", "all_PHQ9_pre")]
data_depression['all_PHQ9_post']= data5['all_PHQ9_post']
depressionlong = melt(data_depression, id = c("id", "Group"),
                      measured= c ("all_PHQ9_pre", "all_PHQ9_post"))

#usefull column names#
colnames(depressionlong) = c ("id", "Group", "Time", "Depression")

#rename levels and reorder
depressionlong$Time = factor (depressionlong$Time,
                              levels = c ("all_PHQ9_pre", "all_PHQ9_post"),
                              labels = c("Baseline","Follow-Up"))
#####Conduction of ANOVA Analysis####
library(tidyverse)
library(ggpubr)
library(rstatix)
library(datarium)

depressionlong <- depressionlong %>%
  convert_as_factor(id, Time, Group)
set.seed(123)
depressionlong %>% sample_n_by(Group, Time, size = 1)

depressionlong %>% sample_n_by(Group, size = 1)

#summary statistics of the score variable: mean and sd
depressionlong %>%
  group_by(Time, Group) %>%
  get_summary_stats(Depression, type = "mean_sd")

#Visualization, box plots
bxp <- ggboxplot(
  depressionlong, x = "Time", y = "Depression",
  color = "Group", palette = "jco"
)
bxp


################Check Assumptions#########################################
```

```
#1.Identify outliers --> three outliers found (exclude from dataset?)
depressionlong %>%
  group_by(Time, Group) %>%
  identify_outliers(Score)

#2.Normality
depressionlong %>%
  group_by(Time, Group) %>%
  shapiro_test(Score)

ggqqplot(depressionlong, "Score", ggtheme = theme_bw()) +
  facet_grid(Time ~ Group)
# We can assume normality of the data as all points fall approximately along the reference line,
for each cell.

#3.Homogneity of variance --> violated
depressionlong %>%
  group_by(Time) %>%
  levene_test(Score ~ Group)
#There was homogeneity of variances for all cells (p > 0.05), except for the condition time:t3
#(p = 0.0034), as assessed by Levene's test of homogeneity of variance.

#4.Homogeneity of covariances
box_m(depressionlong[, "Score", drop = FALSE], depressionlong$Group)
#There was homogeneity of covariances, as assessed by Box's test of equality of covariance
matrices (p > 0.001).

#5.Assumption of sphericity --> Mauchlys test
ezANOVA(data = depressionlong,
        dv = Score,
        wid = id,
        within = Time,
        between = Group,
        detailed = TRUE,
        type = 3)

# when performing the Mauchly's test of sphericity,
#it indicates that the assumption of sphericity is violated (p = 0.005).
#Hence, the correction method of Greenhouse–Geisser is applied to the
#calculation of the ANOVA table to reasure, that the output is reliable.

#6. Non-parametric test
depressionlong %>%
  kruskal.test(Score ~ Group, data = .)
```

```
##
## Kruskal-Wallis rank sum test
##
## data:Score by Group
## Kruskal-Wallis chi-squared = 46.165, df = 1, p-value <
## 0.00000000001087
depressionlong$Score %>% length()
## [1] 246
depressionlong$Group %>% length()
## [1] 246

#Outcome:
#The null-hypothesis that stress mindset scores per measurement point are distributed equally
#for all groups was tested using a Kruskal-Wallis test with an (alpha)
#of 0.05. Results showed that the null-hypothesis could be rejected,
# X^2(1,N = 246) = 46.165, p < .001.



################ANALYSIS##################################################

# Two-way mixed ANOVA test
res.aov <- anova_test(
  data = depressionlong, dv = Score, wid = id,
  between = Group, within = Time
)
get_anova_table(res.aov)

#Output:
# From the output above, it can be seen that, there is a statistically significant two-way
#interactions between group and time on stress mindset score, F(1.78, 142.41) = 20.33, p <
0.0001.

###Post-hoc tests####
#Simple main effect
# 1. Effect of group at each time point
one.way <- depressionlong %>%
  group_by(Time) %>%
  anova_test(dv = Score, wid = id, between = Group) %>%
  get_anova_table() %>%
  adjust_pvalue(method = "bonferroni")
one.way

#Simple pairwise comparisons
```

```
# Pairwise comparisons between group levels
pwc <- depressionlong %>%
  group_by(Time) %>%
  pairwise_t_test(Score ~ Group, p.adjust.method = "bonferroni")
pwc

##Output (noch umändern):
#Considering the Bonferroni adjusted p-value (p.adj), it can be seen that the simple main effect of
#group was significant at t2 (p = 0.018) and t3 (p < 0.0001) but not at t1 (p = 1).Pairwise
comparisons
#show that the mean anxiety score was significantly different in grp1 vs grp3 comparison at t2 (p
= 0.0063);
#in grp1 vs grp3 (p < 0.0001) and in grp2 vs grp3 (p = 0.0013) at t3.


# 2. Effect of time at each level of group
one.way2 <- depressionlong %>%
  group_by(Group) %>%
  anova_test(dv = Score, wid = id, within = Time) %>%
  get_anova_table() %>%
  adjust_pvalue(method = "bonferroni")
one.way2
# Pairwise comparisons between time points at each group levels
# Paired t-test is used because we have repeated measures by time
pwc2 <- depressionlong %>%
  group_by(Group) %>%
  pairwise_t_test(
    Score ~ Time, paired = TRUE,
    p.adjust.method = "bonferroni")
pwc2
#OUtput (muss noch geändert werden):
#There was a statistically significant effect of time on anxiety score for each of
#the three groups. Using pairwise paired t-test comparisons, it can be seen that for grp1 and grp2,
#the mean anxiety score was not statistically significantly different between t1 and t2 time points.
#The pairwise comparisons t1 vs t3 and t2 vs t3 were statistically significantly different for all
groups.

##################################Anxiety ANOVA#############################

####mixed Anova#####
data_anxiety <- data2 [ , c ("id", "Group", "all_GAD7_pre")]
data_anxiety['all_GAD7_post']= data5['all_GAD7_post']
anxietylong = melt(data_anxiety, id = c("id", "Group"),
                   measured= c ("all_GAD7_pre", "all_GAD7_post"))
```

```
#usefull column names#
colnames(anxietylong) = c ("id", "Group", "Time", "Anxiety")

#rename levels and reorder
anxietylong$Time = factor (anxietylong$Time,
                           levels = c ("all_GAD7_pre", "all_GAD7_post"),
                           labels = c("Baseline","Follow-Up"))
#####Conduction of ANOVA Analysis####
library(tidyverse)
library(ggpubr)
library(rstatix)
library(datarium)

anxietylong <-anxietylong %>%
  convert_as_factor(id, Time, Group)
set.seed(123)
anxietylong %>% sample_n_by(Group, Time, size = 1)

anxietylong %>% sample_n_by(Group, size = 1)

#summary statistics of the score variable: mean and sd
anxietylong %>%
  group_by(Time, Group) %>%
  get_summary_stats(Anxiety, type = "mean_sd")

#Visualization, box plots
bxp <- ggboxplot(
  anxietylong, x = "Time", y = "Anxiety",
  color = "Group", palette = "jco"
)
bxp

######################Check Assumptions#####################################

#1.Identify outliers --> three outliers found (exclude from dataset?)
anxietylong %>%
  group_by(Time, Group) %>%
  identify_outliers(Score)

#2.Normality
anxietylong %>%
  group_by(Time, Group) %>%
  shapiro_test(Score)
```

```
ggqqplot(anxietylong, "Score", ggtheme = theme_bw()) +
  facet_grid(Time ~ Group)
# We can assume normality of the data as all points fall approximately along the reference line,
for each cell.

#3.Homogneity of variance --> violated
anxietylong %>%
  group_by(Time) %>%
  levene_test(Score ~ Group)
#There was homogeneity of variances for all cells (p > 0.05), except for the condition time:t3
#(p = 0.0034), as assessed by Levene’s test of homogeneity of variance.

#4.Homogeneity of covariances
box_m(anxietylong[, "Score", drop = FALSE], anxietylong$Group)
#There was homogeneity of covariances, as assessed by Box’s test of equality of covariance
matrices (p > 0.001).

#5.Assumption of sphericity --> Mauchlys test
ezANOVA(data = anxietylong,
        dv = Score,
        wid = id,
        within = Time,
        between = Group,
        detailed = TRUE,
        type = 3)
# when performing the Mauchly’s test of sphericity,
#it indicates that the assumption of sphericity is violated (p = 0.005).
#Hence, the correction method of Greenhouse–Geisser is applied to the
#calculation of the ANOVA table to reasure, that the output is reliable.

#6. Non-parametric test
anxietylong %>%
  kruskal.test(Score ~ Group, data = .)
##
## Kruskal-Wallis rank sum test
##
## data:Score by Group
## Kruskal-Wallis chi-squared = 46.165, df = 1, p-value <
## 0.00000000001087
anxietylong$Score %>% length()
## [1] 246
anxietylong$Group %>% length()
## [1] 246
```

```
#Outcome:
#The null-hypothesis that stress mindset scores per measurement point are distributed equally
#for all groups was tested using a Kruskal-Wallis test with an (alpha)
#of 0.05. Results showed that the null-hypothesis could be rejected,
# X^2(1,N = 246) = 46.165, p < .001.

###############ANALYSIS################################################

# Two-way mixed ANOVA test
res.aov <- anova_test(
  data = anxietylong, dv = Score, wid = id,
  between = Group, within = Time
)
get_anova_table(res.aov)

#Output:
# From the output above, it can be seen that, there is a statistically significant two-way
#interactions between group and time on stress mindset score, F(1.78, 142.41) = 20.33, p <
0.0001.

###Post-hoc tests####
#Simple main effect
# 1. Effect of group at each time point
one.way <- anxietylong %>%
  group_by(Time) %>%
  anova_test(dv = Score, wid = id, between = Group) %>%
  get_anova_table() %>%
  adjust_pvalue(method = "bonferroni")
one.way

#Simple pairwise comparisons
# Pairwise comparisons between group levels
pwc <- anxietylong %>%
  group_by(Time) %>%
  pairwise_t_test(Score ~ Group, p.adjust.method = "bonferroni")
pwc

##Output (noch umändern):
#Considering the Bonferroni adjusted p-value (p.adj), it can be seen that the simple main effect of
#group was significant at t2 (p = 0.018) and t3 (p < 0.0001) but not at t1 (p = 1).Pairwise
comparisons
#show that the mean anxiety score was significantly different in grp1 vs grp3 comparison at t2 (p
= 0.0063);
```

```
#in grp1 vs grp3 (p < 0.0001) and in grp2 vs grp3 (p = 0.0013) at t3.

# 2. Effect of time at each level of group
one.way2 <- anxietylong %>%
  group_by(Group) %>%
  anova_test(dv = Score, wid = id, within = Time) %>%
  get_anova_table() %>%
  adjust_pvalue(method = "bonferroni")
one.way2
# Pairwise comparisons between time points at each group levels
# Paired t-test is used because we have repeated measures by time
pwc2 <- anxietylong %>%
  group_by(Group) %>%
  pairwise_t_test(
    Score ~ Time, paired = TRUE,
    p.adjust.method = "bonferroni")
pwc2
#OUtput (muss noch geändert werden):
#There was a statistically significant effect of time on anxiety score for each of
#the three groups. Using pairwise paired t-test comparisons, it can be seen that for grp1 and grp2,
#the mean anxiety score was not statistically significantly different between t1 and t2 time points.
#The pairwise comparisons t1 vs t3 and t2 vs t3 were statistically significantly different for all groups.


######################################END##################################
```