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RESEARCH ARTICLE

Visualization and Breathing as Means to Reduce Objective and Subjective Stress of Students during Exam Times

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ABSTRACT

Exam stress is a highly prevalent topic for students. Knowing time-saving and short-term strategies to deal with exam stress might be highly beneficial. Hence, the present study examines if students can profit from stress reduction strategies (either visualization or breathing techniques) during a mock exam. If so, students can be encouraged to use these strategies for their own benefits during exam times. Fifty-four participants were recruited to the study. 79.6% of the group was female, the mean age was 20.37 years (SD = 1.39). Nineteen students were in the visualization group (35.2%), 19 students were in the breathing exercise group (35.2%) and 16 students were part of the control group (29.6%). Data analysis shows a small but significant reduction of stress in the breathing exercise group. We suggest further research strategies and implications for fostering mental health of students in higher education.

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1. Introduction

1.1. Literature Review

1.1.1. The Situation of Students

Students experience a phase of life that offers them many opportunities (Arnett, 2015), but at the same time represents a phase of vulnerability (Seiffge-Krenke, 2017, 2019). "Emerging adulthood" is full of opportunities, but also challenging, for example due to the requirements for educational qualifications that should be achieved (Settersten & Ray, 2010) and the challenge of making life decisions when the norms in this regard are hardly or not at all available (Syed, 2016).

Even before the COVID-19 pandemic, mental health issues were common among students, including procrastination, depressive symptoms, and exhaustion (Eissler *et al*., 2020; Maricuţoiu & Sulea, 2019; Reich & Cierpka, 2017). Meta-analyses showed elevated levels of non-specific anxiety in a third of undergraduate students worldwide (Ahmed *et al*., 2023) and clinically significant signs of anxiety in the population of PhD students (Satinsky *et al*., 2021). The COVID-19 pandemic put additional burden on students, as measures in place to prevent the virus spreading led to an increase in feelings of loneliness, stress, anxiety, and depressive symptoms (Elmer *et al*., 2020; Lippke *et al*., 2021; Weiss *et al*., 2022). Currently, mental stress is perceived as high and students still complain about loneliness, although universities have gone back to face-to-face teaching. Students are currently doing worse than before the pandemic (Lewkowicz, 2023; Techniker Krankenkasse, 2023). In the study by Techniker Krankenkasse (2023) surveying the situation of German students, 68% of students compared to 44% in 2015 reported that they felt exhausted by stress. 29% report loneliness in the last 12 months (no comparable data from 2015). 40% of female students rate their emotional exhaustion as quite high, compared to 26% of male students. Emotional exhaustion was in turn linked to the subjective state of health (Techniker Krankenkasse, 2023). In particular, the feeling of stress among students has increased significantly compared to the general population (also see Winzer *et al*., 2014). As perceived (academic) stress and burnout are, amongst others, associated with impaired academic achievement (Andrews & Wilding, 2004; Keyes *et al*., 2012; Vaez & Laflamme, 2008), it is important to equip students with strategies to manage stress, thus increasing their mental health and enabling them to study successfully.

1.1.2. Association between Mental Health and Study Success

Studies show the association between mental health and academic success both at school (Suldo *et al*., 2014) and university. Thus, Eisenberg *et al*. (2009) showed longitudinally that psychological problems led to poorer grades in students and an increased probability of dropping out, whereas stable mental health was associated with higher student satisfaction and grit (Lipson & Eisenberg, 2018). Encouragingly, Kivlighan *et al*. (2021) showed that psychological counseling for students leads to an improvement in the average grades during their studies. Particularly stress affects mental and physical health as well as academic performance in both school and university settings (Shankar & Park, 2016).

Teacher education students are especially affected by the mental health crisis experienced by students and pupils alike. First, they themselves are at high risk to experience poor mental health and perceive high levels of stress whilst at university (Gustems-Carnicer *et al*., 2019). Secondly, they will have to deal with pupils in classrooms, who are themselves poorly equipped to deal with the demands of course work, assignments, and tests (Boekaerts, 1999; Jansen & van der Meer, 2012) and who are increasingly burdened by mental health issues such as anxiety and depression (Ravens-Sieberer *et al*., 2021, 2022).

To improve students' mental health, specific interventions have shown to be effective (for reviews see Barnett *et al*., 2021; Cuijpers *et al*., 2021; Regehr *et al*., 2013; Winzer *et al*., 2018; Worsley *et al*., 2022). These are, however, usually expensive and time consuming. For example, the interventions included in the review and meta-analysis by Regehr *et al*. (2013) typically cover 1 to 1.5 h sessions over several weeks. The present study examines if a short intervention (either a visualization exercise or a breathing technique) is effective, thus allowing students to easily incorporate such techniques into their daily life. These techniques are discussed in more detail in the following section.

1.1.3. Visualization and Breathing Techniques

Hypnotic techniques, such as visualization, can signal security (Böhmer & Schmidt, 2022) and promote positive emotional states (Schmidt, 2022). Visualization is a mental technique that utilizes the brain's inability to differentiate between something which is actually real and something which is imagined very vividly (Hunold & Reiß, 2017; Meyer & Hermann, 2011). Visualizations reduce pain (Nørgaard *et al*., 2015), help with learning (Fruth & Fruth, 2017) and are used in sports (Meyer & Hermann, 2011) and in school (Knörzer *et al*., 2011). Knörzer *et al*. (2011) describe the use within school settings. In their program, mental training is used to visualize a goal. While the participants are instructed to calm down, sit relaxed and focus on their breathing, they should imagine a place where they felt very good and relaxed and then imagine how they watch themselves on a movie screen achieving a goal.

A meta-analysis found that hypnotic techniques are effective in treating anxiety also at follow-up measurements (Valentine *et al*., 2019), which implies sustainable effects. At the same time, hypnosis induces calmness and hence, slower breathing (Fisch & Teut, 2021).

Breathing alone can reduce stress as it activates the parasympathetic nervous system (Jerath *et al*., 2006). When people are stressed, feel anxious and/or insecure, their breathing is typically shallow (Baldasarre *et al*., 2003). However, when the midriff and the belly are part of the breathing process, so that the breath is consciously being led into the abdomen, breathing is being experienced as calming (Baldasarre *et al*., 2003).

Thus, both visualization and breathing techniques have shown to be effective in terms of stress reduction.

1.1.4. Physiological Effects of Stress

The experience of stress is associated with lower well-being (Extremera & Rey, 2015) as it has various physiological effects on the human body, including changes in blood pressure, pulse rate, and skin conductance. Possible associations are outlined below:

Emotional stress that may arise because of anxiety or anger, can lead to a temporary increase in blood pressure (Carroll *et al*., 2012) and can cause an increase in heart rate (pulse rate) as the body prepares for a fight or flight-response (Chu *et al*., 2022). This in turn leads to increased sweating and, consequently, an increase in (electrical) skin conductance (Ernst *et al*., 2023). Electrodermal activity refers to electrical changes, measured at the surface of the skin, due to emotional activation (Zukauskas, 2017). (Emotional) stress, cognitive workload or physical exertion can increase the skin's electrical conductance in a measurably significant way (Ernst *et al*., 2023).

Aside from emotional stress, physical stress, such as strenuous exercise or physical labor, can also cause a rapid increase in heart rate as the body works harder to meet increased oxygen and energy demands and can also result in sweating and an increase in skin conductance similar to emotional stress (Chu *et al*., 2022). However, this increase is typically a normal response to the physical demands placed on the body, whereas rises due to emotional stress might not express themselves as sweat on the surface of the skin; however, electrical conductance increases (Ernst *et al*., 2023).

When stress becomes chronic, this can contribute to long-term increases in blood pressure. This is a concern because prolonged high blood pressure can lead to hypertension, a risk factor for various cardiovascular diseases (Torpy *et al*., 2007). Chronic stress can also result in a chronically elevated pulse rate, which can strain the heart over time (Vrijkotte *et al*., 2000) and it may lead to increased baseline skin conductance due to continuous activation of the sympathetic nervous system (Rimes *et al*., 2017).

It is important to note that individual responses to stress can vary, and some people may be more sensitive to stress-induced changes in these physiological parameters than others. Additionally, chronic stress can have long-term health consequences, so managing stress through relaxation techniques, exercise, and other stress-reduction strategies is important for overall well-being.

2. Research Questions

Our research question was the following: Compared to a passive control group, does a strategy such as a visualization or a breathing exercise lead to a reduction in stress and an increase in well-being before, during and after a (mock) exam? We also assumed that visualization is more effective in reducing stress compared to a breathing exercise and in comparison, to the control group (no intervention before the exam), as visualization entails slower breathing as well as visualization (Fisch & Teut, 2021).

3. Methods

3.1. Participants

We recruited participants from undergraduate teacher education courses. The majority of participants took part in an "Introduction to Psychology" course in the first or second semester of their studies. In total, 54 participants were recruited to the study. 79.6% of the group were female, the mean age was 20.37 years (SD = 1.39). Nineteen students were in the visualization group (35.2%), 19 students were in the breathing exercise group (35.2%) and 16 students were part of the passive control group (29.6%). Students signed up for their preferred time slot and we randomly choose the condition.

3.2. Measures and Procedure

Participants attended the experiment in groups of two or three. They were equipped with a smartwatch (Empatica e4 wearable), which measured skin conductance throughout the entire experiment. Participants were first asked to complete a questionnaire, which consisted of information on age and gender, followed by 24 items taken from the "Befindlichkeits-Skala" (Von Zerssen & Petermann, 2011), which measures subjective wellbeing (mental state). The answer format was changed from the original, so that for each semantic differential, participants had to state whether they, for example, felt "fresh, rather fresh, rather run down, run down". Cronbach's Alpha was 0.87 at T1, and 0.90 at T2.

After completion, participant's blood pressure and pulse were taken (Beurer BM27). Triplets or pairs of participants were randomly allocated to one of three conditions: Group 1: Visualization, Group 2: Breathing exercise, Group 3: Control Group (waiting).

The visualization groups were presented with a five-minute recording containing a visualization exercise adapted from Hunold and Reiß (2017). They were instructed to focus on their posture and breathing before they were taken through the visualization of the upcoming mock exam situation.

Similarly, the breathing exercise groups listened to a five-minute recording containing a breathing exercise adapted from Kaltwasser (2013) and Revenstorf and Zeyer (2016). After listening to the same instructions on focusing on posture and breathing, they were instructed to deepen and monitor their breathing. Both sets of instructions can be requested from the first author.

The control group waited for 5 minutes without being given any instructions on what to do.

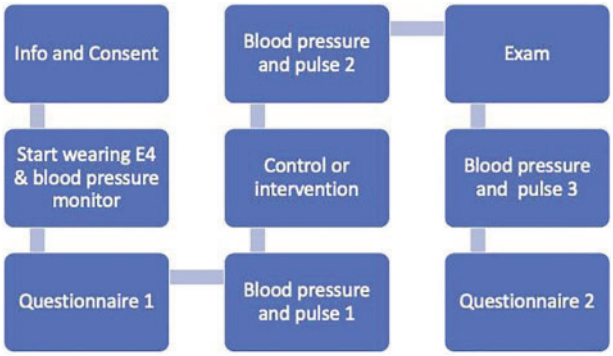

Fig. 1. Procedure with the main steps of the experiment.

Afterwards, blood pressure and pulse were taken again. Participants were then led to an exam room, where they sat a fifteen- minute mock exam consisting of a proofreading exercise, writing a summary of an abstract in English, and solving a hard Sudoku. The exam was designed so that the given 15 minutes would obviously not suffice, thus inducing stress in the participants. As we mainly recruited students from their first semester, we decided to include more general tasks and no study-content within the exam.

After the exam, blood pressure and pulse were taken again. Fig. 1 gives an overview of the experimental procedure.

3.3. Data Preparation and Analysis

As the assumption was that functional coping with stress implies effective regulation and not the value in, for example, blood pressure per se, we did not exclude any outliers.

Regarding skin conductance, which was measured using empatica e4 wearables, we used the average EDA score for the minutes between 16 and 25 to make sure to capture the skin conductance during the exam. To prepare the data, excel and the software R was used. All analyses were then conducted using IBM SPSS.

4. Results

We first analyzed any changes in **subjective wellbeing** with a mixed ANOVA, where the wellbeing scale was the within-group variable and groups were the between-groups variable. According to the Box's test, the assumption of homogeneity of variances-covariances matrices was not violated ($p = 0.09$; $p > 0.001$). There was homogeneity of the error variances as assessed by Levene's test ($p > 0.05$). There was no statistically significant interaction between time and group, $F(2, 51) = 0.44$, $p = 0.65$, partial $\eta^2 = 0.02$.

Regarding the for **physiological signs of stress,** an one-way between groups ANOVA was conducted for skin conductance. There was no statistically significant difference between the three groups in terms of the average EDA value, $F(2, 43) = 1.44$, $p = 0.25$.

Regarding pulse and blood pressure, repeated measurement MANOVAs were conducted. For pulse a significant main effect was found, $F(2, 100) = 11.21$, $p < 0.001$, the interaction was not significant $F(4, 100) = 0.52$, $p = 0.72$.

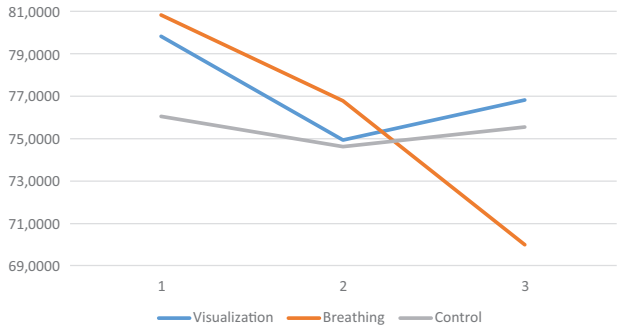

Fig. 2. Diastolic blood pressure for the three groups over time.

For systolic blood pressure, a significant main effect, $F(1.69, 84.69) = 26.82$, $p < 0.001$, and no significant interaction $F(3.39, 84.69) = 1.20$, $p = 0.32$, were found.

However, there was a statistically significant main effect of time for diastolic blood pressure, $F(1.73, 86.45) = 6.95$, $p < 0.01$ and a significant interaction effect of time and group, $F(3.46, 86.45) = 3.58$, $p < 0.05$ (see Fig. 2). Post hoc Tukey HSD tests were not significant.

5. Discussion

Knowing and being able to utilize stress reduction strategies is valuable psychological knowledge and helps to live a good life (Niemiec, 2019). Many studies have shown that relaxation tools such as progressive muscle relaxation, deep breathing, guided imagery, clinical hypnosis, and biofeedback reduce stress efficiently (Niemiec, 2019, Learn relaxation, third tip).

The present study examined if students could profit from such strategies during a mock exam. We found that taking part in a five-minute breathing exercise led to a significant reduction of diastolic blood pressure, which suggests that a reduction in perceived stress was achieved. Contrary to our assumption that a visualization exercise should be more effective than a breathing exercise, as it comprises both elements of breathing and visualization, we found no effects of visualization on both subjective wellbeing and physical markers of stress. It is feasible to assume that without prior practice, concentrating on one's breath and thus experiencing embodiment with focusing on physical sensations is easier than staying focused on instructed visualization, which entails a stronger cognitive component. It might be comparable to progressive muscle relaxation which is perceived as very easy to learn (Chaudhuri *et al.*, 2014) and might be also easier than autogenic training or meditation due to the active tensing and relaxing of muscle groups.

As stress is a relevant topic during studies and for many people also in their later professional life, it seems fruitful to plan more research in this field. The present study has some limitations which we share with other studies. One aspect is the small sample size, which leads to a lower power to detect meaningful differences between the three groups. Furthermore, visualization and breathing exercises work best, when a routine is established, and these techniques are well trained (Fisch & Teut, 2021). In the present study, the exercises were only presented once directly before the mock exam. However, future studies should also focus on the necessary length of the intervention as these should ideally be short and easy to apply. Most other interventions find small, but lasting effects when interventions last at least a few weeks (e.g., Cuijpers *et al.*, 2021; Regehr *et al.*, 2013; Winzer *et al.*, 2018). Integrating a 10-minutes mindfulness practice in every class showed promising effects on college students' learning (Yamada & Victor, 2012). Hence, it might be that the regularity might be more important than the length of the intervention.

In further studies, we plan on sharing the instructions with the intervention group to allow for individual training. This would also help to reduce the limitations associated with cross-sectional studies.

Although our findings are limited, they suggest that it is certainly fruitful to pursue this line of research. In times when students are subjected to high levels of stress, it is important to equip them with effective and evidence-based strategies that ultimately lead to better mental health and better academic performance.

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Conflict of Interest

Authors declare that they do not have any conflict of interest.

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