Exploring the Effect of Wearable Stress Feedback on Stress and Relaxation; A Two Week-Long Retrospective and Ambulatory Field Study

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Abstract

Stress has a significant impact on both our society and individuals. Stress is associated with numerous physical- and mental health problems, causing society potentially billions of dollars in work-related stress alone. Recently, modern wearables claim to be able to measure stress. Research has shown wearable stress feedback to be effective in reducing stress when used in combination with stress management interventions. Relaxation plays an important role in stress recovery, offering a more comprehensive understanding of stress. This study explores the effect of wearable stress feedback on perceived stress and perceived relaxation during regular and stressful moments. The study reflects real-world conditions, utilising retrospective- and ambulatory questionnaires in a two-week long, within-subject, field study design. Wearable stress feedback had a small negative effect on stress and a small positive effect on relaxation in the overall sample. In the stressed subgroup, wearables had a small negative effect on relaxation. However, the results were insignificant. Moreover, nearly half of the participants reported substantial differences between wearing and not wearing a wearable. Exploring these differences is essential to understanding how and why wearables are effective. Furthermore, future research should focus on the influence of wearable wearing duration, integration of stress feedback training and achieving high compliance rates for ESM. Despite the small and insignificant results, this study provides a more comprehensive understanding of the effect of wearables on perceived stress and perceived relaxation in real-world conditions. Moreover, this study highlights the importance of individual differences and other key areas of focus for future research.

Exploring the Effect of Wearable Stress Feedback on Stress and Relaxation; A Two Week-Long Retrospective and Ambulatory Field Study

The adoption of wearable technology is rapidly increasing, with 29% of U.S. adults reporting the use of such devices in 2020. Consumers use wearable devices to monitor health and physical activity, using a wide variety of statistics (Dhingra et al., 2023). Wearables can promote physical activity. Ferguson et al. (2022) studied the effectiveness of wearables by analysing 39 systematic reviews which included 163.841 participants. Wearables were shown to stimulate physical activity, with consumers of wearables taking 1800 extra steps each day, walking 40 minutes longer and losing approximately 1 kg of body mass. Psychophysical management has been developed more recently for wearables but has not gained as much attention. Psychophysiology is the study of the relationship between physiological signals recorded from the body and brain to cognitive and emotional processes (O'Donnell & Hetrick, 2015).

An interesting psychophysiology construct which wearables are now claiming to measure is stress. Wearables operationalize stress levels by measuring physiological reactions in the body (Cheng et al., 2021). Consumers of wearables can see their stress levels in a matter of seconds. A scoping review of Ramírez et al. (2023) concluded that wearables are effective in reducing stress, mostly by promoting stress management intervention (SMI) during stress episodes. Most SMI's are focused on self-regulation. However, most digital mental health interventions have low compliance rates (Boucher & Raiker, 2024). Wearable consumers will likely not use any form of SMI. The effect of wearable stress feedback (WSF) without any SMI is underexplored but could be effective on its own.

WSF can reduce stress by promoting self-awareness about daily stressors. Self-awareness can empower individuals to monitor and manage their stress levels (Jerath et al., 2023). No studies researched the effects of WSF in daily life without an SMI. Additionally, measuring stress is difficult due to its complex nature. Stress has biological, mental and contextual components becoming an umbrella term for an almost unbounded set of human experiences (Epel et al., 2018; Hoemann et al., 2023). One way of measuring stress is through relaxation. Effective stress-reducing treatments are often based on increasing relaxation (Steghaus & Poth, 2022). Therefore, measuring relaxation along with stress provides better insights into experienced stress and the effectiveness of the wearable. To explore whether WSF can be an effective tool to increase relaxation for stressed individuals, stressful responses must be analysed. The current study has two aims. The first aim is to explore the effect of WSF on perceived stress, without providing additional SMIs. The second aim of the study is to measure the effect of WSF on perceived relaxation, within a normal sample and a sample with high stress scores.

Stress

The definition of stress can be split into stress exposure (stressor) and stress response. This study investigates the stress response of individuals. Stress response refers to an individual's psychological, emotional and physical reaction to stress exposure. Stress exposure refers to objectively observable events or challenges individuals face in their environment such as an argument, illness or trauma (Harkness & Hayden, 2019). When someone perceives a stressor they will experience stress. Stress disrupts homeostasis by activating the autonomic nervous system, releasing hormones like cortisol into the body. These hormones act upon different mechanisms in the body like heart rate and blood pressure (Ranabir & Reetu, 2011), helping an individual prepare for a threat.

An important distinction can be made between short-term and long-term stress. Short-term stress responses last minutes to hours and are one of our fundamental survival mechanisms. Short-term stress can enhance cognitive and physical performance. While short-term stress can be beneficial in our demanding society (Schneiderman et al., 2004), long-term stress has deleterious effects on the brain, body and health. These effects are especially true when short-term stress is consistently perceived as a threat. Long-term stress is stress which persists for several hours a day for weeks or months. Whenever an individual experiences persistent short-term stress it becomes increasingly difficult for the body to return to the equilibria of homeostasis. This can ultimately result in chronic stress (Dhabhar, 2018).

According to the challenge threat model (Blascovich & Mendes, 2010), individuals see a stressor as either a challenge or a threat. Whether an individual appraises a stressor as a challenge or a threat is based on the demands appraisal and the resources appraisal. The demand appraisal contains the perceived danger and effort a stressor causes. Resources are the skills and knowledge one has to deal with a stressor. A stressor is seen as a challenge when someone perceives their resources to be greater than the demand. A stressor is seen as a threat when the demand is greater than the resources.

Someone perceiving a stressor as a threat can feel overwhelmed, anxious, out of control and negatively affected (Epel et al., 2018). Stress has been linked to numerous physical health problems like cardiovascular disease, hypertension and infectious disease (Cohen et al., 2007). Furthermore, stress has a negative influence on well-being and is a precursor for many psychiatric conditions like depression (Epel et al., 2018). Besides the negative influence on mental and physical well-being, stress is also expensive. Work-related stress results in lower productivity and absenteeism. Hassard, et al. (2017) calculated the total cost of work-related stress in the US in 2014 and estimated a total cost between 221 million and 187 billion dollars annually. Stress has a detrimental impact on our society. Preventing the negative influence of stress can potentially save billions of dollars a year and significantly promote well-being.

Measuring and conceptualising stress is difficult. Most of what is known about stress was measured in a lab using a static, one-time assessment resulting in low ecological and predictive validity. These measurements do not capture the actual daily-life context in which stress can arise let alone biological, mental and contextual responses (Hoemann et al., 2023). To gain a better understanding of the daily-life context of stress, more dynamic, continuous field studies should be conducted. Furthermore, stress is difficult to measure because it has a negative connotation. People tend to under-report negative emotions, including stress (Randall & Fernandes, 1991). The relaxation response does not have a negative connotation.

Relaxation

Relaxation plays a crucial role in recovering from the disruption of homeostasis by activating the parasympathetic nervous system. This reduces cortisol levels and slows down heart rate and blood pressure, enabling the body to recover from stress (Benson et al., 1974; McEwen, 2006). The relaxational state is a state of decreased arousal which promotes a sense of calm and well-being and is regularly seen as the opposite of being stressed (Meier et al., 2020). Most individuals experience relaxation as a pleasant state to be in. To achieve a relaxed state, one must regulate short-term stress levels so they do not exceed a determined level of stress. Short-term stress exceeding this level becomes counterproductive (Itzkowic, 1977). Prominent stress-reducing treatments are relaxation activities. Assessing the effectiveness of a stress-reducing intervention, such as stress feedback, does not only require adequate measures of subjective stress but also subjective relaxation (Steghaus & Poth, 2022). In this study stress feedback will be provided by a wearable.

Wearables

Wright and Keith (2014) describe wearable technology, wearable devices, or simply wearables as intelligent computers incorporated into different accessories, including clothing, fashion accessories, and other everyday items worn by consumers. Wearables, such as smartwatches, fitness trackers and armbands, allow users to monitor their physical and mental health (Ramírez et al., 2023). Modern wearables claim to measure short-term physiological stress responses and provide a stress score to the consumer. Wearables can measure the stress response of individuals by assessing physiological signals like galvanic skin response, temperature or heart rate variability (HRV) (Cheng et al., 2021). The wearables used in this study will measure HRV to calculate a stress level. HRV is a valid measure of the physiological stress response (Immanuel et al., 2023). HRV reflects the balance between the sympathetic and parasympathetic nervous system. When someone experiences stress their sympathetic nervous system will be activated leading to measurable changes in HRV. Photoplethysmography can measure HRV by measuring volumetric variation in blood circulation. Photoplethysmography is a non-invasive technology able to measure these volumetric variations using a light source and a photodetector at the surface of the skin (Li et al., 2023).

Stress management technology, stress and relaxation

Stress management technology, like a wearable, can be an effective tool to reduce perceived stress and increase perceived relaxation. These tools are effective in reducing perceived stress by promoting SMI (Jiménez-Ocaña et al., 2023; Ramírez et al. 2023). No studies have been conducted on the effect of stress feedback on perceived stress or relaxation without any form of SMI. Individuals using technology with a simple step counter take 1126 extra steps a day within the first four months and 434 extra steps a day after three or four years (Chaudhry et al., 2020). These extra steps were taken without any additional intervention. SMIs which are commonly used in combination with wearables studies have been proven to be effective without wearables (Richardson & Rothstein, 2008). The effect of WSF without any SMI is understudied. Stress management technology can be effective without any SMI by empowering individuals to manage their stress. Moreover, SMI can help individuals identify stress patterns and stress triggers in their daily lives. Individuals who are aware of their stress levels, stress patterns and potential stress triggers could be more relaxed having a greater sense of control over their stress (Jerath et al., 2023; Jiménez-Ocaña et al., 2023). However, stress feedback can also increase stress by causing anxiety and panic due to misinterpretation of wearables (Choudhury & Asan, 2021).

WSF during stress

Stress fluctuates with most individuals experiencing periods of relatively low stress throughout the day (Campbell & Ehlert, 2012). Van Oostrum and Zwakenberg (2024) conducted a study exploring the effect of stress feedback on wearables. Many responses during the day indicated zero on a perceived stress scale. The sample of this study will likely be similar to the sample of Van Oostrum and Zwakenberg (2024) as the study will be conducted in the same environment using the same sampling method. The effect of WSF on relaxation for individuals who are not experiencing stress is less significant. Low-stress responses offer limited insights into the potential benefit of WSF during stressful moments. To address this, the effect of WSF should be analyzed when individuals are stressed.

Remembering self and experienced self

Measuring a psychological construct by self-report can be done using two forms of self-report; retrospective self-report and ambulatory self-report. Retrospective self-report is a form of self-report which relies on memory-based reporting. Participants are asked to report experiences by memory, often over long periods. Because memory is not always accurate and suffers from many biases, the result of retrospective self-reports can differ from actual experiences. Ambulatory self-reports are a form of self-report which relies on people describing their thoughts, feelings or behaviour in real-time. Therefore, do not rely on memory making them more ecologically valid (Conner & Barrett, 2012).

These different self-report methods activate different "selves". While retrospective self-report represents the remembering self which depends on memory. Ambulatory self-reports represent the experienced self. The experienced self is more closely linked to real-time sensory and bodily psychological states. This is especially true for stress-related bodily sensations (Conner & Barrett, 2012). This study will test both the remembering self and the experienced self. The remembering self will be tested by asking to reflect on last week's experiences, the experiencing self will be tested using the experience sampling method (ESM). ESM is an instrument in which data about the thoughts, feelings and behaviour of participants is collected multiple times a day. The data is quantitative and collected in real-time in participants' natural environment. ESM provides insights into the mental processes of everyday life (Csikszentmihalyi & Larson, 1987). Measuring stress using ESM enhances ecological validity in contrast to traditional retrospective questionnaires.

Knowledge gap and current study

The impact of stress is substantial to individuals and society. Wearables are a new technology claiming to be able to track short-term stress of users. Wearable technology is effective at reducing stress in combination with SMIs (Jiménez-Ocaña et al., 2023; Ramírez et al. 2023). However, no research has been conducted without SMIs, leaving the independent effect of WSF unknown. WSF could decrease stress in daily life by providing individuals insights into their short-term stress, helping them manage their stress levels (Jerath et al., 2023). Moreover, the relaxation response is an important mechanism for the body to a balanced homeostasis after stress. Exploring the effectiveness of WSF requires adequate measures of relaxation alongside stress (Steghaus & Poth, 2022). Furthermore, to explore the effect of WSF on stress, a subset will be created with the highest stress responses. Additionally, both retrospective and ambulatory questionnaires will be utilised. While retrospective questionnaires are commonly used, ambulatory questionnaires provide better insights into the daily life context in which short-term stress arises. The current study explores the effect of WSF on perceived stress and perceived relaxation in the context of daily life using the following two research questions divided into four sub-questions:

1. How does wearable stress feedback influence the perception of stress?
    a. How does a week with WSF influence retrospective perceptions of perceived stress, compared to a week without WSF?
    b. How does a week with WSF influence perceived stress in real-time, compared to a week without WSF?
2. How does wearable stress feedback influence the perception of relaxation?
    a. How does a week with WSF influence perceptions of relaxation in real-time, compared to a week without WSF?
    b. During stressful moments; how does a week with WSF influence perceptions of relaxation in real-time, compared to a week without WSF?

Method

Design

To explore the effect of WSF on stress and relaxation, a two-week-long, within-subject, counterbalanced design was employed. In a within-subject design, each participant is exposed to all conditions of a study, thereby accounting for individual differences. Additionally, in a counterbalanced design participants are exposed to different conditions in varied sequences, thereby accounting for order effect. This study employs a within-subject, counterbalanced design by dividing participants into two groups. One group will wear the wearable in the first week and the other group will be wearing the wearable in the second week. In the alternate week, participants are still filling out the questionnaires.

Distribution and content of questionnaires

In total, the participants received 73 questionnaires over two weeks. These consist of 3 retrospective self-report questionnaires and 70 ambulatory questionnaires. The three retrospective self-report questionnaires consisted of: the intake questionnaire, the first-week questionnaire and the second-week questionnaire. The intake questionnaire was distributed during the intake. The intake questionnaire included items regarding consent, demographics, perceived stress, stress mindset, interoception, emotion regulation, health anxiety and personality. The first-week questionnaire was distributed seven days after the intake questionnaire and included items regarding perceived stress, stress mindset and health anxiety. The second-week questionnaire was distributed fourteen days after the intake questionnaire. The second-week questionnaire included items regarding perceived stress, stress mindset, interoceptive awareness, emotional regulation and health anxiety. The Dutch versions of the retrospective questionnaires can be found in Appendix A.

The 70 ESM questionnaires were distributed across two weeks with the first day of data collection starting one day after the intake. Each day participants received five questionnaires, which included the morning questionnaire, three daily core questionnaires and the evening questionnaire. This study aimed for a response rate of at least 50% for both conditions. A response rate below 50% is insufficient for valid results.

The morning questionnaire included items regarding sleep and substance usage. The morning questionnaire was randomly distributed between 07:00 - 08:00 and available for 300 minutes with a reminder after 150 minutes. The morning questionnaire was available for six hours as the sample would likely include many students, who tend to wake up late.

The daily core questionnaire included items regarding affect, stress, relaxation, interoceptive awareness and cognition. The daily core questionnaires were randomly distributed between 08:00 - 10:00, 12:00 - 14:00 and 16:00 - 18:00 and available for 30 minutes with a reminder after 15 minutes. The daily core was available for 30 minutes so responses were recorded in designated windows.

The evening questionnaire included items regarding effect, stress, relaxation, interoceptive awareness, cognition, reflection on daily stress and experiences, physical discomfort and the PSS-4. The evening questionnaire was randomly distributed between 20:00 and 22:00 and available for 60 minutes with a reminder after 15 minutes. The evening questionnaire was available for one hour in the late evening as this questionnaire included several questions which required participants to reflect on their day. The Dutch versions of the ambulatory questionnaires can be found in Appendix B.

Participants

Participants were recruited through convenient sampling. The social networks of the researchers and SONA were used. Most participants recruited through the social network were roommates, friends and family. SONA is a platform through which Psychology and Communication Science bachelor students of the University of Twente can participate in studies earning them SONA points. These students must earn fifteen points to receive their bachelor's degree and could earn 3.75 SONA points by participating in this study. Not everyone could participate. The exclusion criteria for this study included participants under the age of eighteen, those with serious psychological conditions, and those who had recently worn a wearable device with stress feedback. The study aimed to collect data from at least twenty participants.

After 38 days of data collection, 24 responses were recorded. One of the participants withdrew after four days leaving 23 completed responses. Of the participants 14 were males, 9 were females. The age ranged from 18 to 55 with a median of 21 ($M = 23.5$, $SD = 9.7$). Most participants were Dutch (20). Moreover, the sample also included two Germans and one Greek. Information about the highest completed education was also gathered. Fifteen participants completed their high school, five participants achieved a WO/university degree or higher, two completed HBO and one MBO. Thirteen participants started with the wearable conditions, the other ten received the wearable in the second week.

Materials

Wearable

The wearable used in this study is the Garmin Forerunner 255, a model which was released on June 1, 2022. A photo of the model can be seen in Figure 1. The Garmin Forerunner 255 can monitor health and physical performance using a plethora of statistics. The display settings of all wearables were set to be identical. The wearable displayed the time, heart rate variability, heart rate and stress score. In Figure 2 a photo of the display can be seen. The Garmins were provided with a charger and guidance. The guidance explained the battery life, the water resistance of the wearable and when to wear the wearable. Participants were instructed to wear the wearable in most situations. However, they could choose to remove it during certain activities, such as sleeping, showering, or exercising. Furthermore, the metrics on the display were explained. The display of the wearable can be altered in many ways. This display was chosen as all relevant metrics are presented clearly with the stress score having a prominent and central location. The stress score has a range of 0 to 100. Participants were asked not to alter the display.

Figure 1

A photo of the front of the Garmin Forerunner 255 including wristband.

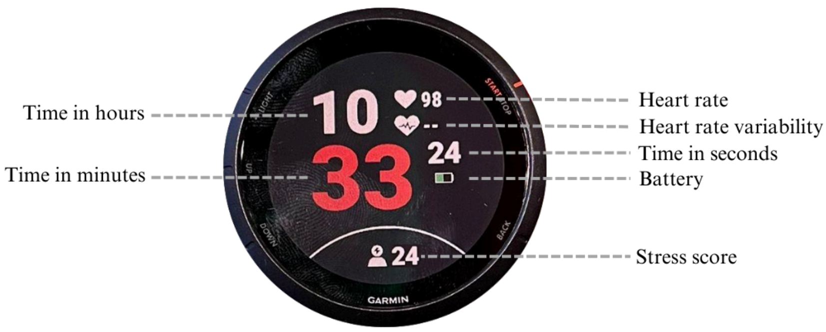


Figure 2

A photo of the Garmin Forerunner 255 display used in the study including an explanation of the metrics.

Questionnaire software

m-Path (https://m-path.io/landing/) was used to collect ESM data. m-Path is a platform used for research and therapy. Participants of m-Path use an app on which they receive notifications when a questionnaire is due. For the retrospective self-report questionnaires, Qualtrics (https://www.qualtrics.com) was used. Qualtrics is an online platform for creating and distributing surveys. Participants filled out the questionnaires after receiving a link or on a computer set up by one of the researchers.

Questionnaires

Perceived Stress Scale (PSS-4 and PSS-10). The Perceived Stress Scale (PSS) is a questionnaire designed to assess individuals perceived stress. The PSS-10 has ten items with a 5-point Likert scale ranging from 0 (never) to 4 (very often). An example of a question of the PSS-10 is; In the last month, how often have you felt that you were effectively coping with important changes that were occurring in your life? (Cohen et al., 1983). The internal consistency is higher than .70 and therefore at least acceptable. The PSS-4 is a short version of the PSS-10 including four items. The internal consistency of the PSS-4 ranges from .60 to .67 which is lower than the internal consistency of the PSS-10 (Lee, 2012).

Relaxation State Questionnaire (RSQ). The Relaxation State Questionnaire (RSQ) is a questionnaire designed to assess individual relaxation states. The RSQ has ten items with a 5-point Likert scale ranging from 1 (Not correct at all) to 5 (Entirely correct). This study adjusted the scale having a range from not at all (0) to very much (100). The internal consistency is good with an average Cronbach's alpha of .86. This study used the following two items of the RSQ; “At this moment I’m feeling very relaxed” ($\alpha = .80$) and “At this moment my heart is beating faster than usual” ($\alpha = .83$) (Steghaus & Poth, 2022). The items could be combined into a core relaxation score by combining the score on the first item and the reversed score on the second item.

Stress in Action. This study is part of a larger research project which is conducted under the framework of Stress in Action. Fifteen ESM items were developed by Stress in Action (https://stress-in-action.nl/) in collaboration with New Science of Mental Disorders (https://www.nsmd.eu/). These questions consider sleep, substance usage, affective state, perceived stress, cognition, reflection on daily stress and experiences and bodily discomfort. The stress items were essential for this study. The stress items were phrased as “At this moment I feel stressed”, “At this moment I feel tense” and "At this moment I feel energetic”. This study utilised these items by combining them into core stress.

Other Questionnaires and Demographic Variables. Most of the questionnaires used during the data collection are collected in the scope of a bigger research project and are therefore not used in this study. These questionnaires can be found in Appendix C. In addition to PSS-10, SHAI-14, stress mindset, ERQ, MAIA-2 and BFI-2 the study also collected demographics including age, gender, nationality and highest completed education.

Procedure

Study procedure

After participants were recruited, they received an email detailing the study’s purpose, the planning, m-Path and Qualtrics, information about the wearable device and an intake meeting was scheduled.

The intake meetings took place on the campus of the University of Twente and consisted of filling out the intake questionnaire, creating and linking m-Path and scheduling the second meeting. When a participant was assigned to use a wearable in the first week, the wearable was provided including an explanation. Furthermore, psychoeducation was discussed. The psychoeducation explained what the stress score of Garmin meant and how it was calculated. The psychoeducation can be found in Appendix D. Participants were instructed to fill out five daily ESM questionnaires, one day after the intake meeting, for two weeks long.

After one week, the second meeting was due. In the second meeting participants were asked to fill out the first-week questionnaire and the final meeting was planned. Afterwards, the participants who were using the wearable in the first week returned the wearable. The participants who were assigned to use a wearable in the second week were provided with the wearable including an explanation about the wearable and psychoeducation.

After two weeks, the third meeting was due. Participants were asked to fill out the second-week questionnaire in the final meeting. Participants who were using a wearable in the second week returned the wearable. After which the participants were thanked for their participation.

Consent form

This research study received ethical approval from the Institutional Review Board (Ethics Committee HSS- BMS). The ethical approval verifies that the study follows the ethical guidelines of the University of Twente. In adherence with the ethical standards, all participants were provided with the consent form that included the goal of the study, potential risks, and specifically the rights of the participants. This explained that participants have the right to withdraw from the study at any time without any consequences. The participants were ensured that their data would be treated confidentially. The consent form and details can be found in Appendix E.

Data analyses

Data analysis was conducted using R-studios (2024.09.1+394), the script can be found in Appendix F. The data collected was first screened to determine the final dataset. Unfinished retrospective self-report questionnaires were excluded. Participants who did not meet the inclusion criteria were excluded. Unanswered questionnaires and items were excluded. The morning questionnaire did not include any relevant information for this study and was therefore excluded. Questionnaires filled out after day fourteen were excluded. All items irrelevant to the research questions were excluded. After the final dataset was determined the descriptive statistics were analysed to gain a better understanding of the data and the participants. After an analysis of the descriptive statistics, the parametric assumptions were tested.

The parametric assumptions of normality and homogeneity of variance were tested. The Shapiro-Wilk test and Kolmogorov-Smirnov test were used to test the assumption of normality. The Shapiro-Wilk test was used for data with less than 50 responses, and the Kolmogorov-Smirnov test for data with more than 50 responses. When $p > .05$ the null hypothesis cannot be rejected meaning the data does not violate the assumption of normality. Pearson's correlation test is used to test the assumption of independence. When $p > .05$ the null hypothesis cannot be rejected meaning the data does not violate the assumption of independence. A scatterplot was used to test the assumption of homogeneity of variance, this was done by visually examining variance of data points in the plot. The assumption was met when the dispersion of scores was roughly equal. When all assumptions are met an inferential analysis can be conducted (Harrison & Rentzelas, 2020). More information on the parametric assumption in this study can be found in Appendix G.

To test the research questions, linear regression analysis was conducted using a simple linear regression model. The coefficient of the analysis indicated the direction and strength of the correlation. The p-value describes the significance of the coefficient (Schneider et al., 2010). An alpha of .05 is used for the linear regression analysis. For research question 1a, the independent variable was the condition of wearing a wearable or not, and the dependent variable was the PSS-10 score. For research question 1b, the independent variable was the condition of wearing a wearable or not, and the dependent variable was core stress. For research questions 2a and b, the independent variable was the condition of wearing a wearable or not, and the dependent variable was core relaxation. However, to test research question 2b a new dataset was created. This dataset included the five highest scores on core stress of each participant for each condition. By choosing an equal number of stressful moments for all individuals, individual differences were accounted for.

Results

Included data

Responses from 23 participants were recorded, some of which were excluded from either questionnaire. Two participants were excluded from the retrospective self-report questionnaires, one did not complete all questionnaires and one participant was excluded as she filled out the first- and second-week questionnaires on the same day. Additionally, one participant filled out the second-week questionnaire twice, her first response was recorded on the intended date. Therefore, her last response was excluded.

Filling out five questionnaires a day over two weeks is a demanding task for voluntary participants. Eight of the 23 participants were not able to achieve a response rate of 50% for both conditions and were therefore excluded. The median response rate of included participants was 63.7. The mean compliance in the first week was 67% and in the second week 60%. Participants starting without a wearable had a higher response rate (M = 70%) than those who started with one (M = 59%).

Descriptive statistics

Descriptive statistics were analysed to gain an understanding of the sample (Table 1). The mean score on the PSS-10 was 13.9 (SD = 5.96). For the ESM responses, a stress core mean of 38.8 (SD = 14.3) and a relaxation core mean of 62.8 (SD = 18.17) were recorded. For the sample with the highest stress responses, a stress core mean of 52.9 (SD = 11.2) was found and a relaxation core mean of 53.7 (SD = 19.9).

Table 1

Descriptive Statistics for PSS-10, Stress Sore and Relaxation Core

Wearable Status		Not Wearing			Wearing		
	n	*M*	*SD*	Responses	*M*	*SD*	Responses
PSS-10	21	13.8	6.58	-	14.0	5.44	-
All ESM Responses							
Stress Core	15	38.7	14.4	285	38.8	14.1	293
Relaxation Core	15	63.8	18.00	285	61.8	18.3	293
Stressful ESM Responses							
Stress Core	15	53.0	12.0	75	52.8	10.4	75
Relaxation Core	15	55.2	19.8	75	52.2	20.0	75

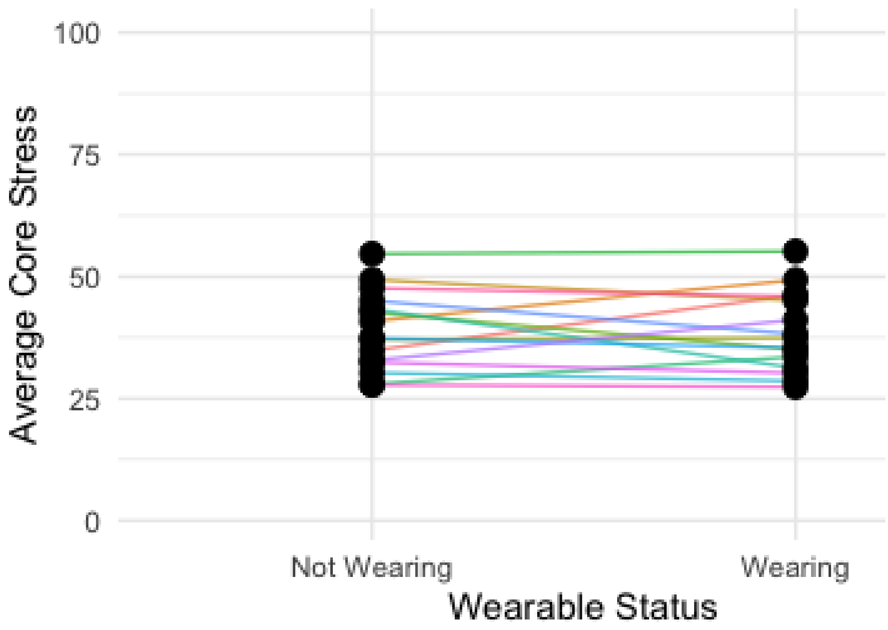
Note. PSS-10 was filled out in the retrospective questionnaire which has a range from 0 - 40. All items of Stress core and Relaxation core had a range of 0 - 100. Stressful moments consist of the five highest reported scores for each condition for each participant.

Effects of wearable on perceived stress

No significant effect was found for the effect of WSF on perceived stress on the remembering self (b = 0.09, SE = 1.86, p = *.96*). No significant effect was found for the effect of WSF on perceived stress on the experiencing self (b = 0.15, SE = 1.19, p = .90). See Table 2 for all results of the linear regression model. To gain insights into individual differences in stress on experiencing self a spaghetti plot was created (Figure 3). The stress scores of seven participants have changed with at least 5 points per condition.

Figure 3

Spaghetti Plot Comparing Individual's Core Stress and Wearable Status on Original Scale

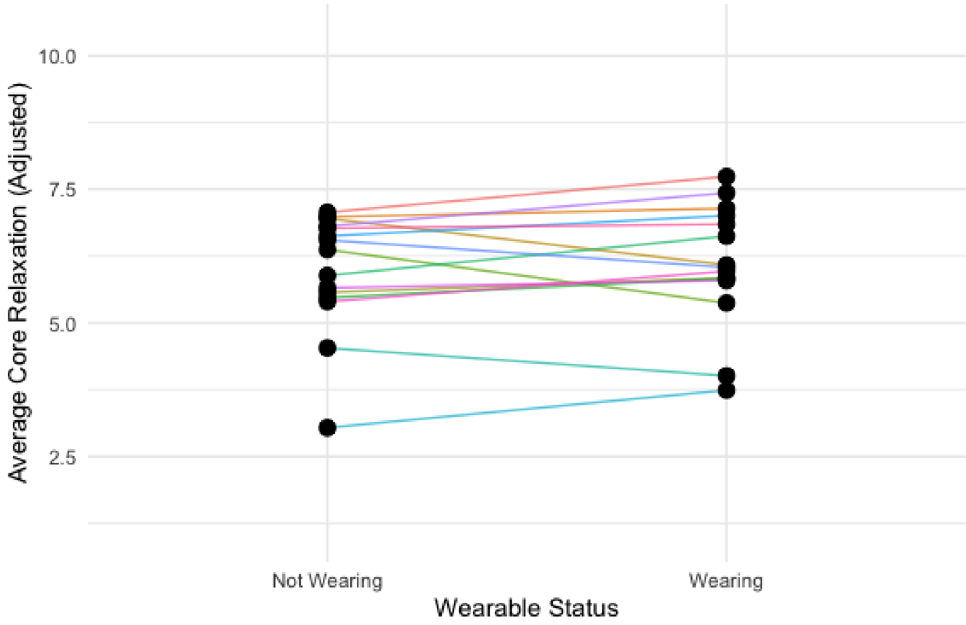


Effects of wearable on relaxation

The relaxation core data met the assumption of normality after transforming the data using square root. No significant effect was found for the effect of WSF on relaxation on the experiencing self (b = 0.22, SE = 0.19, p = .24). A spaghetti plot was created to gain insights into individual differences (Figure 4). Adjusted relaxation scores of eight participants have changed by at least 0.5 points per condition. No significant effect was found on the effect of a wearable on relaxation for the sample with the highest stress scores (b = -3.027, SE = 3.25, p *= .354)*. See Table 2 for all results of the linear regression model. A spaghetti plot was created per individual to gain more insights into the individual differences (Figure 5). Relaxation scores of nine participants have changed with at least 10 points per condition.

Figure 4

Spaghetti Plot Comparing Individuals Core Relaxation and Wearable Status



Note. Relaxation scores are transformed using square root.

Figure 5

Spaghetti Plot Comparing Individual's Core Relaxation and Wearable Status in Stressed Subset

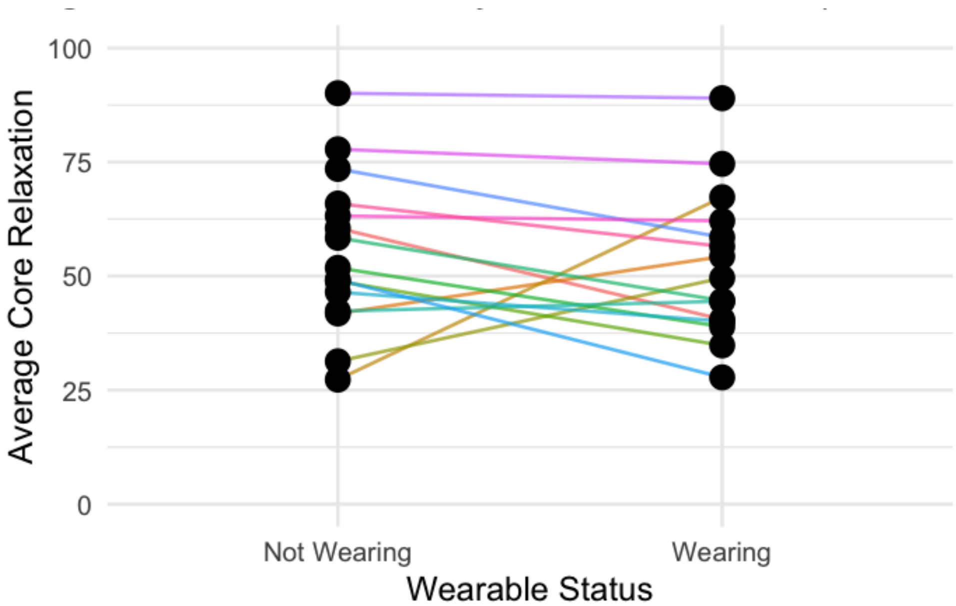


Table 2

Effect of a wearable on stress and relaxation on remembering and experiencing self

	b	*SE*	*t*	*p*
Stress Remembering Self				
Intercept	14.50	1.35	10.78	<.001
Week with wearable	0.09	1.86	0.05	.961
Stress Experiencing Self				
Intercept	38.67	0.84	45.77	<.001
Week with wearable	0.15	1.19	0.124	.901
Relaxation Experiencing Self				
Intercept	8.27	0.13	61.41	<.001
Week with wearable	0.22	0.19	1.19	.235
Relaxation while under stress Experiencing Self				
Intercept	55.23	2.30	24.022	<.001
Week with wearable	-3.027	3.25	-0.931	.354

Note. Relaxation score of the overall sample is transformed using square root. Stress Remembering Self has a range from 0 - 40. Stress Experiencing Self and Relaxation while under stress Experiencing Self has a range of 0 - 100. Intercept represents a week without a wearable.

Discussion

This study aimed to explore the effect of WSF on perceived stress and perceived relaxation. An insignificant and very small positive effect was found for the influence of a wearable on perceived stress in retrospective questionnaires. An insignificant and very small positive effect was found for the influence of a wearable on perceived stress in ambulatory questionnaires. An insignificant and very small positive effect was found for the influence of a wearable on perceived relaxation in ambulatory questionnaires. An insignificant and small negative effect was found for the influence of a wearable on perceived relaxation while individuals experience stressful episodes in retrospective questionnaires. The results suggest a very small positive trend of WSF on stress and relaxation in the sample. Additionally, the results show a very small negative trend on relaxation during the participants' most stressful responses. This study is not able to provide evidence for the negative effect of WSF on stress and can therefore not build upon the findings of previous studies (Ramírez et al., 2023; Jiménez-Ocaña et al., 2023). However, for all four models considerable individual differences were found suggesting individual differences greatly influence the effect of WSF.

Insignificant results

Finding insignificant effects is not unusual for wearable research. In the systematic review of Ferguson et al. (2022) 57% of studies showed insignificant results. 31 out of 40 studies found a significant effect on the effect of stress feedback on wearables in Ramírez et al. (2023) scoping review, however, these studies used SMI. This study did not utilise any SMI. Nonetheless, the study found minor trends in real-world conditions.

Real-World Conditions

This field study offers valuable insights into the effect of WSF on stress and relaxation in real-world conditions without any additional SMI. Over half of the studies in Ramírez et al. (2023) scoping review were controlled experiments, limiting ecological validity. In contrast, this study was implemented in a natural setting. Participants were provided with a wearable, filled out a maximum of six questionnaires a day and otherwise continued with their normal daily lives. Additionally, the study used ambulatory self-reports, capturing participant responses in real time. Furthermore, this study allowed participants to use WSF how they saw fit, providing limited instructions. This represents more typical consumer behaviour as most consumers lack pre-required knowledge and do not invest time to learn more about stress feedback (Ding et al., 2021). Additionally, most digital mental health interventions have notoriously low response rates (Boucher & Raiker, 2024). Consumers of wearables will likely not use any additional form of SMI. Therefore, no additional SMI was provided in this study. However, consumers will use WSF for longer than one week.

Wearable Duration

Participants wore the wearable for one week, a short period in which the wearable was new. It takes time to adjust to technology like a wearable. Yen et al. (2021) studied the effect of wearables on physical activity during a twelve-week-long intervention. The study found that the wearing duration significantly impacted the effectiveness. Participants were more likely to be physically active when they wore the wearable for longer periods. Furthermore, Yu et al. (2018) mentioned that acquiring self-regulation skills through biofeedback is not easy, it takes time and practice. Therefore, WSF could be more effective when participants use the intervention for longer than a week. Providing individuals time to adjust to a wearable and acquiring self-regulation skills likely influences the effectiveness of WSF.

Individual differences

How individuals experience stress differs greatly between individuals (Campbell & Ehlert, 2012). The effect of a wearable seems to differ notably between participants with some participants experiencing more stress or relaxation while others do not. Some individuals might benefit from awareness by adjusting their behaviour or practising SMI, others might become anxious contributing to even more stress (Choudhury & Asan, 2021). Individuals differ in many ways and identifying which underlying characteristics influence the effectiveness of WSF is challenging. Characteristics which potentially contribute to these individual differences are the personality trait neuroticism and the challenge threat model.

WSF might increase stress in neurotic individuals. Neuroticism is characterised by heightened emotional sensitivity, a tendency towards negative affect and slow physiological recovery rates. Slow recovery of stress results in higher stress feedback. As neurotic individuals are prone to heightened anxiety, high-stress feedback might increase anxiety and stress (Yin et al., 2024).

The challenge-threat model provides insights into individual differences. Zwakenberg (2024) found that some participants using WSF more often experienced an increased stress-coping ability. An improved perception of stress-coping abilities increases the amount of stressors which are seen as a challenge rather than a threat (Blascovich & Mendes, 2010). Stressors which are seen as a challenge result in adaptive physiological responses (Jamieson et al., 2013), contributing to shorter stress duration and reduced overall stress levels.

Stress in the sample

The descriptive statistics are analysed to contextualise the stress score in the sample. According to a study conducted by Cohen and Janicki-Deverts (2012), the mean score for the PSS-10 is 15.21 (SD = 7.28). Therefore, this sample reported comparable levels of perceived stress to the normal population with an average score of 13.9. The average stress score of the stressed subset was 52.9, 14.1 points higher than the entire sample. Moreover, the lowest reported core stress response was 33.33. Considering people tend to under-report stress (Randall & Fernandes, 1991), it is likely that all responses within the stressed subset reflect at least a moderate level of stress. However, due to a lack of normative data, it is not possible to directly compare this score to the population.

Limitation

This study failed to find any significant effect, limiting the credibility of the findings. Additionally, the study was conducted over a relatively short period in which participants had to adjust to WSF. Moreover, a low ESM compliance rate was recorded with 8 out of 23 participants being excluded for not achieving the minimal response rate. Consequently, a limited sample size was recorded. With only a sample size of 21 for the retrospective self-report questionnaires and 15 for ambulatory self-reports. The sample size limits the generalizability of the conclusion. This study reported individual differences, where some participants seemed to excel with the use of a wearable, others did not. As the sample size was small, only a small number of individual deviations were found. Consequently, limiting the ability to identify patterns within individual differences.

Implementations and Future Research

This study indicated a trend in which WSF without instructions, training or SMI negatively impacts relaxation during stressful moments. Relaxation is a crucial mechanism to recover from stress. The use of WSF without proper guidance or SMI might be counterproductive and is therefore not recommended for individuals who aim to enhance relaxation. However, individual differences seem to play an important role in the effects of WSF. W. Li et al. (2024) highlighted the importance of tailoring psychological interventions. Identifying which individuals benefit from stress feedback and understanding why should be an important focus of future research. Particularly, attention should be given to personality traits and the challenge-threat model. As our understanding of the effect of WSF on individual characteristics grows, WSF can be implemented only for those who benefit from it.

The more data a study contains, the more power it has. Of the potential 1610 ESM questionnaires only 667 questionnaires were used in the data analysis. When using ESM as a data collection method, it is expected that not all items are filled out. However, in this study, only 41% of the items were used for the analysis. Eight participants had to be excluded from data analysis due to low compliance and the other fifteen had a median response rate of 63.7%. A lot of potential data was missed, leaving much room for improvement.

This study design implements some of the strategies of the open handbook of ESM (KU Leuven, 2020). These were clear instructions, individualised briefing, realistic scheduling, addressing of non-compliant participants and short and manageable questionnaires. These strategies were implemented by emphasising the importance of high response and giving clear instructions in the intake, second and third meetings. Additionally, participants with low compliance were contacted during the data collection and encouraged to fill out more questionnaires. However, some recommended strategies were not implemented.

Namely, daily contact during the initial days, regular reminders and positive framing. Further research should prioritise a high compliance rate by implementing these strategies.

The impact of wearable use duration should be a topic of research. The long-term effectiveness of WSF is uncertain as consumers often show enthusiasm and exhibit high engagement within the first months of wearable use after which engagement fluctuates (Chaudhry et al., 2020; Nelson et al., 2020). Therefore, a longer duration of WSF can decrease effectiveness. Additionally, adaptation time could have limited the effect of WSF as participants only had one week to adjust to WSF. Future research can reduce the impact of adoption time by increasing the duration of the intervention. Additionally, studies which implement a short intervention duration could benefit from stress feedback training. Even Though stress feedback training might decrease ecological validity, research shows stress feedback training decreases adaptation time and increases trust in the system (Cohen et al., 2016).

Conclusion

This study explored the effect of WSF on perceived stress and perceived relaxation, without the use of additional SMI. Small and insignificant results were found. The results showed that WSF slightly decreases stress and increases relaxation for the overall sample. Additionally, WSF decreased relaxation for the most stressful responses of individuals. This study provides valuable insights into the effect of WSF on stress and relaxation in real-world conditions. The field study reflects typical consumer behaviour by utilizing ambulatory self-reports, providing minimal instruction and not implementing any SMI. The results suggest WSF should be avoided for individuals seeking to increase relaxation during stressful moments. However, considerable individual differences were found. For some individuals, WSF might be an effective tool to reduce stress and increase relaxation. Future research should explore these individual differences to gain a better understanding of how and why WSF impacts individuals differently. Particular attention should be given to the personality trait neuroticism and the challenge threat model. Moreover, future research should be conducted into the effect of the duration of wearable use and stress feedback training. Despite the limitations, this study contributed to a growing understanding of WSF focusing on real-world implications of wearables. A better understanding of the underlying mechanisms influencing the effect of WSF on stress can enable wearables to become a breakthrough intervention in the management of stress.

Literature

Benson, H., Beary, J. F., & Carol, M. P. (1974). The relaxation response. *Psychiatry*, *37*(1), 37–46. https://doi.org/10.1080/00332747.1974.11023785

Blascovich, J., & Mendes, W. B. (2010). Social Psychophysiology and Embodiment. In Handbook of Social Psychology (pp. 194–227).

Boucher, E. M., & Raiker, J. S. (2024). Engagement and retention in digital mental health interventions: a narrative review. *BMC Digital Health*, *2*(1). https://doi.org/10.1186/s44247-024-00105-9

Campbell, J., & Ehlert, U. (2012). Acute psychosocial stress: Does the emotional stress response correspond with physiological responses? *Psychoneuroendocrinology*, *37*(8), 1111–1134. https://doi.org/10.1016/j.psyneuen.2011.12.010

Chaudhry, U. a. R., Wahlich, C., Fortescue, R., Cook, D. G., Knightly, R., & Harris, T. (2020). The effects of step-count monitoring interventions on physical activity: systematic review and meta-analysis of community-based randomised controlled trials in adults. *International Journal of Behavioral Nutrition and Physical Activity*, *17*(1). https://doi.org/10.1186/s12966-020-01020-8

Cheng, Y., Wang, K., Xu, H., Li, T., Jin, Q., & Cui, D. (2021). Recent developments in sensors for wearable device applications. *Analytical And Bioanalytical Chemistry*, *413*(24), 6037–6057. https://doi.org/10.1007/s00216-021-03602-2

Choudhury, A., & Asan, O. (2021). Impact of using wearable devices on psychological Distress: Analysis of the health information national Trends survey. *International Journal Of Medical Informatics*, *156*, 104612. https://doi.org/10.1016/j.ijmedinf.2021.104612

Cohen, I., Brinkman, W., & Neerincx, M. A. (2016). Effects of different real-time feedback types on human performance in high-demanding work conditions. *International Journal of Human-Computer Studies*, *91*, 1–12. https://doi.org/10.1016/j.ijhcs.2016.03.007

Cohen, S., & Janicki‐deverts, D. (2012). Who's Stressed? Distributions of Psychological Stress in the United States in Probability Samples from 1983, 2006, and 20091. *Journal of Applied Social Psychology*, *42*(6), 1320–1334. https://doi.org/10.1111/j.1559-1816.2012.00900.x

Cohen, S., Janicki-Deverts, D., & Miller, G. E. (2007). Psychological stress and disease. *JAMA*, *298*(14), 1685. https://doi.org/10.1001/jama.298.14.1685

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A Global Measure of Perceived Stress. *Journal Of Health And Social Behavior*, *24*(4), 385. https://doi.org/10.2307/2136404

Conner, T. S., & Barrett, L. F. (2012). Trends in ambulatory Self-Report. *Psychosomatic Medicine*, *74*(4), 327–337. https://doi.org/10.1097/psy.0b013e3182546f18

Crum, A. J., Salovey, P., & Achor, S. (2013). Rethinking stress: The role of mindsets in determining the stress response. *Journal Of Personality And Social Psychology*, *104*(4), 716–733. https://doi.org/10.1037/a0031201

Dhabhar, F. S. (2018). The short-term stress response – Mother nature's mechanism for enhancing protection and performance under conditions of threat, challenge, and opportunity. *Frontiers in Neuroendocrinology*, *49*, 175–192. https://doi.org/10.1016/j.yfrne.2018.03.004

Dhingra, L. S., Aminorroaya, A., Oikonomou, E. K., Nargesi, A. A., Wilson, F. P., Krumholz, H. M., & Khera, R. (2023). Use of Wearable Devices in Individuals With or at Risk for Cardiovascular Disease in the US, 2019 to 2020. *JAMA Network Open*, *6*(6), e2316634. https://doi.org/10.1001/jamanetworkopen.2023.1663

Ding, X., Wei, S., Gui, X., Gu, N., & Zhang, P. (2021). Data Engagement Reconsidered: A Study of Automatic Stress Tracking Technology in Use. *CHI Conference*. https://doi.org/10.1145/3411764.3445763

Electronic Resources in Medical Libraries, *11*(4), 204–216. https://doi.org/10.1080/15424065.2014.969051

Epel, E. S., Crosswell, A. D., Mayer, S. E., Prather, A. A., Slavich, G. M., Puterman, E., & Mendes, W. B. (2018). More than a feeling: A unified view of stress measurement for population science. *Frontiers in Neuroendocrinology*, *49*, 146–169. https://doi.org/10.1016/j.yfrne.2018.03.001

Ferguson, T., Olds, T., Curtis, R., Blake, H., Crozier, A. J., Dankiw, K., Dumuid, D., Kasai, D., O'Connor, E., Virgara, R., & Maher, C. (2022). Effectiveness of wearable activity trackers to increase physical activity and improve health: a systematic review of systematic reviews and meta-analyses. *The Lancet Digital Health*, *4*(8), e615–e626. https://doi.org/10.1016/s2589-7500(22)00111-x

Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: implications for affect, relationships, and well-being. *Journal Of Personality And Social Psychology*, *85*, 348–362. https://doi.org/10.1037/0022-3514.85.2.348

Harkness, K. L., & Hayden, E. P. (2019). Introduction. *Oxford Academic*, xvi–6. https://doi.org/10.1093/oxfordhb/9780190681777.013.36

Harrison, E. H., & Rentzelas, P. R. (2020). *Your psychology dissertation* (1st ed.). SAGE.

Hassard, J., Teoh, K. R. H., Visockaite, G., Dewe, P., & Cox, T. (2017). The cost of work-related stress to society: A systematic review. *Journal of Occupational Health Psychology*, *23*(1), 1–17. https://doi.org/10.1037/ocp0000069

Hoemann, K., Wormwood, J. B., Barrett, L. F., & Quigley, K. S. (2023). Multimodal, Idiographic Ambulatory Sensing Will Transform our Understanding of Emotion. *Affective Science*, *4*(3), 480–486. https://doi.org/10.1007/s42761-023-00206-0

Immanuel, S., Teferra, M. N., Baumert, M., & Bidargaddi, N. (2023). Heart Rate Variability for Evaluating Psychological Stress Changes in Healthy Adults: A Scoping Review. *Neuropsychobiology*, *82*(4), 187–202. https://doi.org/10.1159/000530376

Itzkowic, P. (1977). RELAXATION1 1Delivered at a Seminar for staff and students, Anatomy Department, The University of Sydney, November 3, 1976.Received January, 1977. *Australian Journal Of Physiotherapy*, *23*(2), 62–64. https://doi.org/10.1016/s0004-9514(14)61023-0

Jamieson, J. P., Mendes, W. B., & Nock, M. K. (2013). Improving acute stress responses. *Current Directions in Psychological Science*, *22*(1), 51–56. https://doi.org/10.1177/0963721412461500

Jerath, R., Syam, M., & Ahmed, S. (2023). The Future of Stress Management: Integration of Smartwatches and HRV Technology. *Sensors*, *23*(17), 7314. https://doi.org/10.3390/s23177314

Jiménez-Ocaña, A. A., Pantoja, A., Valderrama, M. A., & Giraldo, L. F. (2023). A Systematic Review of Technology-Aided Stress Management Systems: Automatic Measurement, Detection and Control. *IEEE Access*, *11*, 116109–116126. https://doi.org/10.1109/access.2023.3325763

KU Leuven. (2020). *Open Handbook of Experience Sampling Methodology* (2nd ed.). The center for Research on Experience sampling and The center for Research on Experience sampling and Ambulatory methods Leuven (REAL) - Belgium.

Lee, E. (2012). Review of the Psychometric Evidence of the Perceived Stress Scale. *Asian Nursing Research*, *6*(4), 121–127. https://doi.org/10.1016/j.anr.2012.08.004

Li, K., Cardoso, C., Moctezuma-Ramirez, A., Elgalad, A., & Perin, E. (2023). Heart Rate Variability Measurement through a Smart Wearable Device: Another Breakthrough for Personal Health Monitoring? *International Journal of Environmental Research and Public Health*, *20*(24), 7146. https://doi.org/10.3390/ijerph20247146

Li, W., Gleeson, J., Fraser, M. I., Ciarrochi, J., Hofmann, S. G., Hayes, S. C., & Sahdra, B. (2024). The efficacy of personalized psychological interventions in adolescents: a scoping review and meta-analysis. *Frontiers in Psychology*, *15*. https://doi.org/10.3389/fpsyg.2024.1470817

McEwen, B. S. (2006). Protective and damaging effects of stress mediators: central role of the brain. *Dialogues in Clinical Neuroscience*, *8*(4), 367–381. https://doi.org/10.31887/dcns.2006.8.4/bmcewen

Mehling, W. E., Acree, M., Stewart, A., Silas, J., & Jones, A. (2018). The Multidimensional Assessment of Interoceptive Awareness, Version 2 (MAIA-2). *PLoS ONE*, *13*(12), e0208034. https://doi.org/10.1371/journal.pone.0208034

Meier, M., Unternaehrer, E., Schorpp, S. M., Wenzel, M., Benz, A., Bentele, U. U., Dimitroff, S. J., Denk, B., & Prüssner, J. C. (2020). The Opposite of Stress. *Experimental Psychology (Formerly Zeitschrift Für Experimentelle Psychologie)*, *67*(2), 150–159. https://doi.org/10.1027/1618-3169/a000483

Nelson, E. C., Sools, A. M., Vollenbroek-Hutten, M. M. R., Verhagen, T., & Noordzij, M. L. (2020). Embodiment of Wearable Technology: Qualitative longitudinal study. *JMIR Mhealth and Uhealth*, *8*(11), e16973. https://doi.org/10.2196/16973

O'Donnell, B., & Hetrick, W. (2015). Psychophysiology of mental health. In *Elsevier eBooks* (pp. 372–376). https://doi.org/10.1016/b978-0-12-397045-9.00142-7

Ramírez, M. L. G., Vázquez, J. P. G., Rodríguez, M. D., Padilla-López, L. A., Galindo-Aldana, G. M., & Cuevas-González, D. (2023). Wearables for Stress

Management: A Scoping Review. *Healthcare*, *11*(17), 2369. https://doi.org/10.3390/healthcare11172369

Ranabir, S., & Reetu, K. (2011). Stress and hormones. *Indian Journal of Endocrinology and Metabolism*, *15*(1), 18. https://doi.org/10.4103/2230-8210.77573\

Randall, D. M., & Fernandes, M. F. (1991). The social desirability response bias in ethics research. *Journal Of Business Ethics*, *10*(11), 805–817. https://doi.org/10.1007/bf00383696

Richardson, K. M., & Rothstein, H. R. (2008). Effects of occupational stress management intervention programs: A meta-analysis. *Journal of Occupational Health Psychology*, *13*(1), 69–93. https://doi.org/10.1037/1076-8998.13.1.69

Salkovskis, P. M., Rimes, K. A., Warwick, H. M. C., & Clark, D. M. (2002). The Health Anxiety Inventory: development and validation of scales for the measurement of health anxiety and hypochondriasis. *Psychological Medicine*, *32*(05). https://doi.org/10.1017/s0033291702005822

Schneider, A., Hommel, G., & Blettner, M. (2010). Linear Regression analysis. *Deutsches Ärzteblatt International*. https://doi.org/10.3238/arztebl.2010.0776

Schneiderman, N., Ironson, G., & Siegel, S. D. (2004). Stress and Health: Psychological, Behavioral, and Biological Determinants. *Annual Review Of Clinical Psychology*, *1*(1), 607–628. https://doi.org/10.1146/annurev.clinpsy.1.102803.144141

Soto, C. J., John, O. P., Department of Psychology, Colby College, United States, & Department of Psychology, University of California, Berkeley, United States. (2017). Short and extra-short forms of the Big Five Inventory–2: The BFI-2-S and BFI-2-XS. In *Journal Of Research in Personality* [Journal-article]. https://www.colby.edu/wp-content/uploads/2013/08/Soto_John_2017b.pdf

Steghaus, S., & Poth, C. H. (2022). Assessing momentary relaxation using the Relaxation State Questionnaire (RSQ). *Scientific Reports*, *12*(1). https://doi.org/10.1038/s41598-022-20524-w

Tester. (2019, November 30). *Transform data to normal distribution in R: easy Guide - Datanovia*. Datanovia. https://www.datanovia.com/en/lessons/transform-data-to-normal-distribution-in-r/

Van Oostrum, J. O. (2024). *M12 BSc. Thesis: Exploring the Impact of Wearable Devices on Perceived Stress and Health Anxiety: A Mixed-Methods Approach* [Bachelor Thesis]. University of Twente.

Wright, R., & Keith, L. (2014). Wearable Technology: If the Tech Fits, Wear It. *Journal Of Electronic Resources in Medical Libraries, 11(4), 204–216. https://doi.org/10.1080/15424065.2014.969051*

Yen, H., Liao, Y., & Huang, H. (2021). Smart wearable device users' behavior is essential for physical activity improvement.*International Journal of Behavioral Medicine*, *29*(3), 278–285. https://doi.org/10.1007/s12529-021-10013-1

Yin, M., Yu, H., Zou, M., He, Y., & Wang, X. (2024). The relationship between neuroticism and the acute psychological stress response: Evidence from the autonomic nervous system. *Current Psychology*, *43*(22), 20153–20164. https://doi.org/10.1007/s12144-024-05813-z

Zwakenberg, K. Z. (2024). *Exploring Wearable Stress Feedback: A Mixed-Methods Approach to Perceived Stress and Challenge-Threat Appraisals* [Bachelor Thesis]. University of Twente.

Appendix A:

The Retrospective Questionnaires

StressWearables Baseline

Start of Block: Consent

Q28 Informed Consent Thank you for participating in our study. This study investigates the relationship between stress feedback from wearables, perceived stress, perceived relaxation and interoceptive awareness. Participating in this study is voluntary and it is possible to withdraw at any time during the study without providing a reason. The questionnaires consists of several questions about stress, relaxation, interoception, health anxiety, emotion regulation and personality. In the first questionnaire, there will be some questions about demographics. Please answer all questions as honestly as possible. Your participation will take two weeks in which you are expected to fill out five questionnaires daily. With an additional questionnaire at the start of the first week, at the start of the second week and the end of the second week. All data collected will be anonymised and will only be seen by the researchers, but cannot be traced back to you. This study is part of a bigger research project. Therefore, your anonymised data could also be used in other studies regarding stress feedback from wearables. The data will be stored following the guidelines of the University of Twente. If there are any questions or remarks, feel free to contact the researchers: Finn de Jong: f.dejong-4@student.utwente.nl Daan Leijser: d.m.j.leijser@student.utwente.nl Supervisor: Matthijs Noordzij: m.l.noordzij@utwente.nl

- ○ **I've read the informed consent, and agree to participate in this study. My results can be used for the purpose of this study, and the research project of which this study is part. (1)**
- ○ **I do not provide consent, and refuse to take part in the study (2)**

End of Block: Consent

Start of Block: ID

ID Wat is je deelnamecode?

____

End of Block: ID

Start of Block: Background

Age Hoe oud ben je?

____

Gender Wat is je geslacht?

- ○ **Man (1)**
- ○ **Vrouw (2)**
- ○ **Anders, namelijk ... (3)** ____
- ○ **Ik geef liever geen antwoord op deze vraag (99)**

Education Wat is je hoogst afgeronde opleiding?

- ○ **Geen (0)**
- ○ **Ik zit nog op school (1)**

○ **Lagere School / Basisschool (2)**

○ **Middelbare school (bijvoorbeeld LTS, VMBO, Mavo, Havo, VWO, Huishoudschool, etc.) specificeer welke: (3)**

____

○ **MBO (Middelbaar Beroeps Onderwijs, ook bijvoorbeeld MTS) (4)**

○ **HBO (Hoger Beroeps Onderwijs, ook bijvoorbeeld HTS) (5)**

○ **WO/Universiteit of hoger (Wetenschappelijk Onderwijs) (6)**

○ **Anders, namelijk: (7)** ____

○ **Ik geef liever geen antwoord op deze vraag (99)**

Nationality Welke nationaliteit(en) heb je?

☐ **Nederlands (1)**

☐ **Anders, namelijk (2)**

____

End of Block: Background

Start of Block: Perceived Stress

PSS Hieronder staan een aantal stellingen over gevoelens die mensen kunnen ervaren. Geef aan hoe vaak jij deze gevoelens in de afgelopen maand hebt gehad.

	Nooit (1)	Bijna nooit (2)	Soms (3)	Vaak (4)	Zeer vaak (5)

Hoe vaak was je overstuur vanwege iets wat onverwacht gebeurde? (PSS-4_1)	○	○	○	○	○
Hoe vaak had je het gevoel dat je niet in staat was om controle te hebben over de belangrijke dingen in je leven? (PSS-4_2)	○	○	○	○	○
Hoe vaak voelde je je nerveus en gestrest? (PSS-4_3)	○	○	○	○	○
Hoe vaak voelde je je zelfverzekerd over je vermogen om met persoonlijke problemen om te gaan? (PSS-4_4)	○	○	○	○	○
Hoe vaak had je het gevoel dat dingen gingen zoals je wilde? (PSS-4_5)	○	○	○	○	○

Hoe vaak had je het gevoel dat je niet kon omgaan met alle dingen die je moest doen? (PSS-4_6)	o	o	o	o	o
Hoe vaak had je het gevoel je irritaties onder controle te kunnen houden? (PSS-4_7)	o	o	o	o	o
Hoe vaak voelde je dat je grip had op de dingen? (PSS-4_8)	o	o	o	o	o
Hoe vaak was je boos omdat dingen buiten je controle lagen? (PSS-4_9)	o	o	o	o	o
Hoe vaak had je het gevoel dat moeilijkheden zich zo hoog opstapelden dat je ze niet kon overwinnen? (PSS-4_10)	o	o	o	o	o

End of Block: Perceived Stress

Start of Block: Stress Mindset

SMM Hieronder staan acht uitspraken waar je het mee eens of oneens kan zijn. Gelieve op de volgende schaal van 'helemaal mee oneens' tot 'helemaal mee eens' aangeven in hoeverre jij het met elke uitspraak eens of oneens bent.

	Helemaal mee oneens (0)	Mee oneens (1)	Niet mee eens, niet mee oneens (2)	Mee eens (3)	Helemaal mee eens (4)
De gevolgen van stress zijn negatief en zouden vermeden moeten worden. (SMM_1)	o	o	o	o	o
Het ervaren van stress bevordert mijn leren en groei. (SMM_2)	o	o	o	o	o
Het ervaren van stress put mijn gezondheid en vitaliteit uit. (SMM_3)	o	o	o	o	o
Het ervaren van stress verbetert mijn prestaties en productiviteit. (SMM_4)	o	o	o	o	o

Het ervaren van stress remt mijn leren en groei. (SMM_5)	○	○	○	○	○
Het ervaren van stress verbetert mijn gezondheid en vitaliteit. (SMM_6)	○	○	○	○	○
Het ervaren van stress hindert mijn prestaties en productiviteit. (SMM_7)	○	○	○	○	○
De effecten van stress zijn positief en zouden benut moeten worden. (SMM_8)	○	○	○	○	○

End of Block: Stress Mindset

Start of Block: Interoception

MAIA-2 MAIA-2

	Nooit (0)	Zeer zelden (1)	Zelden (2)	Af en toe (3)	Vaak (4)	Altijd (5)

Als ik gespannen ben, voel ik waar in mijn lichaam de spanning zit (MAIA-2_1a)	○	○	○	○	○	○
Ik merk het als ik niet lekker in mijn vel zit (MAIA-2_2a)	○	○	○	○	○	○
Ik merk waar ik me in mijn lichaam lekker voel (MAIA-2_3a)	○	○	○	○	○	○
Ik merk het als mijn ademhaling verandert, bijvoorbeeld of ik langzamer of sneller ga ademen (MAIA-2_4a)	○	○	○	○	○	○
Lichamelijke spanning of ongemak merk ik niet op (negeer ik) tot het veel erger wordt (MAIA-2_5bR)	○	○	○	○	○	○
Ik leid mezelf af van gevoelens van ongemak (MAIA-2_6bR)	○	○	○	○	○	○
Bij pijn of ongemakken tracht ik op mijn tanden te bijten en door te zeten (MAIA-2_7bR)	○	○	○	○	○	○

Ik probeer pijn te negeren (MAIA-2_8bR)	○	○	○	○	○	○
Ik zet gevoelens van ongemak van me af door me op iets anders te richten (MAIA-2_9bR)	○	○	○	○	○	○
Als ik onplezierige lichamelijke sensates heb, ga ik me met iets anders bezig houden, zodat ik het niet hoef te voelen (MAIA-2_10bR)	○	○	○	○	○	○
Wanneer ik lichamelijke pijn voel, raak ik van streek (MAIA-2_11cR)	○	○	○	○	○	○
Als ik maar een beetje last van iets heb, ga ik me zorgen maken dat er iets mis is (MAIA-2_12cR)	○	○	○	○	○	○
Ik kan een onaangenaam gevoel in mijn lijf opmerken zonder me er zorgen over te maken (MAIA-2_13c)	○	○	○	○	○	○
Bij ongemak of pijn kan ik rustig blijven en me geen zorgen maken (MAIA-2_14c)	○	○	○	○	○	○

Als ik ongemak of pijn ervaar, dan blijf ik er mee bezig (MAIA-2_15cR)	○	○	○	○	○	○
Ik kan op mijn ademhaling leten zonder te worden afgeleid door wat er om me heen gebeurt (MAIA-2_16d)	○	○	○	○	○	○
Ik kan me bewust blijven van wat ik in mijn lichaam voel, zelfs als er om me heen van alles gebeurt (MAIA-2_17d)	○	○	○	○	○	○
Als ik met iemand in gesprek ben, kan ik aandacht schenken aan mijn houding (MAIA-2_18d)	○	○	○	○	○	○
Als ik afgeleid ben, kan ik mijn aandacht weer terugbrengen naar mijn lichaam (MAIA-2_19d)	○	○	○	○	○	○
Ik kan mijn aandacht verschuiven van denken naar het voelen van mijn lijf (MAIA-2_20d)	○	○	○	○	○	○

Ik kan me bewust blijven van mijn hele lichaam, zelfs als ik ergens pijn heb of ongemak voel (MAIA-2_21d)	○	○	○	○	○	○
Ik kan me bewust richten op mijn lichaam als geheel (MAIA-2_22d)	○	○	○	○	○	○
Ik merk hoe mijn lichaam verandert als ik boos ben (MAIA-2_23e)	○	○	○	○	○	○
Als er iets mis is in mijn leven, kan ik dat aan mijn lichaam voelen (MAIA-2_24e)	○	○	○	○	○	○
Ik merk dat mijn lichaam anders voelt na een rustgevende ervaring (MAIA-2_25e)	○	○	○	○	○	○
Ik merk dat mijn ademhaling vrij en gemakkelijk wordt als ik me op mijn gemak voel (MAIA-2_26e)	○	○	○	○	○	○
Ik merk hoe mijn lichaam verandert wanneer ik me gelukkig / vrolijk voel (MAIA-2_27e)	○	○	○	○	○	○

Als er te veel op me afkomt, kan ik een rustige plek in mezelf vinden (MAIA-2_28f)	○	○	○	○	○	○
Als ik de aandacht op mijn lichaam richt, krijg ik een gevoel van rust (MAIA-2_29f)	○	○	○	○	○	○
Ik kan mijn ademhaling gebruiken om spanning te verminderen (MAIA-2_30f)	○	○	○	○	○	○
Als ik gevangen zit in gedachten, kan ik mijn geest tot rust brengen door me op mijn lichaam/ademhaling te concentreren (MAIA-2_31f)	○	○	○	○	○	○
Ik luister naar informatie die mijn lichaam me over mijn emotionele toestand geeft (MAIA-2_32g)	○	○	○	○	○	○
Wanneer ik van streek ben, neem ik de tijd om na te gaan hoe mijn lichaam aanvoelt (MAIA-2_33g)	○	○	○	○	○	○

Ik luister naar mijn lichaam om te weten wat ik moet doen (MAIA-2_34g)	○	○	○	○	○	○
Ik voel me thuis in mijn lichaam (MAIA-2_35h)	○	○	○	○	○	○
Mijn lichaam voelt als een veilige plek (MAIA-2_36h)	○	○	○	○	○	○
Ik vertrouw op wat ik in mijn lijf voel (MAIA-2_37h)	○	○	○	○	○	○

End of Block: Interoception

Start of Block: Emotion Regulation

ERQ Geef alstublieft aan in hoeverre je het eens of oneens bent met de onderstaande uitspraken. Dat doe je door voor elke uitspraak een antwoord te kiezen dat overeenkomt met de volgende schaal die varieert van 1 (*sterk mee oneens*) tot 7 (*sterk mee eens*), waarbij 4 wordt gezien als *neutraal*.

	1 - sterk mee oneens (1)	2 (2)	3 (3)	4 - neutraal (4)	5 (5)	6 (6)	7 - sterk mee eens (7)

Wanneer ik meer positieve emoties wil voelen (zoals blijdschap of plezier), dan verander ik datgene waar ik op dat moment aan denk. (ERQ_1)	o	o	o	o	o	o	o
Ik houd mijn emoties voor mezelf. (ERQ_2)	o	o	o	o	o	o	o
Wanneer ik minder negatieve emoties wil ervaren, dan verander ik datgene waar ik op dat moment aan denk. (ERQ_3)	o	o	o	o	o	o	o

Wanneer ik positieve emoties ervaar, dan zorg ik ervoor dat ik die niet tot uitdrukking breng. (ERQ_4)	o	o	o	o	o	o	o
Wanneer ik in een stressvolle situatie ben, dan laat ik mezelf daarover nadenken op een manier die me helpt om kalm te blijven. (ERQ_5)	o	o	o	o	o	o	o
Ik controleer mijn emoties door ze niet tot uitdrukking te brengen. (ERQ_6)	o	o	o	o	o	o	o

Wanneer ik meer positieve emoties wil voelen, dan verander ik de manier waarop ik over de situatie denk. (ERQ_7)	o	o	o	o	o	o	o
Ik controleer mijn emoties door te veranderen hoe ik denk over de situatie waarin ik verkeer. (ERQ_8)	o	o	o	o	o	o	o
Wanneer ik negatieve emoties ervaar, dan zorg ik ervoor dat ik die niet tot uitdrukking breng. (ERQ_9)	o	o	o	o	o	o	o

Wanneer ik minder negatieve emoties wil voelen, dan verander ik de manier waarop ik over de situatie denk. (ERQ_10)	○	○	○	○	○	○	○

End of Block: Emotion Regulation

Start of Block: Health Anxiety

SHAI Lees elke groep uitspraken zorgvuldig en kies dan de uitspraak die het beste beschrijft hoe je je de afgelopen zes maanden hebt gevoeld.

SHAI-1 1. Ik maak me zorgen over mijn gezondheid.

○ **Nooit (1)**

○ **Af en toe (2)**

○ **Vaak (3)**

○ **Meestal (4)**

SHAI-2 2. Vergeleken met andere mensen van mijn leeftijd merk ik pijntjes en klachten op.

○ **Minder dan de meeste andere mensen (1)**

○ **Net zoveel als de meeste andere mensen (2)**

○ **Meer dan de meeste andere mensen (3)**

○ **Altijd in mijn lichaam (4)**

SHAI-3 3. Welke uitspraak beschrijft het beste uw bewustzijn van lichamelijke sensaties of veranderingen?

○ **Over het algemeen ben ik me niet bewust van lichamelijke sensaties of veranderingen (1)**

○ **Soms bewust (2)**

○ **Vaak bewust (3)**

○ **Voortdurend bewust (4)**

SHAI-4 4. Ik kan het denken aan ziekte weerstaan.

○ **Zonder problemen (1)**

○ **Meestal (2)**

○ **Ik probeer gedachtes aan ziekte te weerstaan, maar ben er vaak niet toe in staat (3)**

○ **Gedachten aan ziekte zijn zo sterk dat ik niet eens meer probeer ze te weerstaan (4)**

SHAI-5 5. Ik ben bang om een ernstige ziekte te hebben.

- **Helemaal niet (1)**
- **Soms (2)**
- **Vaak (3)**
- **Altijd (4)**

SHAI-6 6. Ik heb beelden (mentale afbeeldingen) van mezelf die ziek is.

- **Nooit (1)**
- **Af en toe (2)**
- **Vaak (3)**
- **Voortdurend (4)**

SHAI-7 7. Ik heb moeite om mijn gedachten af te houden van gedachten over mijn gezondheid.

- **Nooit (1)**
- **Soms (2)**
- **Vaak (3)**
- **Altijd - Niets kan mijn gedachten afhouden van gedachten over mijn gezondheid (4)**

SHAI-8 8. Als mijn arts me vertelt dat er niets mis is, ben ik

- Langdurig opgelucht (1)
- Eerst opgelucht maar de zorgen keren soms later terug (2)
- Eerst opgelucht maar de zorgen keren altijdlater terug (3)
- Niet opgelucht als mijn arts me vertelt dat er niets mis is (4)

SHAI-9 9. Als ik over een ziekte hoor, denk ik dat ik het zelf heb.

- Nooit (1)
- Soms (2)
- Vaak (3)
- Altijd (4)

SHAI-10 10. Als ik een lichamelijke sensatie of verandering opmerk, vraag ik me af wat het betekent.

- Zelden (1)
- Vaak (2)
- Altijd (3)
- Als ik een lichamelijke sensatie of verandering heb, moet ik weten wat het betekent (4)

SHAI-11 11. Ik voel meestal dat mijn risico op het ontwikkelen van een ernstige ziekte

- Heel laag is. (1)
- Tamelijk laag is. (2)
- Gemiddeld is. (3)
- Hoog is. (4)

SHAI-12 12. Ik denk dat ik een ernstige ziekte heb.

- Nooit (1)
- Soms (2)
- Vaak (3)
- Meestal (4)

SHAI-13 13. Als ik een onverklaarde lichamelijke sensatie opmerk, vind ik het

- Niet moeilijk om aan andere dingen te denken. (1)
- Soms moeilijk om aan andere dingen te denken. (2)
- Vaak moeilijk om aan andere dingen te denken. (3)
- Altijd moeilijk om aan andere dingen te denken. (4)

SHAI-14 14. Mijn familie of vrienden zouden zeggen dat ik

- ○ **Me niet genoeg zorgen maak over mijn gezondheid. (1)**
- ○ **Een normale houding heb ten opzichte van mijn gezondheid. (2)**
- ○ **Me te veel zorgen maak over mijn gezondheid. (3)**
- ○ **Een hypochonder (iemand die zich veel zorgen maakt om zijn of haar gezondheid) ben. (4)**

End of Block: Health Anxiety

Start of Block: Personality

Personality Hier zijn een aantal kenmerken die al dan niet op jou van toepassing zijn. Bent u het er bijvoorbeeld mee eens dat u iemand bent die graag tijd doorbrengt met anderen? Geef voor elke stelling aan in welke mate u het eens of oneens bent met die stelling.Er zijn geen goede of foute antwoorden, alleen jouw eigen beoordeling telt. Ik zie mezelf als iemand die...

	Helemaal oneens (1)	Oneens (2)	Eens noch oneens (3)	Eens (4)	Helemaal eens (5)
Doorgaans stil is (Personality_1_Er)	○	○	○	○	○
Betrokken, meelevend is (Personality_2_A)	○	○	○	○	○
Geneigd is tot slordigheid (Personality_3_Cr)	○	○	○	○	○

Zich veel zorgen maakt (Personality_4_N)	○	○	○	○	○
Gefascineerd is door kunst, muziek of literatuur (Personality_5_O)	○	○	○	○	○
De toon zet, als een leider handelt (Personality_6_E)	○	○	○	○	○
Soms onbeleefd tegen anderen is (Personality_7_Ar)	○	○	○	○	○
Moeite heeft om met taken te beginnen (Personality_8_Cr)	○	○	○	○	○
Ertoe neigt zich terneergeslagen, somber te voelen (Personality_9_N)	○	○	○	○	○
Weinig interesse in abstracte ideeën heeft (Personality_10_Or)	○	○	○	○	○
Vol energie is (Personality_11_E)	○	○	○	○	○
Van het beste in mensen uitgaat (Personality_12_A)	○	○	○	○	○
Betrouwbaar is, verwachtingen altijd waarmaakt (Personality_13_C)	○	○	○	○	○

Emotioneel stabiel is, niet gemakkelijk overstuur (Personality_14_Nr)	o	o	o	o	o
Origineel is, met nieuwe ideeën komt (Personality_15_O)	o	o	o	o	o

End of Block: Personality

StressWearables - Follow-up after 1 week

Start of Block: ID

ID Wat is je deelnamecode?

____

End of Block: ID

Start of Block: Perceived Stress

PSS Hieronder staan een aantal stellingen over gevoelens die mensen kunnen ervaren. Geef aan hoe vaak jij deze gevoelens in de afgelopen week hebt gehad.

	Nooit (1)	Bijna nooit (2)	Soms (3)	Vaak (4)	Zeer vaak (5)

Hoe vaak was je overstuur vanwege iets wat onverwacht gebeurde? (PSS-4_1)	○	○	○	○	○
Hoe vaak had je het gevoel dat je niet in staat was om controle te hebben over de belangrijke dingen in je leven? (PSS-4_2)	○	○	○	○	○
Hoe vaak voelde je je nerveus en gestrest? (PSS-4_3)	○	○	○	○	○
Hoe vaak voelde je je zelfverzekerd over je vermogen om met persoonlijke problemen om te gaan? (PSS-4_4)	○	○	○	○	○
Hoe vaak had je het gevoel dat dingen gingen zoals je wilde? (PSS-4_5)	○	○	○	○	○

Hoe vaak had je het gevoel dat je niet kon omgaan met alle dingen die je moest doen? (PSS-4_6)	o	o	o	o	o
Hoe vaak had je het gevoel je irritaties onder controle te kunnen houden? (PSS-4_7)	o	o	o	o	o
Hoe vaak voelde je dat je grip had op de dingen? (PSS-4_8)	o	o	o	o	o
Hoe vaak was je boos omdat dingen buiten je controle lagen? (PSS-4_9)	o	o	o	o	o
Hoe vaak had je het gevoel dat moeilijkheden zich zo hoog opstapelden dat je ze niet kon overwinnen? (PSS-4_10)	o	o	o	o	o

End of Block: Perceived Stress

Start of Block: Stress Mindset

SMM Hieronder staan acht uitspraken waar je het mee eens of oneens kan zijn. Gelieve op de volgende schaal van 'helemaal mee oneens' tot 'helemaal mee eens' aangeven in hoeverre jij het met elke uitspraak eens of oneens bent.

	Helemaal mee oneens (0)	Mee oneens (1)	Niet mee eens, niet mee oneens (2)	Mee eens (3)	Helemaal mee eens (4)
De gevolgen van stress zijn negatief en zouden vermeden moeten worden. (SMM_1)	o	o	o	o	o
Het ervaren van stress bevordert mijn leren en groei. (SMM_2)	o	o	o	o	o
Het ervaren van stress put mijn gezondheid en vitaliteit uit. (SMM_3)	o	o	o	o	o
Het ervaren van stress verbetert mijn prestaties en productiviteit. (SMM_4)	o	o	o	o	o

Het ervaren van stress remt mijn leren en groei. (SMM_5)	○	○	○	○	○
Het ervaren van stress verbetert mijn gezondheid en vitaliteit. (SMM_6)	○	○	○	○	○
Het ervaren van stress hindert mijn prestaties en productiviteit. (SMM_7)	○	○	○	○	○
De effecten van stress zijn positief en zouden benut moeten worden. (SMM_8)	○	○	○	○	○

End of Block: Stress Mindset

Start of Block: Health Anxiety

SHAI Lees elke groep uitspraken zorgvuldig en kies dan de uitspraak die het beste beschrijft hoe je je de afgelopen week hebt gevoeld.

SHAI-1 1. Ik maak me zorgen over mijn gezondheid.

Nooit (1)

Af en toe (2)

Vaak (3)

Meestal (4)

SHAI-2 2. Vergeleken met andere mensen van mijn leeftijd merk ik pijntjes en klachten op.

Minder dan de meeste andere mensen (1)

Net zoveel als de meeste andere mensen (2)

Meer dan de meeste andere mensen (3)

Altijd in mijn lichaam (4)

SHAI-3 3. Welke uitspraak beschrijft het beste uw bewustzijn van lichamelijke sensaties of veranderingen?

Over het algemeen ben ik me niet bewust van lichamelijke sensaties of veranderingen (1)

Soms bewust (2)

Vaak bewust (3)

Voortdurend bewust (4)

SHAI-4 4. Ik kan het denken aan ziekte weerstaan.

- ○ **Zonder problemen (1)**
- ○ **Meestal (2)**
- ○ **Ik probeer gedachtes aan ziekte te weerstaan, maar ben er vaak niet toe in staat (3)**
- ○ **Gedachten aan ziekte zijn zo sterk dat ik niet eens meer probeer ze te weerstaan (4)**

SHAI-5 5. Ik ben bang om een ernstige ziekte te hebben.

- ○ **Helemaal niet (1)**
- ○ **Soms (2)**
- ○ **Vaak (3)**
- ○ **Altijd (4)**

SHAI-6 6. Ik heb beelden (mentale afbeeldingen) van mezelf die ziek is.

- ○ **Nooit (1)**
- ○ **Af en toe (2)**
- ○ **Vaak (3)**
- ○ **Voortdurend (4)**

SHAI-7 7. Ik heb moeite om mijn gedachten af te houden van gedachten over mijn gezondheid.

- **Nooit (1)**
- **Soms (2)**
- **Vaak (3)**
- **Altijd - Niets kan mijn gedachten afhouden van gedachten over mijn gezondheid (4)**

SHAI-8 8. Als mijn arts me vertelt dat er niets mis is, ben ik

- **Langdurig opgelucht (1)**
- **Eerst opgelucht maar de zorgen keren soms later terug (2)**
- **Eerst opgelucht maar de zorgen keren altijdlater terug (3)**
- **Niet opgelucht als mijn arts me vertelt dat er niets mis is (4)**

SHAI-9 9. Als ik over een ziekte hoor, denk ik dat ik het zelf heb.

- **Nooit (1)**
- **Soms (2)**
- **Vaak (3)**
- **Altijd (4)**

SHAI-10 10. Als ik een lichamelijke sensatie of verandering opmerk, vraag ik me af wat het betekent.

- **Zelden (1)**
- **Vaak (2)**
- **Altijd (3)**
- **Als ik een lichamelijke sensatie of verandering heb, moet ik weten wat het betekent (4)**

SHAI-11 11. Ik voel meestal dat mijn risico op het ontwikkelen van een ernstige ziekte

- **Heel laag is. (1)**
- **Tamelijk laag is. (2)**
- **Gemiddeld is. (3)**
- **Hoog is. (4)**

SHAI-12 12. Ik denk dat ik een ernstige ziekte heb.

- **Nooit (1)**
- **Soms (2)**
- **Vaak (3)**

○ **Meestal (4)**

SHAI-13 13. Als ik een onverklaarde lichamelijke sensatie opmerk, vind ik het

○ **Niet moeilijk om aan andere dingen te denken. (1)**

○ **Soms moeilijk om aan andere dingen te denken. (2)**

○ **Vaak moeilijk om aan andere dingen te denken. (3)**

○ **Altijd moeilijk om aan andere dingen te denken. (4)**

SHAI-14 14. Mijn familie of vrienden zouden zeggen dat ik

○ **Me niet genoeg zorgen maak over mijn gezondheid. (1)**

○ **Een normale houding heb ten opzichte van mijn gezondheid. (2)**

○ **Me te veel zorgen maak over mijn gezondheid. (3)**

○ **Een hypochonder (iemand die zich veel zorgen maakt om zijn of haar gezondheid) ben. (4)**

End of Block: Health Anxiety

StressWearables - FollowUp after 2 weeks

Start of Block: ID

ID Wat is je deelnamecode?

____

End of Block: ID

Start of Block: Perceived Stress

PSS Hieronder staan een aantal stellingen over gevoelens die mensen kunnen ervaren. Geef aan hoe vaak jij deze gevoelens in de afgelopen week hebt gehad.

	Nooit (1)	Bijna nooit (2)	Soms (3)	Vaak (4)	Zeer vaak (5)
Hoe vaak was je overstuur vanwege iets wat onverwacht gebeurde? (PSS-4_1)	o	o	o	o	o
Hoe vaak had je het gevoel dat je niet in staat was om controle te hebben over de belangrijke dingen in je leven? (PSS-4_2)	o	o	o	o	o
Hoe vaak voelde je je nerveus en gestrest? (PSS-4_3)	o	o	o	o	o

Hoe vaak voelde je je zelfverzekerd over je vermogen om met persoonlijke problemen om te gaan? (PSS-4_4)	○	○	○	○	○
Hoe vaak had je het gevoel dat dingen gingen zoals je wilde? (PSS-4_5)	○	○	○	○	○
Hoe vaak had je het gevoel dat je niet kon omgaan met alle dingen die je moest doen? (PSS-4_6)	○	○	○	○	○
Hoe vaak had je het gevoel je irritaties onder controle te kunnen houden? (PSS-4_7)	○	○	○	○	○
Hoe vaak voelde je dat je grip had op de dingen? (PSS-4_8)	○	○	○	○	○

Hoe vaak was je boos omdat dingen buiten je controle lagen? (PSS-4_9)	o	o	o	o	o
Hoe vaak had je het gevoel dat moeilijkheden zich zo hoog opstapelden dat je ze niet kon overwinnen? (PSS-4_10)	o	o	o	o	o

End of Block: Perceived Stress

Start of Block: Stress Mindset

SMM Hieronder staan acht uitspraken waar je het mee eens of oneens kan zijn. Gelieve op de volgende schaal van 'helemaal mee oneens' tot 'helemaal mee eens' aangeven in hoeverre jij het met elke uitspraak eens of oneens bent.

	Helemaal mee oneens (0)	Mee oneens (1)	Niet mee eens, niet mee oneens (2)	Mee eens (3)	Helemaal mee eens (4)
De gevolgen van stress zijn negatief en zouden vermeden moeten worden. (SMM_1)	o	o	o	o	o

Het ervaren van stress bevordert mijn leren en groei. (SMM_2)	o	o	o	o	o
Het ervaren van stress put mijn gezondheid en vitaliteit uit. (SMM_3)	o	o	o	o	o
Het ervaren van stress verbetert mijn prestaties en productiviteit. (SMM_4)	o	o	o	o	o
Het ervaren van stress remt mijn leren en groei. (SMM_5)	o	o	o	o	o
Het ervaren van stress verbetert mijn gezondheid en vitaliteit. (SMM_6)	o	o	o	o	o
Het ervaren van stress hindert mijn prestaties en productiviteit. (SMM_7)	o	o	o	o	o

De effecten van stress zijn positief en zouden benut moeten worden. (SMM_8)	○	○	○	○	○

End of Block: Stress Mindset

Start of Block: Interoceptive Awareness

MAIA-2 MAIA-2

	Nooit (0)	Zeer zelden (1)	Zelden (2)	Af en toe (3)	Vaak (4)	Altijd (5)
Als ik gespannen ben, voel ik waar in mijn lichaam de spanning zit (MAIA-2_1a)	○	○	○	○	○	○
Ik merk het als ik niet lekker in mijn vel zit (MAIA-2_2a)	○	○	○	○	○	○
Ik merk waar ik me in mijn lichaam lekker voel (MAIA-2_3a)	○	○	○	○	○	○
Ik merk het als mijn ademhaling verandert, bijvoorbeeld of ik langzamer of	○	○	○	○	○	○

sneller ga ademen (MAIA-2_4a)						
Lichamelijke spanning of ongemak merk ik niet op (negeer ik) tot het veel erger wordt (MAIA-2_5bR)	○	○	○	○	○	○
Ik leid mezelf af van gevoelens van ongemak (MAIA-2_6bR)	○	○	○	○	○	○
Bij pijn of ongemakken tracht ik op mijn tanden te bijten en door te zeten (MAIA-2_7bR)	○	○	○	○	○	○
Ik probeer pijn te negeren (MAIA-2_8bR)	○	○	○	○	○	○
Ik zet gevoelens van ongemak van me af door me op iets anders te richten (MAIA-2_9bR)	○	○	○	○	○	○
Als ik onplezierige lichamelijke sensates heb, ga ik me met iets anders bezig houden, zodat ik het niet hoef te voelen (MAIA-2_10bR)	○	○	○	○	○	○

Wanneer ik lichamelijke pijn voel, raak ik van streek (MAIA-2_11cR)	○	○	○	○	○	○
Als ik maar een beetje last van iets heb, ga ik me zorgen maken dat er iets mis is (MAIA-2_12cR)	○	○	○	○	○	○
Ik kan een onaangenaam gevoel in mijn lijf opmerken zonder me er zorgen over te maken (MAIA-2_13c)	○	○	○	○	○	○
Bij ongemak of pijn kan ik rustig blijven en me geen zorgen maken (MAIA-2_14c)	○	○	○	○	○	○
Als ik ongemak of pijn ervaar, dan blijf ik er mee bezig (MAIA-2_15cR)	○	○	○	○	○	○
Ik kan op mijn ademhaling leten zonder te worden afgeleid door wat er om me heen gebeurt (MAIA-2_16d)	○	○	○	○	○	○

Ik kan me bewust blijven van wat ik in mijn lichaam voel, zelfs als er om me heen van alles gebeurt (MAIA-2_17d)	○	○	○	○	○	○
Als ik met iemand in gesprek ben, kan ik aandacht schenken aan mijn houding (MAIA-2_18d)	○	○	○	○	○	○
Als ik afgeleid ben, kan ik mijn aandacht weer terugbrengen naar mijn lichaam (MAIA-2_19d)	○	○	○	○	○	○
Ik kan mijn aandacht verschuiven van denken naar het voelen van mijn lijf (MAIA-2_20d)	○	○	○	○	○	○
Ik kan me bewust blijven van mijn hele lichaam, zelfs als ik ergens pijn heb of ongemak voel (MAIA-2_21d)	○	○	○	○	○	○
Ik kan me bewust richten op mijn lichaam als geheel (MAIA-2_22d)	○	○	○	○	○	○
Ik merk hoe mijn lichaam verandert als ik boos ben (MAIA-2_23e)	○	○	○	○	○	○

Als er iets mis is in mijn leven, kan ik dat aan mijn lichaam voelen (MAIA-2_24e)	○	○	○	○	○	○
Ik merk dat mijn lichaam anders voelt na een rustgevende ervaring (MAIA-2_25e)	○	○	○	○	○	○
Ik merk dat mijn ademhaling vrij en gemakkelijk wordt als ik me op mijn gemak voel (MAIA-2_26e)	○	○	○	○	○	○
Ik merk hoe mijn lichaam verandert wanneer ik me gelukkig / vrolijk voel (MAIA-2_27e)	○	○	○	○	○	○
Als er te veel op me afkomt, kan ik een rustige plek in mezelf vinden (MAIA-2_28f)	○	○	○	○	○	○
Als ik de aandacht op mijn lichaam richt, krijg ik een gevoel van rust (MAIA-2_29f)	○	○	○	○	○	○
Ik kan mijn ademhaling gebruiken om spanning te verminderen (MAIA-2_30f)	○	○	○	○	○	○

Als ik gevangen zit in gedachten, kan ik mijn geest tot rust brengen door me op mijn lichaam/ademhaling te concentreren (MAIA-2_31f)	o	o	o	o	o	o
Ik luister naar informatie die mijn lichaam me over mijn emotionele toestand geeft (MAIA-2_32g)	o	o	o	o	o	o
Wanneer ik van streek ben, neem ik de tijd om na te gaan hoe mijn lichaam aanvoelt (MAIA-2_33g)	o	o	o	o	o	o
Ik luister naar mijn lichaam om te weten wat ik moet doen (MAIA-2_34g)	o	o	o	o	o	o
Ik voel me thuis in mijn lichaam (MAIA-2_35h)	o	o	o	o	o	o
Mijn lichaam voelt als een veilige plek (MAIA-2_36h)	o	o	o	o	o	o
Ik vertrouw op wat ik in mijn lijf voel (MAIA-2_37h)	o	o	o	o	o	o

End of Block: Interoceptive Awareness

Start of Block: Emotional Regulation

ERQ Geef alstublieft aan in hoeverre je het eens of oneens bent met de onderstaande uitspraken. Dat doe je door voor elke uitspraak een antwoord te kiezen dat overeenkomt met de volgende schaal die varieert van 1 (*sterk mee oneens*) tot 7 (*sterk mee eens*), waarbij 4 wordt gezien als *neutraal*.

	1 - sterk mee oneens (1)	2 (2)	3 (3)	4 - neutraal (4)	5 (5)	6 (6)	7 - sterk mee eens (7)
Wanneer ik meer positieve emoties wil voelen (zoals blijdschap of plezier), dan verander ik datgene waar ik op dat moment aan denk. (ERQ_1)	o	o	o	o	o	o	o
Ik houd mijn emoties voor mezelf. (ERQ_2)	o	o	o	o	o	o	o

Wanneer ik minder negatieve emoties wil ervaren, dan verander ik datgene waar ik op dat moment aan denk. (ERQ_3)	o	o	o	o	o	o	o
Wanneer ik positieve emoties ervaar, dan zorg ik ervoor dat ik die niet tot uitdrukking breng. (ERQ_4)	o	o	o	o	o	o	o
Wanneer ik in een stressvolle situatie ben, dan laat ik mezelf daarover nadenken op een manier die me helpt om kalm te blijven. (ERQ_5)	o	o	o	o	o	o	o

Ik controleer mijn emoties door ze niet tot uitdrukking te brengen. (ERQ_6)	○	○	○	○	○	○	○
Wanneer ik meer positieve emoties wil voelen, dan verander ik de manier waarop ik over de situatie denk. (ERQ_7)	○	○	○	○	○	○	○
Ik controleer mijn emoties door te veranderen hoe ik denk over de situatie waarin ik verkeer. (ERQ_8)	○	○	○	○	○	○	○

Wanneer ik negatieve emoties ervaar, dan zorg ik ervoor dat ik die niet tot uitdrukking breng. (ERQ_9)	o	o	o	o	o	o	o
Wanneer ik minder negatieve emoties wil voelen, dan verander ik de manier waarop ik over de situatie denk. (ERQ_10)	o	o	o	o	o	o	o

End of Block: Emotional Regulation

Start of Block: Health Anxiety

SHAI Lees elke groep uitspraken zorgvuldig en kies dan de uitspraak die het beste beschrijft hoe je je de afgelopen week hebt gevoeld.

SHAI-1 1. Ik maak me zorgen over mijn gezondheid.

o **Nooit (1)**

○ **Af en toe (2)**

○ **Vaak (3)**

○ **Meestal (4)**

SHAI-2 2. Vergeleken met andere mensen van mijn leeftijd merk ik pijntjes en klachten op.

○ **Minder dan de meeste andere mensen (1)**

○ **Net zoveel als de meeste andere mensen (2)**

○ **Meer dan de meeste andere mensen (3)**

○ **Altijd in mijn lichaam (4)**

SHAI-3 3. Welke uitspraak beschrijft het beste uw bewustzijn van lichamelijke sensaties of veranderingen?

○ **Over het algemeen ben ik me niet bewust van lichamelijke sensaties of veranderingen (1)**

○ **Soms bewust (2)**

○ **Vaak bewust (3)**

○ **Voortdurend bewust (4)**

SHAI-4 4. Ik kan het denken aan ziekte weerstaan.

○ **Zonder problemen (1)**

○ **Meestal (2)**

○ **Ik probeer gedachtes aan ziekte te weerstaan, maar ben er vaak niet toe in staat (3)**

○ **Gedachten aan ziekte zijn zo sterk dat ik niet eens meer probeer ze te weerstaan (4)**

SHAI-5 5. Ik ben bang om een ernstige ziekte te hebben.

○ **Helemaal niet (1)**

○ **Soms (2)**

○ **Vaak (3)**

○ **Altijd (4)**

SHAI-6 6. Ik heb beelden (mentale afbeeldingen) van mezelf die ziek is.

○ **Nooit (1)**

○ **Af en toe (2)**

○ **Vaak (3)**

○ **Voortdurend (4)**

SHAI-7 7. Ik heb moeite om mijn gedachten af te houden van gedachten over mijn gezondheid.

- ○ **Nooit (1)**
- ○ **Soms (2)**
- ○ **Vaak (3)**
- ○ **Altijd - Niets kan mijn gedachten afhouden van gedachten over mijn gezondheid (4)**

SHAI-8 8. Als mijn arts me vertelt dat er niets mis is, ben ik

- ○ **Langdurig opgelucht (1)**
- ○ **Eerst opgelucht maar de zorgen keren soms later terug (2)**
- ○ **Eerst opgelucht maar de zorgen keren altijdlater terug (3)**
- ○ **Niet opgelucht als mijn arts me vertelt dat er niets mis is (4)**

SHAI-9 9. Als ik over een ziekte hoor, denk ik dat ik het zelf heb.

- ○ **Nooit (1)**
- ○ **Soms (2)**
- ○ **Vaak (3)**
- ○ **Altijd (4)**

SHAI-10 10. Als ik een lichamelijke sensatie of verandering opctroncmerk, vraag ik me af wat het betekent.

- **Zelden (1)**
- **Vaak (2)**
- **Altijd (3)**
- **Als ik een lichamelijke sensatie of verandering heb, moet ik weten wat het betekent (4)**

SHAI-11 11. Ik voel meestal dat mijn risico op het ontwikkelen van een ernstige ziekte

- **Heel laag is. (1)**
- **Tamelijk laag is. (2)**
- **Gemiddeld is. (3)**
- **Hoog is. (4)**

SHAI-12 12. Ik denk dat ik een ernstige ziekte heb.

- **Nooit (1)**
- **Soms (2)**
- **Vaak (3)**
- **Meestal (4)**

SHAI-13 13. Als ik een onverklaarde lichamelijke sensatie opmerk, vind ik het

○ **Niet moeilijk om aan andere dingen te denken. (1)**

○ **Soms moeilijk om aan andere dingen te denken. (2)**

○ **Vaak moeilijk om aan andere dingen te denken. (3)**

○ **Altijd moeilijk om aan andere dingen te denken. (4)**

SHAI-14 14. Mijn familie of vrienden zouden zeggen dat ik

○ **Me niet genoeg zorgen maak over mijn gezondheid. (1)**

○ **Een normale houding heb ten opzichte van mijn gezondheid. (2)**

○ **Me te veel zorgen maak over mijn gezondheid. (3)**

○ **Een hypochonder (iemand die zich veel zorgen maakt om zijn of haar gezondheid) ben. (4)**

End of Block: Health Anxiety

Appendix B:

The Ambulatory Questionnaires

1. **Ochtendvragenlijst**
    1. Hoelang heb je ongeveer geslapen
        1. Er kan 00 tot 23 uur worden gekozen op één as en 00 tot 59 op een ander.
    2. Hoe zou je de kwaliteit van je slaap beoordelen
        1. Er kan een beoordelingen van 0 tot 100 aangegeven worden met behulp van een slider. Aan de linker kant staat heel slecht, aan de rechter kant heel goed.
    3. Gisteren heb ik de volgende middelen gebruikt:
        1. Caffeïne
        2. Nicotine
        3. Alcohol
        4. Cannabis
        5. Andere drugs, namelijk: …
        6. Geen van de bovenstaande

2. **Daily core**
    1. Op dit moment zijn mijn positive gevoelens
        1. Er kan een beoordelingen van 0 tot 100 aangegeven worden met behulp van een slider. Aan de linker kant staat helemaal niet sterk, aan de rechter kant staat heel erg sterk.
    2. Op dit moment zijn mijn negative gevoelens

    1. Er kan een beoordelingen van 0 tot 100 aangegeven worden met behulp van een slider. Aan de linker kant staat helemaal niet sterk, aan de rechter kant staat heel erg sterk.
3. Op dit moment voel ik me gestresst
    1. Er kan een beoordelingen van 0 tot 100 aangegeven worden met behulp van een slider. Aan de linker kant staat helemaal niet, aan de rechter kant staat heel erg.
4. Op dit moment voel ik me gespannen
    1. Er kan een beoordelingen van 0 tot 100 aangegeven worden met behulp van een slider. Aan de linker kant staat helemaal niet, aan de rechter kant staat heel erg.
5. Op dit moment voel ik me energiek
    1. Er kan een beoordelingen van 0 tot 100 aangegeven worden met behulp van een slider. Aan de zijkanten staan geen tekst. In het midden staat een batterij die voller wordt naarmate er een hogere enerie score wordt aangegeven.
6. Sinds de vorige vragenlijst, in hoeverre heb je je mentaal overbelast gevoled door teveel informatie? (bijv. tijdens een gesprek thuis of op werk, tijdens multitasking, etc.)
    1. Er kan een beoordelingen van 0 tot 100 aangegeven worden met behulp van een slider. Aan de linker kant staat helemaal niet, aan de rechter kant staat heel erg.

3. Avondvragenlijst

1. Op dit moment zijn mijn positive gevoelens

    1. Er kan een beoordelingen van 0 tot 100 aangegeven worden met behulp van een slider. Aan de linker kant staat helemaal niet sterk, aan de rechter kant staat heel erg sterk.
2. Op dit moment zijn mijn negative gevoelens
    1. Er kan een beoordelingen van 0 tot 100 aangegeven worden met behulp van een slider. Aan de linker kant staat helemaal niet sterk, aan de rechter kant staat heel erg sterk.
3. Op dit moment voel ik me gestresst
    1. Er kan een beoordelingen van 0 tot 100 aangegeven worden met behulp van een slider. Aan de linker kant staat helemaal niet, aan de rechter kant staat heel erg.
4. Op dit moment voel ik me gespannen
    1. Er kan een beoordelingen van 0 tot 100 aangegeven worden met behulp van een slider. Aan de linker kant staat helemaal niet, aan de rechter kant staat heel erg.
5. Op dit moment voel ik me energiek
    1. Er kan een beoordelingen van 0 tot 100 aangegeven worden met behulp van een slider. Aan de zijkanten staan geen tekst. In het midden staat een batterij die voller wordt naarmate er een hogere enerie score wordt aangegeven.
6. Sinds de vorige vragenlijst, in hoeverre heb je je mentaal overbelast gevoled door teveel informatie? (bijv. tijdens een gesprek thuis of op werk, tijdens multitasking, etc.)
    1. Er kan een beoordelingen van 0 tot 100 aangegeven worden met behulp van een slider. Aan de linker kant staat helemaal niet, aan de rechter kant staat heel erg.
7. Hoe was je dag vandaag?

    1. Er kan een beoordelingen van 0 tot 100 aangegeven worden met behulp van een slider. Aan de linker kant staat helemaal niet, aan de rechter kant staat heel erg.
8. Hoe was je dag vandaag
    1. Er kan een beoordelingen van 0 tot 100 aangegeven worden met behulp van een slider. Aan de linker kant staat relaxed, aan de rechter kant staat stressvol.
9. Beschijf je dag: Wat was de meest onplezierige situatie?
    1. Wil je dit intypen of inspreken?
        1. Intypen
        2. Inspreken
10. Beschijf je dag: Wat was de meest plezierige situatie?
    1. Wil je dit intypen of inspreken?
        1. Intypen
        2. Inspreken
11. Vandaag voelde ik lichamelijk ongemak (bijv. vermoeidheid, griep, hoofdpijn, rugpijn, oorsuizen, spanning, hooikoorts, ongesteldheidspijn)
    1. Yes
    2. No
12. Vandaag had ik gevoel dat ik controle had over de belangrijke dingen in mijn leven
    1. Een stippelijn met vijf stippen zijn te zien met de opties 0 tot en met 4. Aan de linkerkant staat nooit, aan de rechterkant staat heel vaak.
13. Vandaag voelde ik me zelfverzekerd om met persoonlijke problemen om te gaan

   1. Een stippelijn met vijf stippen zijn te zien met de opties 0 tot en met 4. Aan de linkerkant staat nooit, aan de rechterkant staat heel vaak.

14. Vandaag had ik het gevoel dat dingen gingen zoals ik wilde
    1. Een stippelijn met vijf stippen zijn te zien met de opties 0 tot en met 4. Aan de linkerkant staat nooit, aan de rechterkant staat heel vaak.
15. Vandaag had ik het gevoel dat moeilijkheden zich zo hoog opstapelden dat ik ze niet meer aankon
    1. Een stippelijn met vijf stippen zijn te zien met de opties 0 tot en met 4. Aan de linkerkant staat nooit, aan de rechterkant staat heel vaak.
16. Heb je verder nog iets stressvols meegemaakt vandaag wat je niet heb kunnen aangeven? Bijvoorbeeld omdat het niet een onplezierige of plezierige situatie was?
    1. *Een groot wit vak waar in getyped kan worden*

       Sla deze vraag over…

Appendix C:

Additional questoinnaires

The study was conducted in the scope of a bigger research project and therefore used many questionnaires which were irrelevant for this study.These questionnaires consist of The Short Health Anxiety Inventory (SHAI-14), Stress mindset measure (SMM), emotional regulation questionnaire (ERQ), The multidimensional assessment of interoceptive awareness - version 2 (MAIA-2), The Big Five Inventory Version 2 extra short (BFI-2 XS). The SHAI-14 is a fourteen-item long questionnaire measuring health anxiety (α = .82-.94; Salkovskis et al., 2002). The SMM is an eight-item long questionnaire measuring the mindset or beliefs about the nature of stress (α = .86; Crum et al., 2013). The ERQ is a ten-item long questionnaire measuring individual differences in the habitual use of emotion regulation strategies: cognitive reappraisal (α = .79) and expressive suppression (α = .73; Gross & John, 2003). The MAIA-2 is a 37-item long questionnaire measuring interoception (α = .64 - .91; Mehling et al., 2018). BFI-2 XS is a fifteen-item long questionnaire designed to measure personality (α = .56 to .72; Soto et al., 2017).

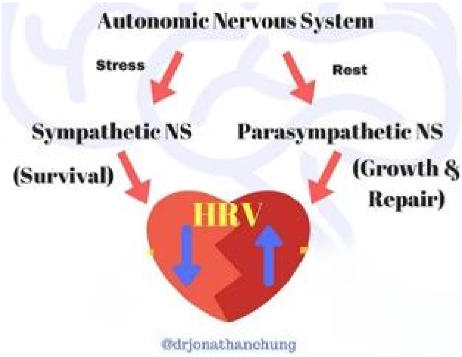
Appendix D:

Psychoeducation

Information Sheet Psychoeducation Group English Version

Study on Stress Wearables

Summary	We are using wrist-worn wearables to gain insights into the influence of stress feedback on perceived stress, relaxation and level of interoceptive awareness (awareness of internal bodily sensations). 
Instructions	We would like you to wear the wearable for a full week. The wearable is worn about two fingers from the crease of either of your wrists to get optimal results. You should feel a slight pressure when the wearable is worn. Please check your stress level multiple times throughout the day. The wearable will be provided with the correct settings. However, it still has access to many other functionalities, such as a step counter or a fitness tracker. We'd like you to refrain from using these additional functions.
Stress	Although stress often has a negative connotation, in reality, stress can also have benefits: Good Stress: Manageable levels of stress can promote recovery and performance. Bad Stress: Prolonged, chronic stress can cause mental health issues and other adverse effects such as an earlier onset of age-related diseases. There are many forms of stress which are measured differently. We examine stress based on wearables measurements, and therefore focus on physiological stress. This stress is the body's reaction to stressors and is, for example, manifested in heightened heart rate and blood pressure.

Stress feedback	The wearable indicates stress via four different levels: -Resting State: 0-25 -Low Stress: 26-50 -Medium Stress: 51-75 -High Stress: 76-100 ! Be aware that those stress levels can indicate either good or bad stress and the wearable cannot measure that. If the wearable indicates for instance high stress it would be a good time to check with yourself how you feel about this and if you are ready for more challenges or a small break.
HRV	 Heart Rate Variability (HRV) relates to the variation in intervals between heartbeats and is a relevant indicator of activities regarding our autonomic nervous system (ANS). The ANS has the function of keeping a balance in our body through the activity of two branches, namely the Sympathetic Nervous System (SNS), which leads to the activation of the body and the Parasympathetic Nervous System (PNS), which is responsible for relaxation. Lower HRV: domination through the SNS when stress is perceived and low variability between heartbeats Higher HRV: domination through the PNS when body is relaxed and high variability between heartbeats Contrary to the believe that high HRV is good and low HRV bad for the body, new evidence shows that a balance is the optimum.
Stress Measurement through wearables	Wearables measure physiological signals through an optical sensor. This process is called Photoplethysmography (PPG), which works with a light sensor. The light of this sensor gets absorbed by blood vessels and photodiodes detect the changes in the blood volume, indicating the pulse. Algorithms can transform these insights into HRV data based on the intervals of the measured pulse. However, PPG measurements of HRV are often inaccurate. Keep in mind that stress measurement through wearables

	is not perfect BUT it can also be a helpful tool to self-check and manage your stress.

Note. The picture of the autonomic nervous system was shortened. Adapted from *Vagal tone and the autonomic nervous system is something I've always been curious about since chiropractic school*, by The Anti-Fragile Chiro [@drjonathanchung], 2018, Instagram. (https://www.instagram.com/p/Bg1fLbKlziB/?utm_source=ig_web_copy_link)

If you have any questions, or need help with your wearable device feel free to contact us:

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d.m.j.leijser@student.utwente.nl

Appendix E:

Informed Consent

Thank you for participating in our study. This study investigates the relationship between stress feedback from wearables, perceived stress, perceived relaxation and interoceptive awareness. Participating in this study is voluntary and it is possible to withdraw at any time during the study without providing a reason. The questionnaires consists of several questions about stress, relaxation, interoception, health anxiety, emotion regulation and personality. In the first questionnaire, there will be some questions about demographics. Please answer all questions as honestly as possible.

Your participation will take two weeks in which you are expected to fill out five questionnaires daily. With an additional questionnaire at the start of the first week, at the start of the second week and at the end of the second week.

All data collected will be anonymised and will only be seen by the researchers, but cannot be traced back to you. This study is part of a bigger research project. Therefore, your anonymised data could also be used in other studies regarding stress feedback from wearables. The data will be stored following the guidelines of the University of Twente. If there are any questions or remarks, feel free to contact the researchers:

Finn de Jong: f.dejong-4@student.utwente.nl
Daan Leijser: d.m.j.leijser@student.utwente.nl

Supervisor:
Matthijs Noordzij: m.l.noordzij@utwente.nl

I read the informed consent, and agree to participate in this study. My results can be used for the purpose of the study and the research project of which this study is part.

- *Yes*
- *No*

Appendix F:

R-Script

```
#Data analyses stress wearables



#0 library ----

library(dplyr)

library(readxl)

library(fuzzyjoin)

library(ggplot2)

library(tidyr)

library(stringr)

library(lubridate)




#1 Baseline qualtrics ----

#1.1 Set working directory

setwd("~/Desktop/R zooi")




#1.2 Transfer datasets
```

```
data <- read.csv("~/Desktop/R zooi/StressWearables Baseline_Final.csv")

#1.3 renaming dataset to baselinequaltrics
baselinequaltrics <- data

#1.5 Checking and removing unanswered and irrelevant

#1.5.1 Checking progress and consent
#1.5.2 Removing 9HA445 (did not finish study), row 1, 2 (information about question) and 3 (did not finish study)
baselinequaltrics <- baselinequaltrics[-c(1 ,2, 3, 13), ]

#1.5.3 Removing irrelevant questionnaires and questions
Baseline_relevant <- baselinequaltrics %>%
  select(-c(
    # SMM columns
    SMM_1:SMM_8,

    # MAIA columns
```

"MAIA.2_1a", "MAIA.2_2a", "MAIA.2_3a", "MAIA.2_4a", "MAIA.2_5bR", "MAIA.2_6bR", "MAIA.2_7bR",

"MAIA.2_8bR", "MAIA.2_9bR", "MAIA.2_10bR", "MAIA.2_11cR", "MAIA.2_12cR", "MAIA.2_13c",

"MAIA.2_14c", "MAIA.2_15cR", "MAIA.2_16d", "MAIA.2_17d", "MAIA.2_18d", "MAIA.2_19d",

"MAIA.2_20d", "MAIA.2_21d", "MAIA.2_22d", "MAIA.2_23e", "MAIA.2_24e", "MAIA.2_25e",

"MAIA.2_26e", "MAIA.2_27e", "MAIA.2_28f", "MAIA.2_29f", "MAIA.2_30f", "MAIA.2_31f",

"MAIA.2_32g", "MAIA.2_33g", "MAIA.2_34g", "MAIA.2_35h", "MAIA.2_36h", "MAIA.2_37h",

SHAI columns

SHAI.1:SHAI.14,

Personality columns

"Personality_1_Er", "Personality_2_A", "Personality_3_Cr", "Personality_4_N", "Personality_5_O",

"Personality_6_E", "Personality_7_Ar", "Personality_8_Cr", "Personality_9_N", "Personality_10_Or",

```
    "Personality_11_E", "Personality_12_A", "Personality_13_C", "Personality_14_Nr",
"Personality_15_O"
  ))


#1.5.4. removing other irrelevant questions
Baseline_relevant <- Baseline_relevant %>%
  select(-c(
"Status", "IPAddress", "Progress", "StartDate", "EndDate", "ResponseId",
"RecipientLastName", "RecipientFirstName", "RecipientEmail", "ExternalReference",
"LocationLatitude", "LocationLongitude"))


#1.6 Changing columns to numerical columns, reversing score and summing
#1.6.1 Age
Baseline_relevant$Age <- as.numeric(Baseline_relevant$Age)



#1.6.2 PSS
#1.6.2.1 Changing to numbers
Baseline_relevant <- Baseline_relevant %>%
  mutate(across(PSS.4_1:PSS.4_10, ~ recode(.,
                                    "Never" = 0,
```

```
                              "Almost never" = 1,
                              "Sometimes" = 2,
                              "Fairly often" = 3,
                              "Very often" = 4)))

#1.6.2.2 Reversing
Baseline_relevant <- Baseline_relevant %>%
  mutate(across(c(PSS.4_4, PSS.4_5, PSS.4_7, PSS.4_8), ~ 4 - .))

#1.6.2.3 summing and making new column
Baseline_relevant <- Baseline_relevant %>%
  rowwise() %>%
  mutate(PSS_total = sum(c_across(PSS.4_1:PSS.4_10), na.rm = TRUE)) %>%
  ungroup()

#1.6.3 ERQ
Baseline_relevant <- Baseline_relevant %>%
  mutate(across(ERQ_1:ERQ_10, ~ as.numeric(gsub(" - .*", "", .))))

Baseline_relevant <- Baseline_relevant %>%
```

```
  rowwise() %>%
  mutate(
    ERQ_CR = sum(c_across(c(ERQ_1, ERQ_3, ERQ_5, ERQ_7, ERQ_8, ERQ_10)), na.rm
= TRUE),
    ERQ_ES = sum(c_across(c(ERQ_2, ERQ_4, ERQ_6, ERQ_9)), na.rm = TRUE)
  ) %>%
  ungroup()


#1.7 Adding FirstWeekWearable


#1.7.1 Adjust codes
Baseline_relevant$ID[22] <- "RZV4D2"


#1.7.2 Perform fuzzy join and overwrite ID column
WatchStatus <- read.csv("~/Desktop/R zooi/WatchStatus.csv")


Baseline_relevant <- Baseline_relevant %>%
  stringdist_left_join(WatchStatus,
                    by = "ID",
                    max_dist = 1,  # Allow one character difference
```

```
                    method = "lv")


#1.7.3 Remove ID.x, rename ID.y to ID, and move FirstWeekWearable after ID

Baseline_relevant <- Baseline_relevant %>%

  select(-ID.y) %>%       # Remove ID.y

  rename(ID = ID.x) %>%   # Rename ID.x to ID

  select(ID, FirstWeekWearable, everything())  # Reorder columns to place
FirstWeekWearable after ID


#1.8 Demographic Statistics

#1.8.1 Gender

table(Baseline_relevant$Gender)


#1.8.2 Age

summary(Baseline_relevant$Age)

table(Baseline_relevant$Age)

mean_age <- mean(Baseline_relevant$Age, na.rm = TRUE)

sd_age <- sd(Baseline_relevant$Age, na.rm = TRUE)

mean_age

sd_age
```

```
#1.8.3 Nationality

table(Baseline_relevant$Nationality)


#1.8.4 Education

table(Baseline_relevant$Education)

education_3_table <- table(Baseline_relevant$Education_3_TEXT)

education_3_table


#1.8.5 UserLanguage

language_counts <- table(Baseline_relevant$UserLanguage)

language_counts


#1.8.6 Duration in seconds

# Convert the Duration column to numeric

Baseline_relevant$Duration..in.seconds. <-
as.numeric(Baseline_relevant$Duration..in.seconds.)

summary(Baseline_relevant$Duration..in.seconds.)

cat("Mean of Duration:", mean(Baseline_relevant$Duration..in.seconds., na.rm = TRUE),
"\n")
```

```
#2 After 1 week qualtrics ----

#2.1 Retrieve dataset

followup_data <- read.csv("~/Desktop/R zooi/StressWearables - Follow-up after 1 week
final.csv", stringsAsFactors = FALSE)


#2.2 renaming dataset

After1week <- followup_data


#2.4 Checking and removing unanswered and irrelevant questions

After1week_relevant <- After1week %>%
  select(-c(

     # SMM columns
    SMM_1:SMM_8,

     # SHAI columns
    SHAI.1:SHAI.14,

    # other irrelevant questions
```

```
  "Status", "IPAddress", "Progress", "StartDate", "EndDate", "ResponseId",
  "RecipientLastName", "RecipientFirstName", "RecipientEmail", "ExternalReference",
  "LocationLatitude", "LocationLongitude"))

#2.5 changing code of XU44A3
After1week_relevant <- After1week_relevant %>%
 mutate(ID = ifelse(ID == "'@zkqd8", "XU44A3", ID))

#2.6 PSS
#2.6.1 Changing to numbers
After1week_relevant <- After1week_relevant %>%
 mutate(across(PSS.4_1:PSS.4_10, ~ recode(.,
                                "Never" = 0,
                                "Almost never" = 1,
                                "Sometimes" = 2,
                                "Fairly often" = 3,
                                "Very often" = 4)))

#2.6.2Reversing
After1week_relevant <- After1week_relevant %>%
```

```
  mutate(across(c(PSS.4_4, PSS.4_5, PSS.4_7, PSS.4_8), ~ 4 - .))


#2.6.3summing and making new column
After1week_relevant <- After1week_relevant %>%
  rowwise() %>%
  mutate(PSS_total = sum(c_across(PSS.4_1:PSS.4_10), na.rm = TRUE)) %>%
  ungroup()


#2.7 Adding FirstWeekWearable
#Make ID all capital letters
After1week_relevant$ID <- toupper(trimws(After1week_relevant$ID))


WatchStatus <- read.csv("~/Desktop/R zooi/WatchStatus.csv")
# Perform fuzzy join and overwrite ID column
After1week_relevant <- After1week_relevant %>%
  stringdist_left_join(WatchStatus,
                       by = "ID",
                       max_dist = 1,  # Allow one character difference
                       method = "lv")
```

```
# Remove ID.x, rename ID.y to ID, and move FirstWeekWearable after ID

After1week_relevant <- After1week_relevant %>%

  select(-ID.y) %>%       # Remove ID.y

  rename(ID = ID.x) %>%   # Rename ID.x to ID

  select(ID, FirstWeekWearable, everything())  # Reorder columns to place
FirstWeekWearable after ID


#2.8 removing first two irrelvent rows

After1week_relevant <- After1week_relevant[-c(1, 2), ]


#2.9 seconds duration numerical

After1week_relevant <- After1week_relevant %>%

  mutate(Duration..in.seconds. = as.numeric(Duration..in.seconds.))



#3 After 2 weeks qualtrics ----

#3.1 Retrieve dataset
```

```
After2weeks <- read.csv("~/Desktop/R zooi/StressWearables - FollowUp after 2 weeks Final.csv", stringsAsFactors = FALSE)


#3.3 Checking and removing unanswered and irrelevant questions
After2weeks_relevant <- After2weeks %>%
  select(-c(


    # SMM columns
    SMM_1:SMM_8,


    # SHAI columns
    SHAI.1:SHAI.14,


    # MAIA columns
    "MAIA.2_1a", "MAIA.2_2a", "MAIA.2_3a", "MAIA.2_4a", "MAIA.2_5bR", "MAIA.2_6bR", "MAIA.2_7bR",
    "MAIA.2_8bR", "MAIA.2_9bR", "MAIA.2_10bR", "MAIA.2_11cR", "MAIA.2_12cR", "MAIA.2_13c",
    "MAIA.2_14c", "MAIA.2_15cR", "MAIA.2_16d", "MAIA.2_17d", "MAIA.2_18d", "MAIA.2_19d",
```

```
    "MAIA.2_20d", "MAIA.2_21d", "MAIA.2_22d", "MAIA.2_23e", "MAIA.2_24e", "MAIA.2_25e",
    "MAIA.2_26e", "MAIA.2_27e", "MAIA.2_28f", "MAIA.2_29f", "MAIA.2_30f", "MAIA.2_31f",
    "MAIA.2_32g", "MAIA.2_33g", "MAIA.2_34g", "MAIA.2_35h", "MAIA.2_36h", "MAIA.2_37h",

    # other irrelevant questions
    "Status", "IPAddress", "Progress", "StartDate", "EndDate", "ResponseId",
    "RecipientLastName", "RecipientFirstName", "RecipientEmail", "ExternalReference",
    "LocationLatitude", "LocationLongitude"))

#3.4Chaning code of XU44A3 and 13ME8C
After2weeks_relevant <- After2weeks_relevant %>%
  mutate(ID = ifelse(ID == "'@zkqd8", "XU44A3", ID))

After2weeks_relevant$ID[After2weeks_relevant$ID == 59056] <- "13ME8C"

#3.5 PSS
```

```
#3.5.1 Changing to numbers

After2weeks_relevant <- After2weeks_relevant %>%

  mutate(across(PSS.4_1:PSS.4_10, ~ recode(.,

                                           "Never" = 0,

                                           "Almost never" = 1,

                                           "Sometimes" = 2,

                                           "Fairly often" = 3,

                                           "Very often" = 4)))


#3.5.2Reversing

After2weeks_relevant <- After2weeks_relevant %>%

  mutate(across(c(PSS.4_4, PSS.4_5, PSS.4_7, PSS.4_8), ~ 4 - .))


#3.5.3summing and making new column

After2weeks_relevant <- After2weeks_relevant %>%

  rowwise() %>%

  mutate(PSS_total = sum(c_across(PSS.4_1:PSS.4_10), na.rm = TRUE)) %>%

  ungroup()


#3.6 ERQ
```

```
After2weeks_relevant <- After2weeks_relevant %>%
  mutate(across(ERQ_1:ERQ_10, ~ as.numeric(gsub(" - .*", "", .))))


After2weeks_relevant <- After2weeks_relevant %>%
  rowwise() %>%
  mutate(
    ERQ_CR = sum(c_across(c(ERQ_1, ERQ_3, ERQ_5, ERQ_7, ERQ_8, ERQ_10)), na.rm
= TRUE),
    ERQ_ES = sum(c_across(c(ERQ_2, ERQ_4, ERQ_6, ERQ_9)), na.rm = TRUE)
  ) %>%
  ungroup()


#3.8 Adding FirstWeekWearable
#Make ID all capital letters
After2weeks_relevant$ID <- toupper(trimws(After2weeks_relevant$ID))
WatchStatus <- read.csv("~/Desktop/R zooi/WatchStatus.csv")


# Perform fuzzy join and overwrite ID column
After2weeks_relevant <- After2weeks_relevant %>%
  stringdist_left_join(WatchStatus,
```

```
                by = "ID",
                max_dist = 1,  # Allow one character difference
                method = "lv")



# Remove ID.x, rename ID.y to ID, and move FirstWeekWearable after ID
After2weeks_relevant <- After2weeks_relevant %>%
  select(-ID.y) %>%       # Remove ID.y
  rename(ID = ID.x) %>%   # Rename ID.x to ID
  select(ID, FirstWeekWearable, everything())  # Reorder columns to place
FirstWeekWearable after ID


#3.9 removing first two irrelvent rows
After2weeks_relevant <- After2weeks_relevant[-c(1, 2), ]


#3.10 making duration in seconds numerical
After2weeks_relevant <- After2weeks_relevant %>%
  mutate(Duration..in.seconds. = as.numeric(Duration..in.seconds.))
```

```
#4 ESM ----

#4.1.1 creating of function
process_dataset <- function(dataset, participant_code, first_week_wearable) {



  # Step 1: Change column names and normalize them
  colnames(dataset) <- as.character(dataset[1, ])  # Use the first row for column names
  dataset <- dataset[-1, ]  # Remove the first row

  # Normalize column names
  colnames(dataset) <- colnames(dataset) %>%
    str_to_lower() %>%                           # Convert to lowercase
    str_replace_all("\\s+\\(.*\\)", "") %>%      # Remove text in brackets and whitespace before
brackets
    str_trim()                                   # Trim any whitespace

  # Step 2: Define columns to remove (normalized for consistency)
  columns_to_remove <- c(
```

```
  "time_sleep",
  "sleep",
  "substance",
  "interoception_perception",
  "interoception_awareness",
  "cognitive",
  "lichamelijkongemak",
  "lichamelijkongemak_what",
  "lichamelijkongemak_last",
  "system_devspecs",
  "labelvoorbeeld",
  "gemoed",
  "mood",
  "labelexample",
  "unpleasant_event_time",
  "time_unpleasant",
  "pleasant_event_time",
  "time_pleasant"
)
```

```
# Remove columns
dataset <- dataset %>%
  select(-any_of(columns_to_remove))  # Remove explicitly listed columns


# Step 3: Add participant code
dataset <- dataset %>%
  mutate(participant_code = participant_code)


# Step 4: Add first week wearable information
dataset <- dataset %>%
  mutate(firstweekwearable = first_week_wearable)


# Step 5: Ensure numeric columns are numeric
numeric_columns <- c(
  "affect_positive",
  "affect_negative",
  "stressed",
  "stress_gespannen",
  "energiek",
  "relaxation",
```

```
  "heartrate",
  "day_valence",
  "day_stress",
  "unpleasantness",
  "stressful_unpleasant",
  "invloed_negative_day",
  "onverwacht_negative_day",
  "pleasantness",
  "stressful_pleasant",
  "invloed_positive_day",
  "onverwacht_positive_day",
  "pss_1",
  "pss_2",
  "pss_3",
  "pss_4"
)

# Ensure all numeric columns are present
for (col in numeric_columns) {
  if (!col %in% colnames(dataset)) {
```

```
    dataset[[col]] <- NA  # Add missing column with NA
  }
}

# Convert numeric columns
dataset <- dataset %>%
  mutate(across(all_of(numeric_columns), as.numeric))

# Step 6: Combine PSS scores into PSS_TOTAL
pss_columns <- c("pss_1", "pss_2", "pss_3", "pss_4")
if (all(pss_columns %in% colnames(dataset))) {
  dataset <- dataset %>%
    mutate(pss_total = rowSums(select(., all_of(pss_columns)), na.rm = TRUE))
} else {
  dataset <- dataset %>%
    mutate(pss_total = NA)
}

# Reorder columns to ensure `pss_total` is the last column
all_columns <- colnames(dataset)
```

```
  dataset <- dataset %>%
    select(all_of(setdiff(all_columns, "pss_total")), pss_total)

  return(dataset)
}

#4.1.2 Loading dataset
YFASH8_18 <- read_excel("~/Desktop/R zooi/YFASH8 (18).xlsx")

#4.1.3 Using function on dataset to process the data
processed_YFASH8_18 <- process_dataset(
  dataset = YFASH8_18,
  participant_code = "YFASH8_18",
  first_week_wearable = FALSE  # Change to FALSE if wearable was not used in the first
week
)

#4.1.4Making all columns lowercase
processed_V50HIR_2 <- dplyr::rename_all(processed_V50HIR_2, tolower)
processed_LQCRSW_1 <- dplyr::rename_all(processed_LQCRSW_1, tolower)
```

```
processed_P80DF6G_3 <- dplyr::rename_all(processed_P80DF6G_3, tolower)

processed_P2QNL7E_4 <- dplyr::rename_all(processed_P2QNL7E_4, tolower)

processed_P5BWI95_5 <- dplyr::rename_all(processed_P5BWI95_5, tolower)

processed_MFS2U6_6 <- dplyr::rename_all(processed_MFS2U6_6, tolower)

processed_P29JGWO_7 <- dplyr::rename_all(processed_P29JGWO_7, tolower)

processed_P0GV6L5_8 <- dplyr::rename_all(processed_P0GV6L5_8, tolower)

processed_P1DQF3P_9 <- dplyr::rename_all(processed_P1DQF3P_9, tolower)

processed_X39I90_10 <- dplyr::rename_all(processed_X39I90_10, tolower)

processed_XU443A3_11 <- dplyr::rename_all(processed_XU443A3_11, tolower)

processed_P9U1LZL_12 <- dplyr::rename_all(processed_P9U1LZL_12, tolower)

processed_WF9YFU_13 <- dplyr::rename_all(processed_WF9YFU_13, tolower)

processed_X84MH1_14 <- dplyr::rename_all(processed_X84MH1_14, tolower)

processed_RZV4D2_15 <- dplyr::rename_all(processed_RZV4D2_15, tolower)

processed_JLLPFT_16 <- dplyr::rename_all(processed_JLLPFT_16, tolower)

processed_HKHLJA_17 <- dplyr::rename_all(processed_HKHLJA_17, tolower)

processed_YFASH8_18 <- dplyr::rename_all(processed_YFASH8_18, tolower)

processed_4R7HPJ_19 <- dplyr::rename_all(processed_4R7HPJ_19, tolower)

processed_AMFZ5P_20 <- dplyr::rename_all(processed_AMFZ5P_20, tolower)

processed_8UDI20_21 <- dplyr::rename_all(processed_8UDI20_21, tolower)

processed_F3SFDF_22 <- dplyr::rename_all(processed_F3SFDF_22, tolower)
```

```
processed_13ME8C_23 <- dplyr::rename_all(processed_13ME8C_23, tolower)


#4.1.5 Combine all datasets

ESMDATA_Combined <- bind_rows(
  processed_LQCRSW_1,
  processed_V50HIR_2,
  processed_P80DF6G_3,
  processed_P2QNL7E_4,
  processed_P5BWI95_5,
  processed_MFS2U6_6,
  processed_P29JGWO_7,
  processed_P0GV6L5_8,
  processed_P1DQF3P_9,
  processed_X39I90_10,
  processed_XU443A3_11,
  processed_P9U1LZL_12,
  processed_WF9YFU_13,
  processed_X84MH1_14,
  processed_RZV4D2_15,
  processed_JLLPFT_16,
```

```
  processed_HKHLJA_17,
  processed_YFASH8_18,
  processed_4R7HPJ_19,
  processed_AMFZ5P_20,
  processed_8UDI20_21,
  processed_F3SFDF_22,
  processed_13ME8C_23
)

#4.1.6 check of alles rows goed zijn verwerkt
table(ESMDATA_Combined$participant_code)

#4.1. 7 removing irrelvant columns
ESMDATA_Combined <- ESMDATA_Combined %>%
  select(-tail(names(.), 6))

#4.1.8 Removing all morning questoinnaires as these are irrelvant
ESMDATA_Combined <- ESMDATA_Combined %>%
  filter(rowSums(!is.na(select(., -c(`date and time`, participant_code, firstweekwearable,
pss_total)))) > 0)
```

```
#4.1.7 Save the dataset as a CSV file

write.csv(ESMDATA_Combined, "ESMDATA_Combined.csv", row.names = FALSE)

ESMDATA_Combined <- read.csv("~/Desktop/R zooi/ESMDATA_Combined.csv")


#4.2 Create a new column combining affect_positive and reversed affect_negative

ESMDATA_Combined <- ESMDATA_Combined %>%

  mutate(

    affect_combined = affect_positive - affect_negative  # Reverse affect_negative by
subtracting

  )


#4.3 Create a new column combining stressed, reversed stress_gespannen, and energiek

ESMDATA_Combined <- ESMDATA_Combined %>%

  mutate(

    stress_gespannen_reversed = 100 - stress_gespannen,

    stress_core = (stressed + stress_gespannen_reversed + energiek) / 3

  )


#4.4 Create relaxation_core by combining relaxation and reversed heartrate
```

```
ESMDATA_Combined <- ESMDATA_Combined %>%
  mutate(
    relaxation_core = (relaxation + (100 - heartrate)) / 2  # Reverse heartrate and take the
average
  )


#4.5 Caculating response rate per week per participant (without morning questionnaire)
#4.5.1 Convert "date_and_time" to a proper datetime format
ESMDATA_Combined <- ESMDATA_Combined %>%
  mutate(date.and.time = as.POSIXct(date.and.time, format = "%a, %d %b %Y
%H:%M:%S"))


#4.5.2 Calculate the response rate per participant for each condition
response_rate_condition <- ESMDATA_Combined %>%
  group_by(participant_code) %>%
  mutate(
    first_response_date = min(date.and.time),                   # First response date per participant
    week = ifelse(date.and.time <= first_response_date + days(7), "Week 1", "Week 2") #
Determine the week
  ) %>%
```

```
  group_by(participant_code, firstweekwearable, week) %>%       # Group by participant,
condition, and week
  summarize(
    total_responses = n(),                              # Count responses per condition per week
    response_rate = (total_responses / 28) * 100              # Calculate response rate per week
(max 28)
  ) %>%
  ungroup() %>%
  arrange(participant_code, firstweekwearable, week)


#4.6 Response rate


# Calculate the average response rate for Week 1 and Week 2
average_response_rate <- response_rate_condition %>%
  group_by(week) %>%                           # Group by week
  summarize(
    avg_response_rate = mean(response_rate, na.rm = TRUE), # Calculate average response
rate
    total_participants = n()                    # Count the number of participants
  )
```

View the results

print(average_response_rate)

Calculate the average response rate by week and condition

average_response_rate_condition <- response_rate_condition %>%

  group_by(week, firstweekwearable) %>%   # Group by week and condition

  summarize(

    avg_response_rate = mean(response_rate, na.rm = TRUE),   # Calculate average response rate

    total_participants = n()   # Count the number of participants

)

View the results

print(average_response_rate_condition)

Assuming your data is stored in a data frame called df

average_responserate <- mean(response_rate_per_participant$response_rate, na.rm = TRUE)

Print the result

```
average_responserate


#5 Comparison of PSS_total in qualtrics data ----
#5.1 Checking for ...
#Comparing PSS_total of baseline, week with and week without wearable
comparison_data <- bind_rows(
  Baseline_relevant %>% mutate(Week = "Baseline"),  # Label Baseline dataset
  After1week_relevant %>% mutate(Week = ifelse(FirstWeekWearable == TRUE, "Week
with wearable", "Week without wearable")),  # Label based on FirstWeekWearable
  After2weeks_relevant %>% mutate(Week = ifelse(FirstWeekWearable == TRUE, "Week
with wearable", "Week without wearable"))  # Same logic for After 2 weeks
)


#adding information on which questionnaire data is from
comparison_data <- bind_rows(
  Baseline_relevant %>%
    mutate(Week = "Baseline", Dataset = "Baseline"),


  After1week_relevant %>%
    mutate(
```

```
    Week = ifelse(FirstWeekWearable == TRUE, "Week with wearable", "Week without
wearable"),
    Dataset = "After1week"
  ),

 After2weeks_relevant %>%
  mutate(
    Week = ifelse(FirstWeekWearable == TRUE, "Week with wearable", "Week without
wearable"),
    Dataset = "After2weeks"
  )
)

#Ensure the 'Week' variable is a factor with the desired order
comparison_data$Week <- factor(comparison_data$Week, levels = c("Baseline", "Week
without wearable", "Week with wearable"))

#removal of 4th irrelevant answer of participants, F3FDF and 5BWI95
comparison_data <- comparison_data[-62, ]
```

```
comparison_data <- comparison_data[!comparison_data$ID %in% c("5BWI95", "F3SFDF"),
]


#5.2 Testing assumptions

#5.1.1 Shapiro/normality

shapiro.test(Baseline_relevant$PSS_total)

shapiro.test(After1week_relevant$PSS_total)

shapiro.test(After2weeks_relevant$PSS_total)


#5.1.2 Homogeneity of variance visual

ggplot(comparison_data, aes(x = Week, y = PSS_total)) +

  geom_jitter(width = 0.2, height = 0, color = "blue", alpha = 0.7) +

  theme_minimal() +

  labs(title = "Jittered Scatterplot of PSS_total by Week",

       x = "Week",

       y = "PSS_total") +

  theme(plot.title = element_text(hjust = 0.5))


#5.2 new dataset with only week 1 and 2

qualtricsweek1en2 <- comparison_data %>%
```

```
  filter(Dataset %in% c("After1week", "After2weeks"))


#5.3 Linear regression model between week with wearable and week without wearable and
t-test
# Ensure the Week variable is a factor
qualtricsweek1en2 <- qualtricsweek1en2 %>%
  mutate(Week = as.factor(Week))  # Convert Week to a factor if it's not already


# Fit the linear regression model
lm_model <- lm(PSS_total ~ Week, data = qualtricsweek1en2)


# Display the summary of the model
summary(lm_model)


# Perform a t-test to compare average PSS_total scores between the two conditions
t_test_result <- t.test(PSS_total ~ Week, data = qualtricsweek1en2)


# Display the result
t_test_result
```

#6 Comparison of Stress and relaxation in ESM ----

"ESMDATA_Combined <- read.csv("~/Desktop/R zooi/ESMDATA_Combined.csv")"

#6.1 Removal of participant with compliant below 50% for a condition

List of participant codes to remove

excluded_codes <- c(

"YFASH8_18", "5BWI95_5 ", "13ME8C_23", "2QNL7E_4 ",

"AMFZ5P_20", "F3SFDF_22", "LQCRSW_1", "RZV4D2_15"

)

Create a new dataset excluding the specified participant codes

CompliantESMData <- ESMDATA_Combined %>%

filter(!participant_code %in% excluded_codes)

#6.2 Assigning participant in which week they wore the wearable and removing items filled out after the data collection

#6.2.1 Assigning participant in which week they wore the wearable

#chaning time to workabale unit

CompliantESMData$date.and.time <- as.POSIXct(CompliantESMData$date.and.time, format = "%a, %d %b %Y %H:%M:%S", tz = "UTC")

```
CompliantESMData <- CompliantESMData %>%
  group_by(participant_code) %>%
  mutate(
    # Calculate days since the first date
    day = as.numeric(difftime(as.Date(date.and.time), min(as.Date(date.and.time)), units =
"days")) + 1,

    # Define wearable status based on the corrected "day" logic
    wearable_status = case_when(
      firstweekwearable & day <= 7 ~ "Wearing",                    # First week
      !firstweekwearable & day > 7 & day <= 14 ~ "Wearing",        # Second week
      TRUE ~ "Not Wearing"                                         # Outside assigned weeks
    )
  ) %>%
  ungroup()


#6.2.2 Calculate the number of items recorded on day 15 or higher
day_15_or_higher_count <- CompliantESMData %>%
  group_by(participant_code) %>%
```

```
  mutate(day = as.numeric(difftime(as.Date(date.and.time), min(as.Date(date.and.time)), units = "days")) + 1) %>%
  ungroup() %>%
  filter(day >= 15) %>%
  summarise(total_items = n())
# View the count
print(day_15_or_higher_count)


#6.2.3 Removing day 15 or higher
CompliantESMData <- CompliantESMData %>%
  group_by(participant_code) %>%
  mutate(day = as.numeric(difftime(as.Date(date.and.time), min(as.Date(date.and.time)), units = "days")) + 1) %>%
  ungroup() %>%
  filter(day <= 14)  # Keep only days 1 to 14


#6.3 Creating of column core_relaxation and core_stress
#6.3.1 Core relaxation
CompliantESMData <- CompliantESMData %>%
  mutate(
```

```
    # Combine relaxation and reversed heartrate directly into core_relaxation
    core_relaxation = (relaxation + (100 -heartrate)) / 2 # Reverse heartrate inline
  )

#6.3.2 Core Stress
CompliantESMData <- CompliantESMData %>%
  mutate(
    # Combine stressed, reversed stress_gespannen, and energiek into core_stress
    core_stress = (stressed + stress_gespannen + energiek) / 3
  )

#6.4 Paramatric assumptions of core stress and relaxation
#6.4.1  Normality/shapiro
# Calculate mean and standard deviation of stress
mean_stress <- mean(CompliantESMData$core_stress, na.rm = TRUE)
sd_stress <- sd(CompliantESMData$core_stress, na.rm = TRUE)

# Perform the Kolmogorov-Smirnov test
ks.test(CompliantESMData$core_stress, "pnorm", mean = mean_stress, sd = sd_stress)
```

```
# Calculate mean and standard deviation of core_relaxation

mean_relaxation <- mean(CompliantESMData$core_relaxation, na.rm = TRUE)

sd_relaxation <- sd(CompliantESMData$core_relaxation, na.rm = TRUE)


# Perform the Kolmogorov-Smirnov test

ks.test(CompliantESMData$core_relaxation, "pnorm", mean = mean_relaxation, sd =
sd_relaxation)


#6.4.1.2 Transforming relaxation_core with squareroot

max_core_relaxation <- 101

CompliantESMData <- CompliantESMData %>%

  mutate(core_relaxation_transformed = sqrt(max_core_relaxation - core_relaxation))


# Calculate mean and standard deviation of core_relaxation

mean_relaxation_transformed <- mean(CompliantESMData$core_relaxation_transformed,
na.rm = TRUE)

sd_relaxation_transformed <- sd(CompliantESMData$core_relaxation_transformed, na.rm =
TRUE)

ks.test(CompliantESMData$core_relaxation_transformed, "pnorm", mean =
mean_relaxation_transformed, sd = sd_relaxation_transformed)
```

```
#6.4.1.3 graphs for inside

hist(CompliantESMData$core_relaxation_transformed, probability = TRUE, main =
"Histogram of Core Relaxation")

curve(dnorm(x, mean = mean_relaxation_transformed, sd = sd_relaxation_transformed), col
= "red", lwd = 2, add = TRUE)


qqnorm(CompliantESMData$core_relaxation_transformed)

qqline(CompliantESMData$core_relaxation_transformed, col = "red")


#6.4.2 Homogeneity of variance

#Stress core

# Fit a linear model

model <- lm(core_stress ~ wearable_status, data = CompliantESMData)


# Extract residuals and fitted values

residuals <- resid(model)

fitted_values <- fitted(model)


# Scatterplot of residuals by binary predictor
```

```
ggplot(data = data.frame(Wearable_Status = CompliantESMData$wearable_status, Residuals
= residuals),
       aes(x = as.factor(Wearable_Status), y = Residuals)) +
  geom_jitter(alpha = 0.7, width = 0.2) + # Jitter to reduce overlap
  geom_hline(yintercept = 0, color = "red", linetype = "dashed") +
  theme_minimal() +
  labs(title = "Residuals by Wearable Status",
       x = "Wearable Status (TRUE/FALSE)",
       y = "Residuals")


#relaxation adjusted score
# Fit a linear model with core_relaxation_transformed as the response
model <- lm(core_relaxation_transformed ~ wearable_status, data = CompliantESMData)


# Extract residuals and fitted values
CompliantESMData$residuals <- resid(model)


# Create the scatterplot
library(ggplot2)
ggplot(data = CompliantESMData, aes(x = as.factor(wearable_status), y = residuals)) +
```

```
  geom_jitter(alpha = 0.7, width = 0.2) + # Jittered points for better visualization
  geom_hline(yintercept = 0, color = "red", linetype = "dashed") + # Horizontal line at zero
  theme_minimal() +
  labs(title = "Residuals by Wearable Status for core_relaxation_transformed",
       x = "Wearable Status (TRUE/FALSE)",
       y = "Residuals")


#6.5 Linear regression analysis
model <- lm(core_relaxation_transformed ~ wearable_status, data = CompliantESMData)
model <- lm(core_stress ~ wearable_status, data = CompliantESMData)
summary(model)


#6.6 Spaghetti plot
# Calculate average relaxation scores for core_relaxation_adjusted
avg_scores <- CompliantESMData %>%
  group_by(participant_code, wearable_status) %>%
  summarize(mean_relaxation = mean(core_relaxation_transformed, na.rm = TRUE), .groups
= "drop")


# Create the plot for core_relaxation_adjusted
```

```
ggplot(avg_scores, aes(x = wearable_status, y = mean_relaxation, group = participant_code))
+
  geom_line(aes(color = participant_code), alpha = 0.7) +  # Connect scores for each
participant
  geom_point(size = 3) +  # Add points for individual averages
  theme_minimal() +
  labs(title = "Average Adjusted Relaxation Scores by Wearable Status (Per Participant)",
       x = "Wearable Status",
       y = "Average Core Relaxation (Adjusted)",
       color = "Participant") +
  scale_y_continuous(limits = c(1, 10.5)) +  # Set y-axis range
  theme(plot.title = element_text(hjust = 0.5),
        legend.position = "none")  # Optionally hide the legend for participants


# Calculate average core_stress scores
avg_scores <- CompliantESMData %>%
  group_by(participant_code, wearable_status) %>%
  summarize(mean_stress = mean(core_stress, na.rm = TRUE), .groups = "drop")


# Create the plot for core_stress
```

```
ggplot(avg_scores, aes(x = wearable_status, y = mean_stress, group = participant_code)) +
  geom_line(aes(color = participant_code), alpha = 0.7) +  # Connect scores for each
participant
  geom_point(size = 3) +  # Add points for individual averages
  theme_minimal() +
  labs(title = "Average Stress Scores by Wearable Status (Per Participant)",
       x = "Wearable Status",
       y = "Average Core Stress",
       color = "Participant") +
  scale_y_continuous(limits = c(1, 100)) +  # Set y-axis range
  theme(plot.title = element_text(hjust = 0.5),
        legend.position = "none")  # Optionally hide the legend for participants


#6.7 caclating sample size using G power



#7 Comparison of highest 30% stress score per participant with relaxation ----
#7.1 creating a new dataset with top 5 stress moments both conditions and standardization
top_5_stress_moments_percondition <- CompliantESMData %>%
  group_by(participant_code, wearable_status) %>%
  arrange(desc(core_stress)) %>%  # Correctly close the parentheses for arrange()
```

```
  slice_head(n = 5) %>%  # Select the top 5 rows per group

  select(participant_code, wearable_status, core_stress, core_relaxation, firstweekwearable)




#7.2 Parametric assumptions jippie

#7.2.1 normality/kolmogroc-smirnov

# Step 1: Fit the linear model

model <- lm(core_relaxation_z[, 1] ~ core_stress_z[, 1] * wearable_status,

            data = top_5_stress_moments_percondition)


# Step 2: Get the residuals from the model

residuals_model <- residuals(model)


# Step 3: Perform the Kolmogorov-Smirnov test for normality

ks_test_result <- ks.test(residuals_model, "pnorm", mean(residuals_model),
sd(residuals_model))


# Display the result of the K-S test

ks_test_result
```

```
#7.2.2 Homogeniety/scatterplot

# Step 1: Fit the linear model (if not already done)

model <- lm(core_relaxation_z[, 1] ~ core_stress_z[, 1] * wearable_status,

            data = top_5_stress_moments_percondition)


# Step 2: Get the residuals and fitted values

fitted_values <- fitted(model)

residuals_model <- residuals(model)


# Step 3: Create the scatterplot

plot(fitted_values, residuals_model,

    main = "Residuals vs Fitted Values",

    xlab = "Fitted Values",

    ylab = "Residuals",

    pch = 20, col = "blue")

abline(h = 0, col = "red", lwd = 2)  # Add a horizontal line at y = 0


#7.2.3 Multicollinearity/Vriance Inflration Factor

# Load the necessary library for VIF calculation

# Step 1: Fit the linear model (if not already done)
```

```
model <- lm(core_relaxation_z[, 1] ~ core_stress_z[, 1] * wearable_status,
            data = top_5_stress_moments_percondition)


# Step 2: Calculate VIF
vif(model)



#7.3 Running Linear model
model <- lm(core_relaxation_z[,1] ~ core_stress_z[,1] * wearable_status, data =
top_5_stress_moments_percondition)
summary(model)


ggplot(top_5_stress_moments_percondition, aes(x = core_stress, y = core_relaxation, color =
wearable_status)) +
  geom_point(alpha = 0.6) +
  geom_smooth(method = "lm", se = FALSE) +
  labs(title = "Relationship Between Stress and Relaxation by Wearable Status",
       x = "Core Stress Level", y = "Core Relaxation Level") +
  scale_y_continuous(limits = c(0, 100)) +  # Set y-axis scale from 0 to 100
  theme(
```

```
    legend.position = "bottom",
    legend.title = element_text(size = 10),  # Adjust title size
    legend.text = element_text(size = 9),   # Adjust text size
    legend.spacing.x = unit(0.5, 'cm')      # Add spacing between legend items
  )



#7.4 creating of clear table
# Extract the numeric part of participant_code and reorder
top_5_stress_moments_percondition <- top_5_stress_moments_percondition %>%
  mutate(participant_num = as.numeric(gsub(".*_", "", participant_code))) %>%  # Extract
numeric part
  arrange(participant_num)  # Sort by the numeric part


# Plot with reordered facets
ggplot(top_5_stress_moments_percondition,
       aes(x = core_stress,
           y = core_relaxation,
           color = wearable_status)) +
```

```
  geom_point(alpha = 0.6) +                  # Points for each observation

  geom_smooth(method = "lm", se = FALSE, size = 0.8) +  # Trend lines

  facet_wrap(~ factor(participant_code, levels = unique(participant_code)), ncol = 4) +  #
Ordered facets

  labs(title = "Individual Stress-Relaxation Trends by Wearable Status",

       x = "Standardized Stress (z-score)",

       y = "Standardized Relaxation (z-score)",

       color = "Wearable Status") +

  theme_minimal(base_size = 10) +

  theme(

    strip.text = element_text(size = 8),  # Smaller participant labels

    legend.position = "bottom"           # Legend at the bottom

  )

# nog eentje dan

# Step 1: Aggregate data and sort by the numeric suffix of participant_code

aggregated_data <- top_5_stress_moments_percondition %>%

  group_by(participant_code, wearable_status) %>%

  summarize(

    Mean_Relaxation = mean(core_relaxation, na.rm = TRUE),

    .groups = "drop"
```

```
  ) %>%
  mutate(
    numeric_suffix = as.numeric(sub(".*_(\\d+)$", "\\1", participant_code)),  # Extract numeric
suffix
    participant_code = forcats::fct_reorder(as.factor(participant_code), numeric_suffix)  #
Reorder by numeric suffix
  )


# Step 2: Create faceted bar chart with customized scale and sorted facets
ggplot(aggregated_data,
       aes(x = wearable_status,
           y = Mean_Relaxation,
           fill = wearable_status)) +
  geom_bar(stat = "identity", alpha = 0.8) +  # Bar chart
  facet_wrap(~ participant_code, ncol = 4) +  # Sorted individual graphs
  scale_y_continuous(limits = c(0, 100)) +    # Set y-axis scale from 0 to 100
  labs(
    y = "Average Core Relaxation",  # Keep y-axis title
    fill = "Wearable Status"                # Add legend explanation
  ) +
```

```
  theme_minimal(base_size = 10) +
  theme(
    strip.text = element_text(size = 8),       # Smaller participant labels
    legend.position = "bottom",               # Legend at the bottom
    axis.title.x = element_blank(),           # Remove x-axis title
    axis.text.y = element_blank(),            # Remove y-axis tick labels
    axis.ticks.y = element_blank(),           # Remove y-axis tick marks
    plot.title = element_blank(),             # Remove graph title
    axis.text.x = element_blank()             # Remove x-axis labels
  )


#7.4 apa table
install.packages("apaTables")   # For generating APA-style tables
install.packages("kableExtra") # For flexible table formatting
library(apaTables)


# Fit the model
model <- lm(core_relaxation_z[,1] ~ core_stress_z[,1] * wearable_status, data =
top_5_stress_moments_percondition)
```

```
# Create an APA-style regression table
apa.reg.table(model, filename = "regression_table.doc")


#7.5 feedback verwerken
#7.5.1 desciptive statistics
stress_relaxation_stats <- top_5_stress_moments_percondition %>%
  group_by(wearable_status) %>%
  summarize(
    Mean_Stress = mean(core_stress, na.rm = TRUE),
    SD_Stress = sd(core_stress, na.rm = TRUE),
    N_Stress = sum(!is.na(core_stress)),  # Count of non-missing stress values
    Mean_Relaxation = mean(core_relaxation, na.rm = TRUE),
    SD_Relaxation = sd(core_relaxation, na.rm = TRUE),
    N_Relaxation = sum(!is.na(core_relaxation)),  # Count of non-missing relaxation values
    .groups = "drop"
  )


# Print the results
print(stress_relaxation_stats)
```

```
#7.5.2 lm

model <- lm(core_relaxation ~ wearable_status, data = top_5_stress_moments_percondition)

summary(model)


#8 Descriptive statistics ----

#8.1 remembering self

#8.1.1 prepping data

# Remove rows where ID == "F3SFDF"

Baseline_relevant <- Baseline_relevant %>%

  filter(ID != "F3SFDF")


After2weeks_relevant <- After2weeks_relevant %>%

  filter(ID != "F3SFDF")


After1week_relevant <- After1week_relevant %>%

  filter(ID != "F3SFDF")


#8.1.2 retrieving descriptives
```

```
library(dplyr)

# Calculate descriptive statistics for each dataset
descriptive_table <- tibble(
  TimePoint = c("Baseline", "1 Week", "2 Weeks", "Combined"),
  Mean = c(
    mean(Baseline_relevant$PSS_total, na.rm = TRUE),
    mean(After1week_relevant$PSS_total, na.rm = TRUE),
    mean(After2weeks_relevant$PSS_total, na.rm = TRUE),
    mean(c(Baseline_relevant$PSS_total,
           After1week_relevant$PSS_total,
           After2weeks_relevant$PSS_total), na.rm = TRUE)
  ),
  SD = c(
    sd(Baseline_relevant$PSS_total, na.rm = TRUE),
    sd(After1week_relevant$PSS_total, na.rm = TRUE),
    sd(After2weeks_relevant$PSS_total, na.rm = TRUE),
    sd(c(Baseline_relevant$PSS_total,
         After1week_relevant$PSS_total,
         After2weeks_relevant$PSS_total), na.rm = TRUE)
```

```
  ),
  N = c(
    sum(!is.na(Baseline_relevant$PSS_total)),
    sum(!is.na(After1week_relevant$PSS_total)),
    sum(!is.na(After2weeks_relevant$PSS_total)),
    sum(!is.na(c(Baseline_relevant$PSS_total,
                 After1week_relevant$PSS_total,
                 After2weeks_relevant$PSS_total)))
  )
)

# Print the table
print(descriptive_table)

#8.2 Actual self
#8.2.1 Stress_Core and relaxation
library(dplyr)

# Group by wearable_status and calculate descriptive statistics for each variable
stress_stats_by_wearable <- CompliantESMData %>%
```

```
  group_by(wearable_status) %>%
  summarize(
    Variable = c("stress_core", "relaxation_core"),
    Mean = c(mean(core_stress, na.rm = TRUE), mean(core_relaxation, na.rm = TRUE)),
    SD = c(sd(core_stress, na.rm = TRUE), sd(core_relaxation, na.rm = TRUE)),
    N = c(sum(!is.na(core_stress)), sum(!is.na(core_relaxation))),
    .groups = "drop" # Ensures no grouping is retained
  )

# Print the results
print(stress_stats_by_wearable)
```

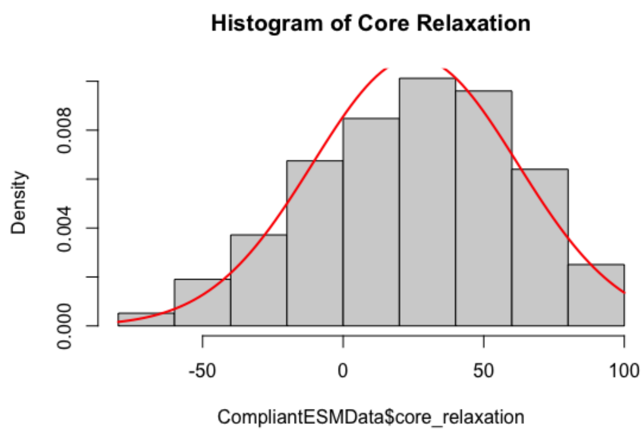
Appendix G:

Parametric assumptions

To test the assumption of normality, the Shapiro-Wilk test was used for the Effects of wearable on perceived stress remembering self, the Kolmogorov-Smirnov test was used for all other models. All assumptions were met expect for the effect of wearable on relaxation on experiencing self. After further analysis, a negative moderate skew was identified (see Figure 4). To meet the assumptions of normality, the data was transformed using square root. sqrt(max(x+1) - x) was used as the skew was moderately negative (Tester, 2019). After data transformation, the assumption of normality was met. The assumption of homogeneity of variance was tested by analysing a scatterplot for all models. All assumptions were met. Multicollinearity was not tested as no model had more than one predictor value.

Figure 4

A histogram of core relaxation.



Note. Scores could be negative as a result of a reversed item.

Appendix H:

AI Statement

“During the preparation of this work the author used Grammerly in order to receive feedback on grammar and spelling. Furthermore, ChatGPT was used in order to summarise literature, receive feedback on structure and flow of text and assist in programming in R. After using these tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the work.”