The Impact of Real-Time Stress Feedback on Perceived Stress: The Moderating Role of Interoceptive Attention and Sensing

Finn de Jong (s2712091)

Department of Psychology, University of Twente

M12 BSc Thesis PSY, 202000384 – 1A

1st Supervisor: Prof. Dr. Matthijs L. Noordzij

2nd Supervisor: Xiaochang Zhao, MSc

Januari 23, 2025

Abstract

Wearable devices have become increasingly popular, and while their effectiveness in promoting physical activity is well-documented, their role in stress management remains underexplored. This study investigated the relationship between feedback from wearable devices and perceived stress, the relationship between wearable devices and interoception, and whether interoceptive attention and sensing moderated the relationship between wearable feedback and perceived stress. To this end an experiment was conducted, in which participants self-reported momentary and recalled perceived stress over a two-week period, with interoception assessed at the beginning and end of the study. No significant effects were found for the hypothesized relationships. Specifically, wearable feedback did not significantly influence perceived stress or interoception, nor did interoceptive attention and sensing moderate the relationship between wearable feedback and perceived stress. However, some evidence suggested a link between higher interoceptive attention and sensing and increased momentary perceived stress. These findings highlight the need for further research incorporating stress-inducing tasks to examine the effects of wearable feedback under heightened stress conditions. Future studies should also explore differences in how interoception impacts momentary versus recalled perceived stress to provide a more comprehensive understanding of these dynamics.

The Impact of Real-Time Stress Feedback on Perceived Stress: The Moderating Role of Interoceptive Attention and Sensing

In recent years, wearable devices have gained widespread popularity, with projections estimating the sale of 559.7 million units worldwide in 2024 (Statista, 2024). Various types of wearable technology are currently available, including extended, virtual, and augmented reality headsets, as well as headphones, smartwatches, and fitness trackers. Notably, smartwatches and fitness trackers often provide users with behavioral and physiological data such as steps, heart rate, blood pressure, and sleep quality (Hosseini et al., 2023). Many of the devices also offer stress level assessments based on the physiological metrics (Jerath et al., 2023). While research has demonstrated the effectiveness of wearable devices in promoting physical activity, their impact on stress management remains underexplored (Ferguson et al., 2022). Nevertheless, emerging studies suggest that wearables could play a significant role in improving stress management (Chalmers et al., 2021; De Zambotti et al., 2019; Ramírez et al., 2023; Jerath et al., 2023; Smith et al., 2020). Interoception, the processing of internal bodily signals, has been proposed as an important factor in stress regulation and emotional management. Interoceptive attention and sensing, two facets of interoception, may also moderate the relationship between stress feedback from wearables and perceived stress, as it influences how strongly individuals experience their physiological responses to stressors (Schulz & Vögele, 2015; Schulz et al., 2020; Solano Durán et al., 2024). This study aims to investigate the effects of stress feedback on perceived levels of stress and interoception, and whether the relationship between stress feedback and perceived stress is moderated by interoception.

Stress and Measurement

Stress is a broad concept involving both external events and internal responses. A stress response occurs in response to stressors, which Epel et al. (2018) describe as life changes like job loss, divorce, or daily challenges, which vary according to individual circumstances. Stressors trigger a range of responses, including emotional reactions such as fear or anxiety, cognitive evaluations of the situation, and biological changes like increased heart rate or hormone release. Epel et al. (2018) also highlight Lazarus and Folkman's (1984) stress and coping theory, which defines stress as the perception that external demands exceed an individual's ability to manage them. Stress responses can be acute, linked to short-term events, or chronic, potentially leading to health issues. While the psychological stress response overlaps with emotions like sadness or fear, it is distinct in that it encapsulates a

vague construct of general distress , though negative emotions are often a key component of stress responses.

Measuring stress in daily life presents challenges. One difficulty is that ecologically valid stress responses cannot, or only partially, be accurately assessed within the controlled conditions of a laboratory, as real-life environments are dynamic, and experimental results may not fully capture the complexity and duration of stress responses as experienced in everyday contexts (Can et al., 2020). Moreover, traditional stress assessments often rely on global recall measures, which raise concerns about ecological validity due to the potential for biases such as recency and primacy effects (Zawadzki et al., 2019). A particularly promising approach is the use of ambulatory self-report measures, where participants provide momentary reports of their experiences while engaging in their daily activities. These self-reports draw on the experience of the "experiencing self", as Kahneman (2011) put it, whereas traditional self-reports speak to the "remembering self". According to Conner and Barrett (2012), ambulatory self-reporting allows for a more accurate understanding of stress in a naturalistic setting. Similarly, wearable devices too are capable of providing ambulatory data.

Wearables, Stress Measurement and Management

Fitness trackers and smartwatches, which are electronic devices worn on the wrist, aim to measure the physiological stress response through various techniques, primarily including heart rate, heart rate variability (HRV), and galvanic skin response. Among these methods, HRV has emerged as the most promising indicator of stress (Gedam & Paul, 2021; Ramírez et al., 2023; Jerath et al., 2020). HRV refers to fluctuations in the time intervals between consecutive heartbeats, reflecting the balance between the sympathetic nervous system (SNS) and parasympathetic nervous system (PNS). During acute stress, SNS activation increases heart rate and reduces HRV, as heart rate becomes more uniform. Conversely, when the PNS is dominant, HRV increases, indicating a more adaptable autonomic response (de Geus & Gevonden, 2024). Through this mechanism, HRV is an important biomarker of autonomic function and the stress response, making HRV a useful tool for stress measurement, and by extension management.

Research suggests that the stress feedback provided by wearable devices can contribute to effective stress management and reduction. Real-time HRV data can be instrumental in identifying specific stressors, allowing for timely interventions (Chalmers et al., 2021). Moreover, increased awareness of one's stress levels may enable individuals to take proactive steps to reduce stress (Ramírez et al., 2023). This increased awareness

processes relating to stress, an internal bodily process, aligns closely with interoception. To understand the role of interoception in stress management and the stress response, it is first necessary to establish a clear definition.

Interoception and Stress

Interoception refers to the processing of internal bodily states, such as hunger, heartbeat and stress. Despite its importance in understanding the mind-body connection, the conceptual and operational definitions of interoception have historically been vague, as noted by Desmedt et al. (2023). It is an active field, with researchers working toward a clearer and more comprehensive definition. In their recent work, Desmedt et al. proposed a comprehensive framework that identifies four distinct facets of interoception, which will serve as the basis for the present study. The first facet, interoceptive attention, refers to any attentional process directed toward internal bodily signals. Interoceptive sensing refers to the nervous system's capacity to sense signals from within the body, operating at both conscious and unconscious levels. Interoceptive interpretation involves the way these internal signals are understood and categorized, encompassing beliefs, attitudes, and any other forms of interpretation. Lastly, interoceptive memory pertains to the memory processes that are linked to or influenced by internal bodily signals.

One prominent way of measuring self-reported interoception has been by employing the Multidimensional Assessment of Interoceptive Awareness (MAIA-2) scale (Mehling, 2018). The MAIA-2 measures self-reported interoception through the use of eight subscales (see Table 1). Desmedt et al. (2023), have shown that most of these subscales can be mapped onto the facets of their definition of interoception, as summarized in Table 1. However, not all subscales fit neatly into this framework. In particular, the "Self-Regulation," and "Body Listening" subscales reflect broader aspects of interoceptive processing that are not directly aligned with any one facet, highlighting the complexity of interoception as a construct.

Table 1

Connections Between Facets of Interoception and MAIA-2 Subscales

Facet	**MAIA-2 Subscale**
Interoceptive Attention	Attention Regulation
	Not-Distracting
Interoceptive Sensing	Noticing
Interoceptive Interpretation	Trusting
	Not-Worrying

	Emotional Awareness
Interoceptive Memory	-
-	Self-Regulation Body Listening

The facets of interoception may be affected by the stress response, and vice versa. Acute stress responses especially can affect the biological pathways through which the body reacts to stressors. These altered signals in turn can change an individual's perceptions of the bodily sensations that caused them, which consequently changes the experience of those sensations, thus affecting interoceptive attention and sensing. A heightened experience of a physical stress response could induce further distress, as a heightened experience of heart palpitations, for example, can feed back into the stress response (Schulz & Vögele, 2015; Schulz et al., 2020). Furthermore, research by Schultchen et al. (2019) suggests that interoceptive sensing may be weakly negatively related to long-term stress, mediated by self-regulation. Conversely, other research suggests the opposite, indicating that interoception as measured by the MAIA-2 may provide resilience against the detrimental effects of stress (Solano Durán et al., 2024), yet they also note that the amount of attention individuals pay to distressing bodily symptoms may be positively related to distress. While there is currently no clear consensus on the relationship between interoception and stress, research indicates that interoception could play a role in the relationship between feedback from wearable devices and perceived stress.

This relationship could be mediary or moderating. Feedback provided by a wearable device could increase interoceptive attention, making the user more aware of their stress levels and allowing them to take appropriate action to reduce them, as noted by Price & Hooven (2018) and Ramírez et al. (2023). On the other hand, the relationship could be of a moderating nature, as upon becoming aware a physical stress response is currently ongoing, interoceptive attention and sensing may heighten or lessen the experience of this response, resulting in higher or lower perceived stress respectively (Schulz & Vögele, 2015; Schulz et al., 2020; Solano Durán et al., 2024). The current study will not focus on the possibility of mediation, as the afforded scale of the experiment would be lacking in statistical power.

Challenges in Integrating Wearable Stress Feedback and Interoception

There are several notable gaps in the current research. The connection between real-time stress feedback from wearable devices and perceived stress remains underexplored

(Ferguson et al., 2020). Although existing studies suggest that wearable devices may help manage stress, they have not measured daily perceived stress in naturalistic, everyday environments (Chalmers et al., 2021; De Zambotti et al., 2019; Ramírez et al., 2023; Jerath et al., 2023; Smith et al., 2020). Furthermore, although previous research has proposed potential links between real-time stress feedback and interoception (e.g., Price & Hooven, 2018; Ramírez et al., 2023), these studies employ varying definitions and measures of interoception and its components, complicating their integration into a cohesive framework.

Additionally, while research conducted outside the context of wearable devices suggests that interoceptive attention and sensing may act as moderators in the relationship between stress feedback and perceived stress (Schulz & Vögele, 2015; Schulz et al., 2020; Solano Durán et al., 2024), no studies to date have explicitly examined the interaction between stress and interoception within the context of wearable devices, resulting in a lack of concrete evidence of a possible relationship between the three variables. This leaves a critical gap in understanding how interoception, stress, and wearable feedback interact. The present study seeks to address these gaps, providing new insights into the interplay between these variables.

The Current Study

The study aims to investigate the impact of real-time stress feedback provided by wearable devices on individuals' perceived stress levels in daily life and to determine the moderating role of interoceptive attention and sensing within this relationship. To achieve this, an intensive longitudinal experimental design was employed. Over a two-week period, participants wore a wrist-worn device that delivered real-time stress feedback for one week and did not wear the device during the other week, thereby serving as their own control. During this time, the Experience Sampling Method (ESM) in addition to weekly self-report questionnaires were utilized to assess participants' perceived stress levels and interoception. The study aimed to address the following research questions:

(RQ1) To what extent does stress feedback from wearable devices impact momentary and recalled levels of perceived stress?

(H1) Stress feedback from wearables devices has an impact on both momentary and recalled levels of perceived stress, with momentary perceived stress being more strongly affected.

(RQ2) Are levels of interoceptive attention, sensing and interpretation affected when comparing them before and after the experiment?

(H2) Levels of interoceptive attention, sensing and interpretation are higher after the experiment when compared to before.

(RQ3) Do interoceptive attention and sensing moderate the change in perceived stress levels between a week with stress feedback from wearable devices and a week without feedback, as examined through groupings of high and low levels of these variables?

(H3) The group with high levels of interoceptive attention and sensing experience more perceived stress as a result of the stress feedback.

Methods

Research Design

The study employed a quantitative, within-subjects repeated-measures design, enabling the measurement of perceived stress and interoception over time across two conditions: wearing a stress feedback device and not wearing the device. In addition, this design allowed participants to serve as their own controls. Data was collected through experience sampling methods (ESM) and weekly online questionnaires, facilitating both ambulatory and recollective assessments of the dependent variables. The measures used in this study were part of a larger battery of tests.

Participants

A total of 21 participants were initially approached or expressed interest in taking part in the study. Of these, 7 failed to complete a sufficient number of questionnaires, resulting in a final sample of 14 participants. The participants ranged in age from 19 to 55 years (M = 25.5, SD = 12.0); 10 identified as male, and four as female. In terms of highest completed education, 9 had completed high school, one an Intermediate Vocational Education, two a Higher Vocational Education, and two a Scientific Education. The sample was primarily Dutch, with 13 identifying as Dutch and one as Greek.

The study's exclusion criteria required participants to be over 18 years old, free from serious psychological conditions, and to have not actively used a wearable device capable of providing stress feedback in recent months. To ensure data quality, participants were included only if they completed over 30% of the ESM surveys, and all of the weekly online questionnaires. Prior to data collection, a target sample size of 30 participants was established. A total of 11 participants were recruited through convenience sampling, while three were recruited via SONA, a university-based research participation system used to engage first- and second-year students, who earn points required for graduation (https://www.sona-systems.com/). Recruitment occurred over a period of three weeks. Ethical approval for the study was obtained from the BMS Ethics Committee at the University of Twente.

Materials

The materials used in this study included educational documents for participants, a wearable device for stress feedback, questionnaires, and digital platforms for distributing surveys and managing responses.

Psychoeducation

A psychoeducation document was provided during intake meetings to explain key concepts, including stress, stress feedback, heart rate variability (HRV), and the use of wearables for stress measurement (Appendix A).

Garmin Forerunner 255

The Garmin Forerunner 255 (https://www.garmin.com/nl-NL/p/780139) served as the wearable device delivering real-time stress feedback. Eight of these devices were used in the study (see Figure 1). Before distribution, each device was configured to display the time (17:02:25), battery life (the battery icon), stress (icon at the bottom of the watch face), heart rate (the heart icon at the top right, 26), and HRV (heart icon with graph, second to the top) on the main watch face for easy access by participants. HRV often did not display a number, however. During the experiment it was discovered an HRV value was only provided when wearing the watch during sleep, which was not required of the participants.

Figure 1

Watch Face of Garmin 255 Used in Experiment

m-Path

The m-Path app (https://m-path.io/landing/) was used to administer ESM surveys. This mobile app allows researchers to schedule and send notifications for questionnaire completion. In this study, participants received five notifications per day, prompting them to complete questionnaires at randomized times within set intervals. The morning questionnaire was sent between 07:00 and 08:00, followed by three core questionnaires at intervals between 08:00–10:00, 12:00–14:00, and 16:00–18:00, and an evening questionnaire between 20:00 and 22:00. Each questionnaire had an expiration period—300 minutes for the morning

questionnaire in order to assure enough time for completion, 30 minutes for core questionnaires, and 60 minutes for the evening questionnaire. All participants received notifications at identical times.

The questions were taken directly from the Stress in Action project, which emphasizes the use of innovative technologies to measure stress in real-life contexts (https://stress-in-action.nl/project-abstract/). A list of the questions utilized in the study can be found in Appendix B.

Qualtrics

Qualtrics, an online survey platform (https://www.qualtrics.com/), hosted three questionnaires administered to participants: one at intake, one after one week, and one at the end of the two-week data collection period. The intake questionnaire provided an overview of the study, requested informed consent, and asked for the participant's unique code (provided at intake) along with demographic information. The complete set of questionnaires is included in Appendix C, D, and E. Participants were given an anonymous link to complete these surveys on their personal devices.

Perceived Stress Scale

Perceived stress was measured using the Perceived Stress Scale (PSS-10), a widely recognized tool by Cohen et al. (1983) with high internal validity (Cronbach's $\alpha > .70$) (Lee, 2012). This scale was included in all three online questionnaires and asked participants to rate the frequency of stress-related thoughts and feelings on a 5-point Likert scale, ranging from "never" to "very often."

Multidimensional Assessment of Interoceptive Awareness – Version 2

The MAIA-2 (Mehling et al., 2018) was used to assess participants' interoception. This measure includes eight subscales, with Cronbach's α values ranging from 0.64 to 0.83. Two subscales—Noticing (0.64) and Worrying (0.67)—fall slightly below the recommended criterion of 0.70. The MAIA-2 consists of 37 items, rated on a 6-point scale from 0 ("never") to 5 ("always"). It was administered in both the intake questionnaire and the final questionnaire after two weeks.

Procedure

Upon enrolment, either through the SONA system or by direct recruitment by a researcher, participants were scheduled for an intake meeting. This meeting served as an orientation to the study's purpose and objectives, which were outlined at the outset. Participants were informed that the study would span a duration of two weeks, with detailed explanations provided about the research design and procedures involved.

During this meeting, participants received psychoeducational information on several key concepts central to the study: stress, heart rate variability (HRV), and stress measurement using wearable devices. Instructions were then provided regarding data collection methods, which involved responses to brief, daily questionnaires administered via the m-Path app and periodic, more comprehensive questionnaires hosted on Qualtrics.

The intake session also included an overview of the five m-Path questionnaires, including their content, expected completion time, and scheduled distribution times. Participants were advised that while they were encouraged to complete as many m-Path questionnaires as possible, missing some entries was anticipated and permissible. At this point, participants were asked to download the m-Path app onto their phones. Upon opening the app, they were prompted to create an alias; researchers provided a pre-assigned alias code to each participant, which would be used later in the Qualtrics survey to link their responses across platforms. Participants started to receive m-path questionnaires the morning after the intake meeting.

Participants were then assigned to either a "device" or "no device" condition. In each condition, participants wore the device for one week. Those in the "device" condition wore a Garmin Forerunner 255 watch for the first week and did not during the second week, while those in the "no device" condition reversed this pattern. Participants beginning in the watch condition received detailed instructions on using the Garmin device during the intake meeting. This included how to access heart rate, HRV, and stress data from the watch face, an explanation of the device's button functions, and clarification that the watch is waterproof. While participants were encouraged to wear the watch consistently, they were informed that it was not mandatory to wear it during sleep or intense physical activities, such as sports.

The intake meeting also covered the procedure for Qualtrics questionnaires, including when to expect them, how they would be delivered, and the importance of completing them on the day they were received. A follow-up meeting was scheduled for one week after the intake meeting. During this second meeting, participants either received or returned the watch, depending on their assigned condition. For those starting in the "no device" condition, a third meeting was planned for the end of the second week to facilitate the return of the device. Shortly after each meeting, participants received a link to the relevant Qualtrics questionnaire via email. Outside these meetings there was little contact with participants regarding the experiment. There was no set protocol for aiding participants in keeping up compliance rates, though participants were contacted and asked to increase their compliance rate when it dropped below 50.

Data Analysis

Data analysis was conducted using R (version 4.4.2, https://www.r-project.org/), a statistical programming language. Prior to performing the analysis, data was first exported from both m-Path and Qualtrics and then imported into RStudio (https://posit.co/download/rstudio-desktop/), an integrated development environment for R. The scales in the data from Qualtrics were then scored, and the scores of the three surveys were merged into a single dataset. Following this, weekly averages were calculated from the m-Path data, and the m-Path data was merged with the survey data. At this point, participants that did not meet the inclusion criteria were excluded. Finally, a grouping variable for high or low average level of interoceptive attention and sensing was created by averaging the noticing, not distracting and attention regulation subscales from the MAIA-2 results of the baseline survey and comparing results to the mean of the dataset. This resulted in each participant having an above average "high" or below average "low" interoceptive grouping variable.

Following this, variables were renamed in order to better suit the purpose of the study. The names of the variables, and what scores they are based on are found in Table 2.

Table 2

Variable Names and Origins

Variable Name	**Origin**
Momentary Stress	One of the ESM questions asking participants to provide a score of how stressed they currently feel. These scores were then averaged over a week, resulting in the Momentary Stress Variable.
Momentary Stress PSS	One of the ESM questions which was taken from the PSS-10. The scores were then averaged over a week, resulting in the Momentary Stress PSS variable.
Recalled Stress	Is equal to the scores on the weekly PSS-10 survey.
Weeks	This variable how many weeks the experiment has currently been for a particular participant (0 – 2).

Watch	The condition of whether participants wore a watch during the week to which the survey scores belong (0 = no watch, 1 = watch).
Interoceptive Grouping	The interoceptive grouping variable indicating whether participants scored above or below average for interoceptive attention and sensing in the baseline survey (low, high).
MAIA – 2 Subscales	The MAIA-2 subscales were included as they are.
Interoceptive Attention	Is the average of the Not Distracting and Attention Regulation subscales of the MAIA-2.
Interoceptive Sensing	Equals the Noticing subscale of the MAIA-2.
Interoceptive Interpretation	Is the average of the Trusting, Not Worrying and Emotional Awareness subscales of the MAIA-2.

The analysis began with descriptive statistics, where means, standard deviations and medians of the dependent stress and interoceptive variables were calculated across the two conditions: not wearing and wearing a wearable device. Subsequently, research questions RQ1 and RQ3 were addressed using aligned rank transform ANOVAs and spaghetti plots. A non-parametric method of analysis was chosen due to the relatively small sample size (n = 14). The dependent variables for the ANOVAs included Momentary Stress, Momentary Stress PSS, and Recalled stress. The independent variable was the Watch variable, with Interoceptive Grouping as a moderating variable. The spaghetti plots plotted the dependent stress variables against the Watch variable, with participants being colour coded depending on the Interceptive Grouping variable.

Finally, RQ2 was examined through the application of a Wilcoxon Signed-Rank test. The dependent variables in this test were the MAIA-2 subscales, Interoceptive Attention, Interoceptive Sensing and Interoceptive Interpretation, while the independent variable was the Weeks variable. Bonferroni correction was applied to adjust the p-values from the Wilcoxon Signed-Rank test to account for multiple comparisons. In addition, spaghetti plots

were created to check for any possible upward or downward trends. The MAIA-2 subscales, and Interoceptive Attention, Sensing and Interpretation were plotted against Weeks.

Results

Before addressing the research questions, descriptive statistics were calculated to gain an overview of the dataset. Specifically, the mean values, standard deviations and medians of the dependent variables were computed for each of the two wearable device conditions (see Table 3).

Table 3

Means, Standard deviations and Medians of Dependent Variables Across Conditions

Dependent Variable	**No Wearable Device**		**With Wearable Device**		**Baseline**	
	Mean (SD)	Median	Mean	Median	Mean	Median
Momentary Stress (0 – 100)	27.20 (11.71)	27.50	26.30 (10.35)	22.80	-	-
Momentary Stress PSS (0 – 4)	1.21 (0.54)	1.21	1.13 (0.41)	1.16	-	-
Recalled Stress (0 – 40)	26.70 (2.00)	27.00	27.10 (2.03)	27.00	27.00 (2.86)	26.50
Noticing (0 – 5)	2.79 (0.80)	2.75	3.19 (0.50)	3.25	2.88 (0.60)	3.25
Not Distracting (0 – 5)	3.01 (0.36)	2.92	2.96 (0.90)	3.17	3.01 (0.61)	3.17
Not Worrying (0 – 5)	2.47 (0.76)	2.60	2.4 (0.72)	2.30	2.56 (0.42)	2.60
Attention Regulation (0 – 5)	3.10 (0.53)	3.00	2.91 (0.94)	3.14	2.84 (0.67)	2.93
Emotional Awareness (0 – 5)	3.00 (0.96)	2.80	3.45 (0.38)	3.50	3.14 (0.71)	3.50
Self-Regulation (0 – 5)	2.88 (0.54)	2.80	2.88 (0.67)	2.60	2.77 (0.81)	2.60
Body Listening (0 – 5)	2.06 (1.12)	1.83	2.25 (0.90)	2.33	2.10 (0.90)	1.83
Trusting (0 – 5)	4.22 (0.59)	4.17	4.21 (0.69)	4.17	4.33 (0.47)	4.33
Interoceptive Attention (0 – 5)	3.06 (0.16)	3.06	2.93 (0.44)	2.99	2.92 (0.45)	3.01
Interoceptive Sensing (0 – 5)	2.79 (0.80)	2.75	3.19 (0.50)	3.25	2.88 (0.60)	3.25
Interoceptive Interpretation (0 – 5)	3.23 (0.32)	3.24	3.35 (0.36)	3.31	3.34 (0.20)	3.38

Note. Baseline values were only available for the trait questionnaires on interoception (MAIA-2) and perceived stress (PSS), hence there are no baseline values for the momentary stress variables.

Aligned rank transform ANOVAs were conducted to examine the effects of wearable device feedback on momentary and recalled perceived stress (RQ1) and to assess whether

interoceptive attention and sensing moderate perceived stress between conditions (RQ3). As shown in Table 4, no significant effects were observed for the Watch condition or Interoceptive Grouping variable on the dependent variables, all ***F***'s < 1.2, all ***p***'s>.05. Furthermore, spaghetti plots revealed no clear upward or downward trend in the stress data depending on the Interoceptive Grouping variable (Figure 2). Therefore, the null hypotheses for both research questions cannot be rejected.

Table 4

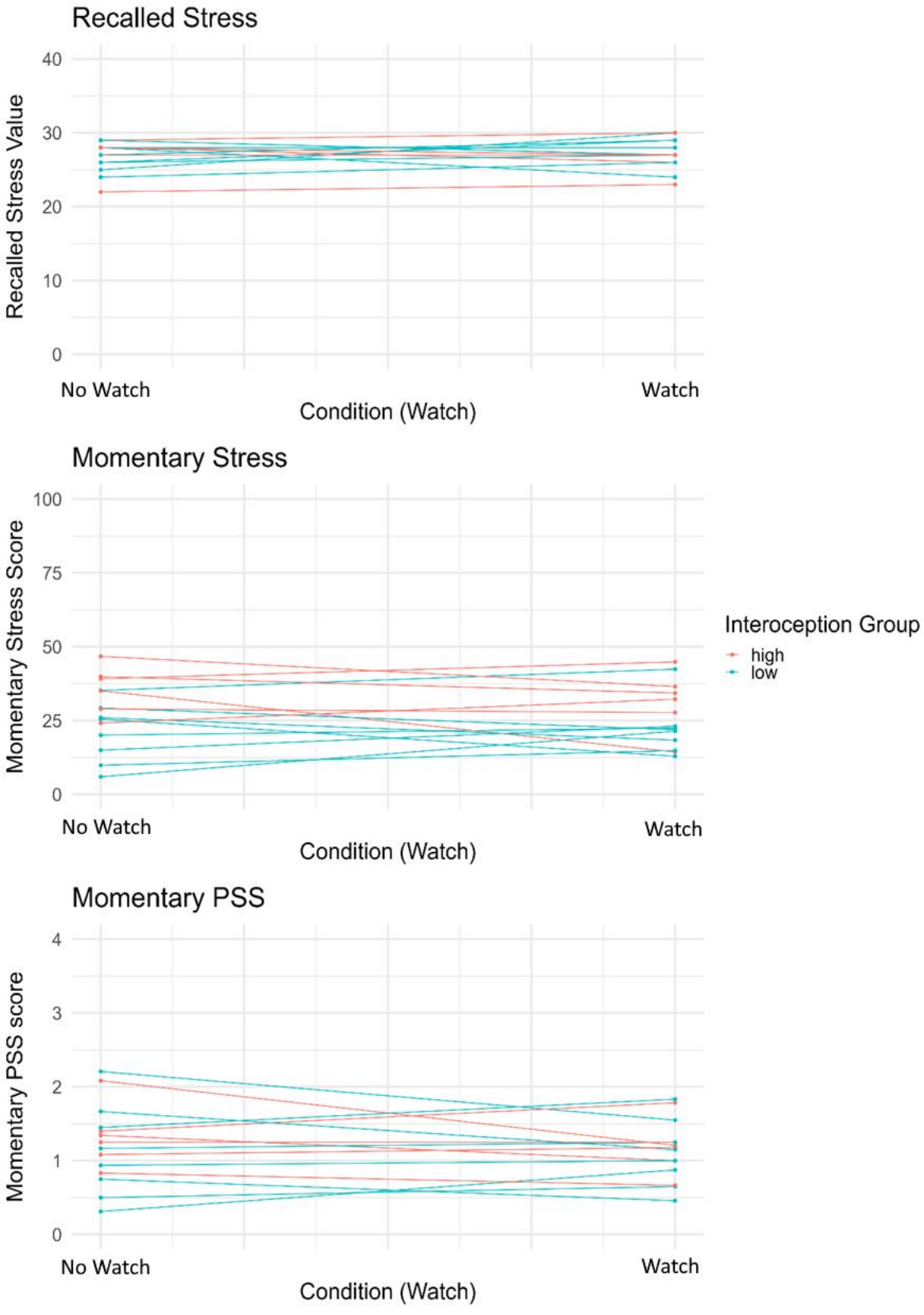
Result of Aligned Rank Transform ANOVA

Effect	Df	Df.res	F value	Pr(>F)
Recalled Stress				
Watch	1	24	0.043	0.84
Interoceptive Grouping * Watch	1	24	1.04	0.32
Momentary Stress				
Watch	1	24	0.14	0.71
Interoceptive Grouping * Watch	1	24	0.17	0.68
Momentary PSS				
Watch	1	24	0.15	0.71
Interoceptive Grouping * Watch	1	24	0.19	0.67

Note. The Watch variable indicates the condition of having worn a wearable for a week. The Interoceptive Grouping variable indicates whether the participant has an above or below average level of interoception.

Figure 2

Spaghetti Plots of Dependent Stress Variables



A Wilcoxon Signed-Rank test was applied to determine the effect of the experiment on Interoceptive Attention, Sensing and Interpretation (RQ2). As shown in Table 5, all *p*'s = 1.00, indicating no significant effect of the wearable device on interoception. Furthermore, there is no clear upwards or downwards trend in the spaghetti plots (see Figure 3). Thus, the null hypothesis for RQ2 cannot be rejected.

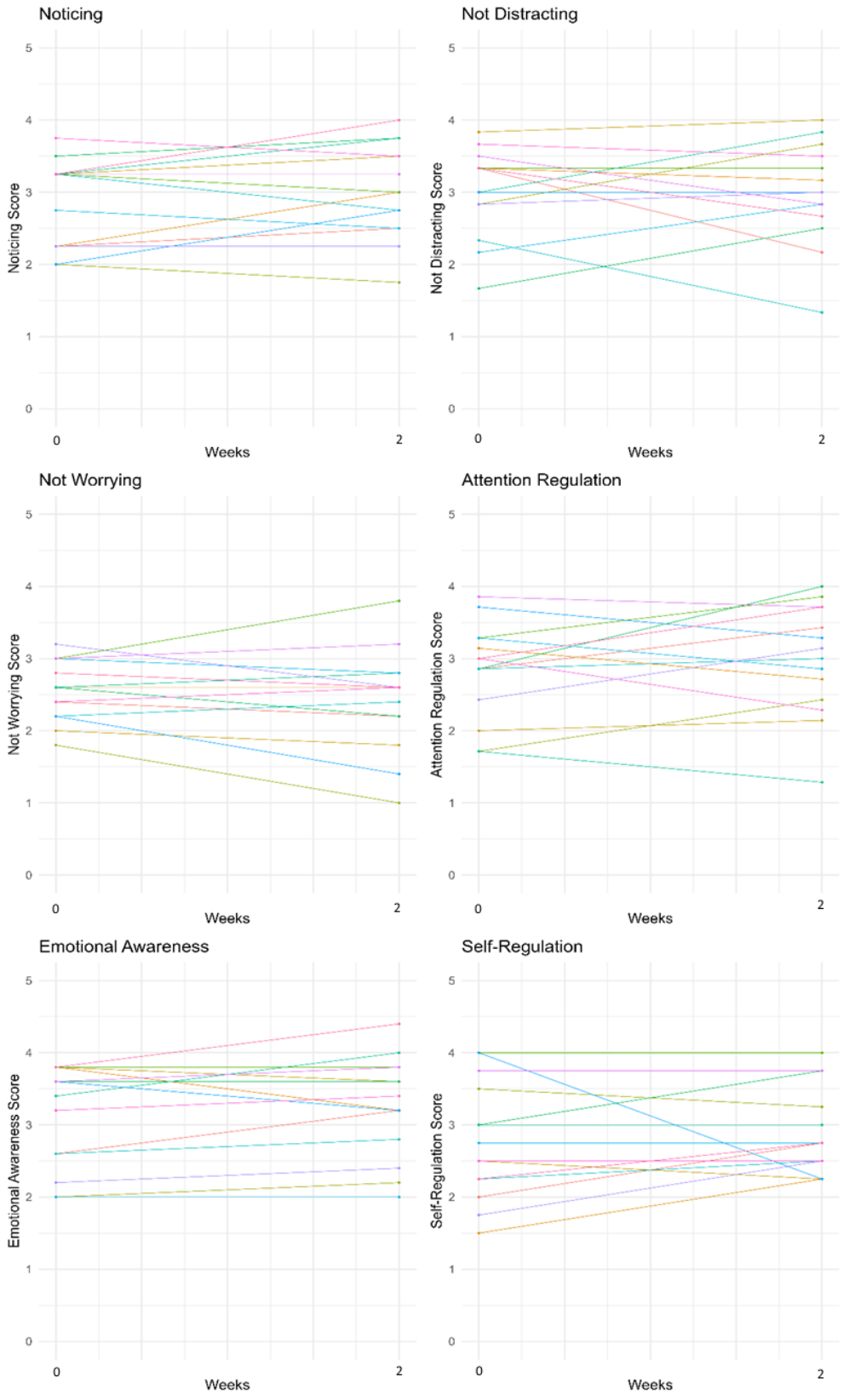
Table 5

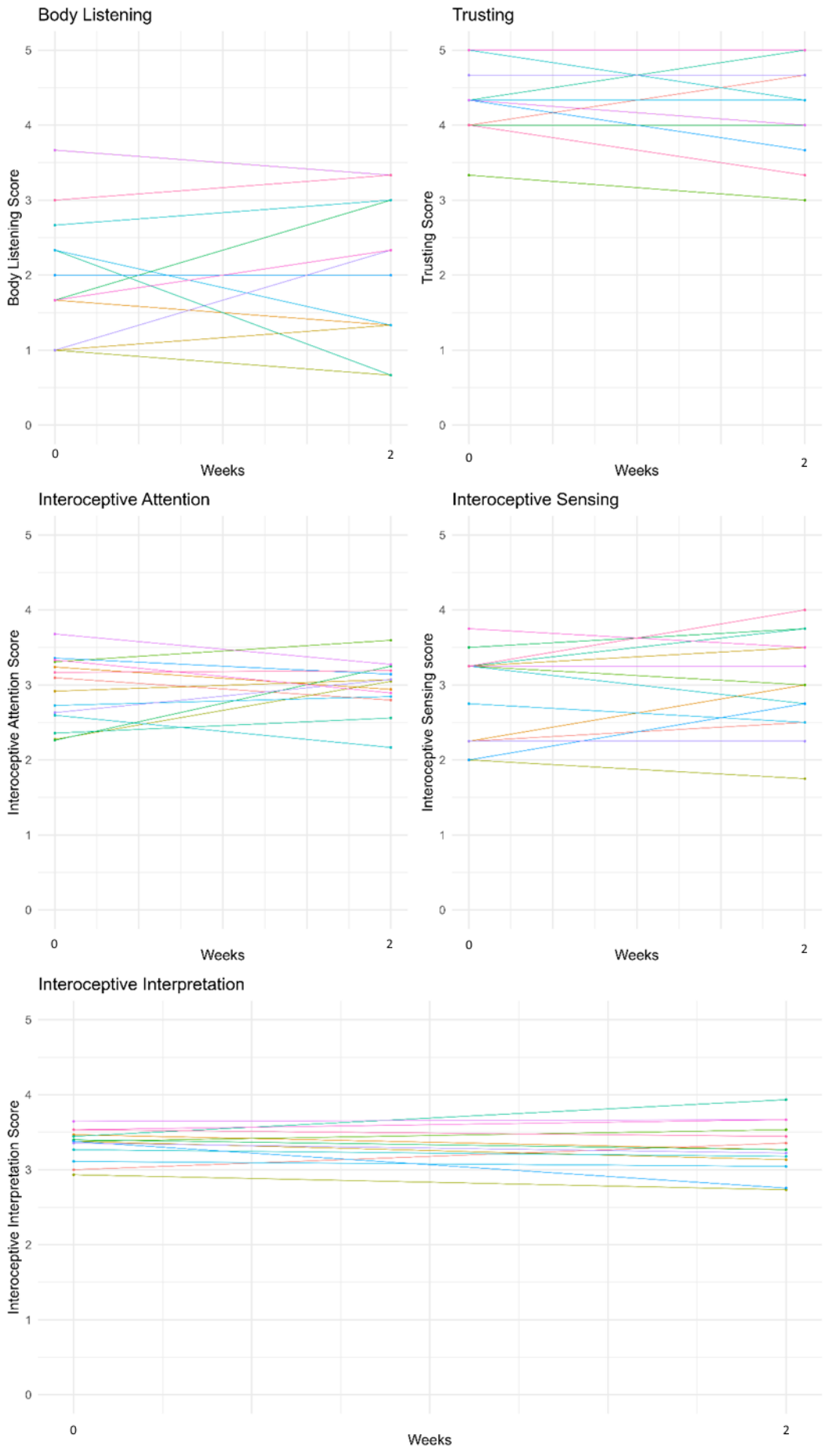
Result of Wilcoxon Signed Rank Test

Variable	Statistic	P Value	Adjusted P Value
Noticing	53.50	0.26	1.00
Not Distracting	37.50	0.94	1.00
Not Worrying	30.00	0.29	1.00
Attention Regulation	69.00	0.31	1.00
Emotional Awareness	48.00	0.19	1.00
Self-Regulation	32.00	0.28	1.00
Body Listening	55.00	0.53	1.00
Trusting	14.00	0.62	1.00
Interoceptive Attention	54.50	0.92	1.00
Interoceptive Sensing	53.50	0.26	1.00
Interoceptive Interpretation	40.00	0.45	1.00

Figure 3

Spaghetti Plots of Interoception Variables




Body Listening
Body Listening Score
Weeks
Trusting
Trusting Score
Weeks
Interoceptive Attention
Interoceptive Attention Score
Weeks
Interoceptive Sensing
Interoceptive Sensing score
Weeks
Interoceptive Interpretation
Interoceptive Interpretation Score
Weeks

Discussion

This study aimed to explore the relationship between real-time stress feedback from wearable devices, perceived stress, and interoception. An experiment was performed, in which participants self-reported momentary and recalled perceived stress, in addition to their level of interoception for two weeks. No significant evidence was found to support the hypothesis that real-time stress feedback affects perceived stress, whether momentary or recalled. Similarly, the results indicated that real-time stress feedback did not significantly impact interoception across its three facets—attention, sensing, and interpretation—nor did the facets of interoceptive attention and sensing moderate the relationship between real-time stress feedback and perceived stress.

Implications

The result for the feedback from a wearable device not affecting perceived stress goes against the findings of (Jerath et al., 2023, Ramírez et al., 2023 and Chalmers 2021). However, it is worth noting that the current sample does not have high perceived stress, scoring on average roughly 1 in 4 on all forms of conducted perceived stress self-reports. Nor does the current study make use of a stress test, which has been the case for Chalmers et al. (2021). As such there could be a floor effect, where participants do not experience enough stress for the feedback from a wearable device to be able to significantly reduce or increase it. Furthermore, unlike earlier studies, the current study was conducted in a naturalistic environment over an extended period of time. Results could suggest that within that context, the effect of wearable device feedback on perceived stress is not as strong as within a controlled environment.

As for a relationship between wearable feedback and interoceptive attention, sensing and interpretation, the primary argument was that observing stress indicators, such as an elevated heart rate on a wearable device, increases awareness of these physiological changes, which would in turn allow the user to take steps managing their stress (Price & Hooven, 2018; Ramírez et al. 2023). However perhaps this form of awareness is fundamentally different from interoception, in that it is not internalized. Merely being aware of the feedback on the wearable device could be impetus enough to move an individual to engage in stress managing tactics, reducing stress. However, this form of awareness may fundamentally differ from interoception, as it is not derived from internal bodily sensations but rather from external feedback which is not internalized. While the information provided by wearable devices may motivate individuals to adopt stress-management strategies and potentially

reduce stress, this process does not necessarily involve the internalized, self-perceived awareness characteristic of interoception. This would be more in line with a perspective highlighted by Foerster (2024), in which wearable feedback distracts from interoceptive sensing rather than increasing it.

The proposed moderating role of interoceptive attention and sensing in the relationship between wearable feedback and stress centers on the idea that heightened awareness and sensitivity to bodily sensations amplify the physical experience of stress, thereby increasing perceived stress levels (Schulz & Vögele, 2015; Schulz et al., 2020; Solano Durán et al., 2024). The lack of moderation in the current sample is not surprising, as the relationship it is meant to moderate was found to be insignificant. However, while insignificant, Figure 3 reveals a clear distinction in momentary perceived stress levels between participants with low and high interoceptive attention and sensing, aligning with previous findings (Schulz & Vögele, 2015; Schulz et al., 2020; Solano Durán et al., 2024). Interestingly, this difference does not extend to recalled stress levels within the current sample, highlighting a need for further investigation.

Limitations

Several limitations of this study should be considered when interpreting these findings. First, participants were briefed at the outset of the experiment about the dual nature of stress (i.e., that stress can be both beneficial and detrimental), the method used by the device to measure their stress levels, the potential inaccuracies of this measurement, and the need for them to reflect on its accuracy. This explicit framing, while useful for experimental purposes, is unlikely to occur in real-world contexts for typical users of wearable devices, potentially introducing bias. Specifically, participants may have placed less trust in the feedback provided, thereby diminishing its potential influence.

Another key limitation relates to the validity of the measures used in this study. Some of the ambulatory self-report items from m-Path used in the experiment were drawn from the Perceived Stress Scale (PSS-10). It is uncertain whether these items, when used in isolation from the complete scale, retained their validity as measures of perceived stress. This selective use of items may have affected the reliability and interpretability of the measures.

In addition to these methodological concerns, the small sample size further impacts the study's findings. The small sample size (n = 14) represents another significant limitation, constraining the generalizability of the findings. The sample, composed primarily of Dutch college students recruited through convenience sampling, may not be representative of broader or more diverse populations. Furthermore, the limited sample size reduces the

statistical power of the study, making it less likely to detect small but meaningful effects. Compounding this issue, is that participants were divided into low and high interoception groups by splitting the already small sample in half. This approach further limits the external validity of the findings and underscores the need for larger samples in future research.

Future Research

There are several directions for future research that could build upon the findings of the current study. One key area to explore is the inclusion of stress-inducing tasks within experimental designs. Conducting a similar experiment that incorporates stress tests would provide valuable insights into how wearable device feedback functions under conditions of heightened perceived stress. When participants experience higher stress levels, the effect of feedback from wearable devices may become more pronounced, offering a clearer understanding of its impact. Another intriguing avenue of research involves examining how interoceptive attention and sensing influence both momentary and recalled perceived stress. Investigating this difference could shed light on whether awareness of the physiological stress response affects momentary perceived stress differently compared to recalled perceived stress.

Additionally, the refinement of measurement tools is an important consideration. Future research should evaluate whether selecting individual items from the PSS-10 affects the validity of these measures. Ensuring the reliability of tools used to assess perceived stress and interoception is critical for the robustness of findings. Additionally, measuring interoception periodically, such as on a weekly basis, rather than solely at the beginning and end of the experiment, would provide more accurate and dynamic insights into the effects of wearable devices on interoception over time.

Beyond methodological improvements, sample size considerations are also crucial. Given that the relationships between wearable feedback, interoception, and perceived stress may operate in more subtle ways, future studies should employ larger sample sizes to enhance statistical power. This approach would improve the ability to detect small but meaningful effects, thereby offering a more comprehensive understanding of these relationships.

Finally, integrating broader theoretical frameworks could enrich future interoceptive research. It is recommended that future studies incorporate the framework proposed by Desmedt et al. (2023). This framework, with its broadly defined facets, allows for the inclusion of a wide range of existing research and measurement tools, providing a comprehensive foundation for investigating interoception.

Conclusion

The aim of this study was to examine the relationship between feedback from wearable devices and perceived stress, the relationship between wearable devices and interoception, and whether interoceptive attention and sensing moderated the relationship between wearable feedback and perceived stress. The findings revealed no significant effects for the hypothesized relationships. Specifically, feedback from wearable devices did not significantly influence perceived stress, nor did it affect interoception. Furthermore, interoceptive attention and sensing did not moderate the relationship between wearable feedback and perceived stress. However, there was some evidence suggesting a link between increased interoceptive attention and sensing, and higher levels of momentary perceived stress.

The results highlight the need for further investigation. Future research should consider incorporating stress-inducing tasks into experimental designs to better capture the impact of wearable feedback under heightened stress conditions. Additionally, studies should explore the potential differences in how interoception affects momentary versus recalled perceived stress, offering a more nuanced understanding of the interaction between interoception and stress perception over time.

References

Can, Y., S., Gokay, D., Kılıç, D.,R., Ekiz, D., Chalabianloo, N., Ersoy, C. How Laboratory Experiments Can Be Exploited for Monitoring Stress in the Wild: A Bridge Between Laboratory and Daily Life. *Sensors, 20*(3). https://doi.org/10.3390/s20030838

Chalmers, T., Hickey, B. A., Newton, P., Lin, C. T., Sibbritt, D., McLachlan, C. S., Clifton-Bligh, R., Morley, J., & Lal, S. (2021). Stress Watch: The Use of Heart Rate and Heart Rate Variability to Detect Stress: A Pilot Study Using Smart Watch Wearables. *Sensors (Basel, Switzerland)*, *22*(1), 151. https://doi.org/10.3390/s22010151

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. Journal of health and social behavior, 24(4), 385–396.

Conner, T. S., & Barrett, L. F. (2012). Trends in ambulatory self-report: the role of momentary experience in psychosomatic medicine. *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

Desmedt, O., Luminet, O., Maurage, P., & Corneille, O. (2023). Discrepancies in the Definition and Measurement of Human Interoception: A Comprehensive Discussion and Suggested Ways Forward. Perspectives on Psychological Science, 0(0). https://doi.org/10.1177/17456916231191537

De Zambotti, M., Cellini, N., Goldstone, A., Colrain, I. M., & Baker, F. C. (2019). Wearable Sleep Technology in Clinical and Research Settings. *Medicine and science in sports and exercise*, *51*(7), 1538–1557. https://doi.org/10.1249/MSS.0000000000001947

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

Foerster, D. (2024). Sensing a Heartbeat: A New Perspective on Self-Tracking Technologies through the Integration of Interoception. *Body & Society*, *30*(2), 37-58. https://doi.org/10.1177/1357034X241245994

Gedam, S., & Paul, S. (2021). A review on mental stress detection using wearable sensors and machine learning techniques. *IEEE Access*, *9*, 84045–84066. https://doi.org/10.1109/access.2021.3085502

de Geus, E. J. C., & Gevonden, M. J. (2024). Acquisition and analysis of ambulatory autonomic nervous system data. In M. R. Mehl, M. Eid, C. Wrzus, G. M. Harari, & U. W. Ebner-Priemer (Eds.), *Mobile sensing in psychology: Methods and applications* (pp. 129–167). The Guilford Press.

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

Kahneman, D. (2011). *Thinking Fast and Slow*. Farrar, Straus and Giroux.

Kim, H. G., Cheon, E. J., Bai, D. S., Lee, Y. H., & Koo, B. H. (2018). Stress and Heart Rate Variability: A Meta-Analysis and Review of the Literature. *Psychiatry investigation*, *15*(3), 235–245. https://doi.org/10.30773/pi.2017.08.17

Lazarus R. S., Folkman S. (1984). Stress, Appraisal and Coping. Springer Publisher Company New York

Lee, E., H. (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

Masoumian Hosseini, M., Masoumian Hosseini, S. T., Qayumi, K., Hosseinzadeh, S., & Sajadi Tabar, S. S. (2023). Smartwatches in healthcare medicine: assistance and monitoring; a scoping review. *BMC medical informatics and decision making*, *23*(1), 248. https://doi.org/10.1186/s12911-023-02350-w

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

Price, C. J., & Hooven, C. (2018). Interoceptive Awareness Skills for Emotion Regulation: Theory and Approach of Mindful Awareness in Body-Oriented Therapy (MABT). *Frontiers in Psychology*, *9*. https://doi.org/10.3389/fpsyg.2018.00798

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

Schultchen, D., Bayer, J., Kühnel, J., Melchers, K. G., & Pollatos, O. (2019). Interoceptive accuracy is related to long-term stress via self-regulation. *Psychophysiology*, *56*(10), e13429. https://doi.org/10.1111/psyp.13429

Schulz, A., & Vögele, C. (2015). Interoception and stress. *Frontiers in psychology*, *6*, 993. https://doi.org/10.3389/fpsyg.2015.00993

Schulz, A., Schultchen, D., & Vögele, C. (2020). Interoception, stress, and physical symptoms in stress-associated diseases. *European Journal of Health Psychology, 27*(4), 132–153. https://doi.org/10.1027/2512-8442/a000063

Smith, E. N., Santoro, E., Moraveji, N., Susi, M., & Crum, A. J. (2019). Integrating wearables in stress management interventions: Promising evidence from a randomized trial. *International Journal of Stress Management*, *27*(2), 172–182. https://doi.org/10.1037/str0000137

Solano Durán, P., Morales, J. P., & Huepe, D. (2024). Interoceptive awareness in a clinical setting: the need to bring interoceptive perspectives into clinical evaluation. *Frontiers in psychology*, *15*, 1244701. https://doi.org/10.3389/fpsyg.2024.1244701

Statista. (2024). Wearables unit shipments worldwide from 2014 to 2028. https://www.statista.com/statistics/437871/wearables-worldwide-shipments/

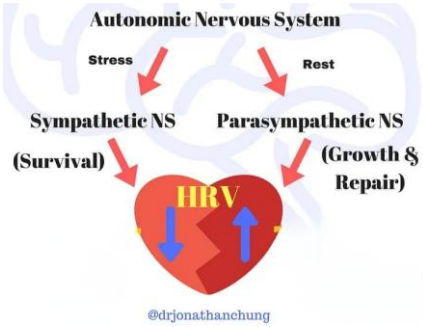
Zawadzki, M. J., Scott, S. B., Almeida, D. M., Lanza, S. T., Conroy, D. E., Sliwinski, M. J., Kim, J., Marcusson-Clavertz, D., Stawski, R. S., Green, P. M., Sciamanna, C. N., Johnson, J. A., & Smyth, J. M. (2019). Understanding stress reports in daily life: a coordinated analysis of factors associated with the frequency of reporting stress. *Journal of behavioral medicine*, *42*(3), 545–560. https://doi.org/10.1007/s10865-018-00008-x

Appendix A

Information Sheet Psychoeducation Group English Version

Study on Stress Wearables

Summary	We are using wrist-worn wearables to get insights into the influence of stress feedback on perceived stress, relaxation and level of interoceptive awareness (awareness of 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 your wrist 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 many other functionalities, such as a step counter or a fitness tracker. We'd like you to refrain from using these additional functions. When the wearable is close to running out of battery, please charge it using the charger. Further note that the wearable is waterproof.
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 bad stress and the wearable cannot measure that. If e wearable indicates for instance high stress it would 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:

f.dejong-4@student.utwente.nl

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

Appendix B

m-Path Questionnaires

Morning

How many hours did you sleep last night (approximately)? [time_sleep] - time

How did you sleep? [sleep] - sliderNegPos

Yesterday, I consumed: [substance] – multipleChoice

Options

1. Caffeine
2. Nicotin
3. Alcohol
4. Cannabis
5. Other drugs, namely
6. None of the above

Daily Core

At this moment my positive feelings are [affect_positive] - sliderNeutralPos

At this moment my negative feelings are [affect_negative] - sliderNeutralPos

At this moment I feel stressed [stressed] - sliderNeutralPos

At this moment I feel tense [stress_gespannen] - sliderNeutralPos

At this moment I feel energetic [energiek] - smiley

At this moment I'm feeling very relaxed [relaxation] - sliderNeutralPos

At this moment my heart is beating faster than usual [heartrate] - sliderNeutralPos

Since the last questionnaire I've noticed how my body changed when I got stressed [Interoception_perception] - sliderNeutralPos

Since the last questionnaire I've listened for information from my body about my stress level [Interoception_awareness] - sliderNeutralPos

Since the last survey, did your mind feel overloaded because of too much information? (e.g., feeling mentally overloaded during a conversation at home or work, while multitasking, etc.) [cognitive] - sliderNeutralPos

Evening

At this moment my positive feelings are [affect_positive] - sliderNeutralPos

At this moment my negative feelings are [affect_negative] - sliderNeutralPos

At this moment I feel stressed [stressed] - sliderNeutralPos

At this moment I feel tense [stress_gespannen] - sliderNeutralPos

At this moment I feel energetic [energiek] - smiley

At this moment I'm feeling very relaxed [relaxation] - sliderNeutralPos

At this moment my heart is beating faster than usual [heartrate] - sliderNeutralPos

Since the last questionnaire I've noticed how my body changed when I got stressed [interoception_perception] - sliderNeutralPos

Since the last questionnaire I've listened for information from my body about my stress level [interoception_awareness] - sliderNeutralPos

Since the last survey, did your mind feel overloaded because of too much information? (e.g., feeling mentally overloaded during a conversation at home or work, while multitasking, etc.) [cognitive] - sliderNeutralPos

How was your day? [day_valence] - sliderNeutralPos

How was your day? [day_stress] - sliderNeutralPos

Describe your day: What was the most unpleasant situation? Do you want to type or record this? [daynegative_input_decision] – multipleChoice

Type or Recording

Describe your day: What was the most unpleasant situation? (Also think about who you were with (first name and relationship to the person), where you were, and what you were doing) [daynegative_open] - open

What time was this situation approximately? [time_unpleasant] - time

How unpleasant was this situation? [unpleasantness] - sliderNeutralPos

How stressful was this situation? [stressful_unpleasant] - sliderNeutralPos

What have you done about this situation? [coping_unpl] – multipleChoice

Options

1. I have tried to think of a solution
2. I have worried about it or kep ruminating about it
3. I have tried not to think about it
4. I have tried to look at it from a more positive perspective
5. I have tried to accept it
6. I have told someone about it
7. I have expressed my feelings about it
8. I have tried to distract myself by doing something else
9. Other, namely...
10. I have not done anything

I felt like I had influence over this situation [invloed_negative_day] - sliderNeutralPos

This situation was unexpected [onverwacht_negative_day] - sliderNeutralPos

Describe your day: What was the most pleasant situation? Do you want to type or record this? [daypositive_input_decision] – multipleChoice

Type or recording

Describe your day: What was the most pleasant situation? (Also think about who you were with (first name and relationship to the person), where you were, and what you were doing) [daypositive_open

What time was this situation approximately? [time_pleasant] - time

How pleasant was this situation? [pleasantness] - sliderNeutralPos

How stressful was this situation? [stressful_pleasant] - sliderNeutralPos

What have you done about this situation? [coping_pl] – multipleChoice

Options

1. I have thought back on it positively
2. I have thought back on it negatively
3. I have tried not to think about it
4. I have told someone about it
5. I have expressed my feelings about it
6. I have tried to distract myself by doing something else
7. Other, namely...
8. I have not done anything

I felt like I had influence over this situation [invloed_positive_day] - sliderNeutralPos

This situation was unexpected [onverwacht_positive_day] - sliderNeutralPos

Today I felt physical discomfort (e.g. fatigue, flu, headache, backache, tinnitus, tension, hay fever, menstrual pain) [lichamelijkongemak] – yesno

What kind of physical discomfort (multiple complaints possible)? [lichamelijkongemak_what] - open

I suffered from these complaint(s) [lichamelijkongemak_last] - sliderNeutralPos

Today I felt that I had control over the important things in my life [PSS_1] - sliderNeutralPos

Today I felt confident that I could handle my problems [PSS_2] - sliderNeutralPos

Today I felt that things were going the way I wanted [PSS_3] - sliderNeutralPos

Today I felt that difficulties were piling up so high that I could no longer cope with them [PSS_4] - sliderNeutralPos

Did you experience anything else stressful today that you were unable to report? For example, because it was not an unpleasant or pleasant situation? [capture_all_stress] – open

Appendix C

Baseline Intake Questionnaire

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)

X→

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)	○	○	○	○	○
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)	○	○	○	○	○
Hoe vaak had je het gevoel dat moeilijkheden zich zo hoog opstapelden dat je ze niet kon	○	○	○	○	○

overwinnen?
(PSS-4_10)

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)	○	○	○	○	○
Het ervaren van stress bevordert mijn leren en groei. (SMM_2)	○	○	○	○	○
Het ervaren van stress put mijn	○	○	○	○	○

gezondheid en vitaliteit uit. (SMM_3)					
Het ervaren van stress verbetert mijn prestaties en productiviteit. (SMM_4)					
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 rus□g 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)							
Ik houd mijn emoties voor mezelf. (ERQ_2)	○	○	○	○	○	○	○
Wanneer ik minder negatieve emoties wil ervaren, dan verander ik datgene waar ik op dat moment aan denk. (ERQ_3)	○	○	○	○	○	○	○

Wanneer ik positieve emoties ervaar, dan zorg ik ervoor dat ik die niet tot uitdrukking breng. (ERQ_4)	○	○	○	○	○	○	○
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)	○	○	○	○	○	○	○
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)						
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)	○	○	○	○	○

Origineel is, met nieuwe ideeën komt (Personality_15_O)	○	○	○	○	○

End of Block: Personality

Appendix D

Follow-up Questionnaire Week 1

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)	○	○	○	○	○

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)	○	○	○	○	○
Hoe vaak had je het gevoel dat moeilijkheden zich zo hoog opstapelden dat je ze niet kon overwinnen? (PSS-4_10)	○	○	○	○	○

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)	○	○	○	○	○
Het ervaren van stress bevordert mijn leren en groei. (SMM_2)	○	○	○	○	○
Het ervaren van stress put mijn gezondheid en vitaliteit uit. (SMM_3)	○	○	○	○	○
Het ervaren van stress verbetert mijn	○	○	○	○	○

prestaties en productiviteit. (SMM_4)					
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

Appendix E

Follow-up Questionnaire Week 2

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)	○	○	○	○	○
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)					
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)					
Hoe vaak had je het gevoel dat moeilijkheden zich zo hoog opstapelden dat je ze niet kon overwinnen? (PSS-4_10)					

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)	○	○	○	○	○
Het ervaren van stress bevordert mijn leren en groei. (SMM_2)	○	○	○	○	○
Het ervaren van stress put mijn gezondheid en vitaliteit uit. (SMM_3)	○	○	○	○	○
Het ervaren van stress verbetert mijn prestaties en	○	○	○	○	○

productiviteit. (SMM_4)					
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: 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 rus□g 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: 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)							
Ik houd mijn emoties voor mezelf. (ERQ_2)	○	○	○	○	○	○	○
Wanneer ik minder negatieve emoties wil ervaren, dan verander ik datgene waar ik op dat moment aan denk. (ERQ_3)	○	○	○	○	○	○	○
Wanneer ik positieve emoties ervaar, dan zorg ik ervoor dat	○	○	○	○	○	○	○

ik die niet tot uitdrukking breng. (ERQ_4)							
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)	○	○	○	○	○	○	○
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)	○	○	○	○	○	○	○
Wanneer ik minder	○	○	○	○	○	○	○

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

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.

- ○ 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

Appendix F

AI Statement

During the prepara&on of this work the author(s) used CHATGPT for the purpose of:

• Brainstorming and ideation

• Developing and testing argumentation

• Summarising, clarifying or providing additional information on topics

• Copy-editingng, including minor revisions for conciseness and clarity of writing

• Receive feedback on the structure or flow of the text.

• Assist in programming and debugging Code in both Python and R (without using the actual data)

After using this tool/service, the author(s) reviewed and edited the
content as needed and take(s) full responsibility for the content of the work.”