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On the receptivity of employees to just-in-time self-tracking and eCoaching for stress management: a mixed-methods approach

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ABSTRACT

Smartphones are powerful tools for reaching the user when it is most needed, i.e. Just-In-Time (JIT). In the context of stress management in professionals, self-tracking can create awareness about stress and eCoaching can provide personalised JIT coping suggestions. Employees should also be receptive to take in or act upon the JIT-messages. Therefore, this study aims to explore what factors (emotional state, events or conditions, and content of the message) affect the employees' receptivity to JIT-messages. 17 participants were invited to use a prototype of the Resilience Navigator app for two weeks. The mixed-methods approach consisted of mixed effects models analysis on data collected via the app (receptivity and the factors of interest) and qualitative analysis on semi-structured interview data collected after the study period. The overall finding was that the participants' receptivity in the context of stress management often mismatches with the most relevant moments for JIT-messages. For example, emotions with a negative valence seemed to influence the receptivity towards JIT-messages negatively, although the perceived relevance was high. As technology can pinpoint the most receptive and relevant moment for sending JIT-messages, we advocate to further study this topic with more robust quantitative data.

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Just-in-time adaptive interventions; receptivity; self-tracking; eCoaching; stress management; convergent mixed-methods design

1. Introduction

Nowadays, 25% of the employees in Europe report to experience stress for all or most of their working time (Eurofound and EU-OSHA 2014). This has large negative consequences for the well-being of the employee but also for organisations and society. Stress is defined here as 'the psychological and physical state that results when the resources of the individual are not sufficient to cope with the demands and pressures of the situation' (Michie 2002). The European Compass for Action on Mental Health and Wellbeing advocates taking preventative measures to reduce stress (Cuijpers et al. 2016). An automated eHealth technology that focuses on improving the self-management of employees has the potential to reduce stress in the preventative phase (Lentferink et al. 2017; Van Gemert-Pijnen et al. 2018).

Two active ingredients to improve self-management via eHealth technology are self-tracking and automated eCoaching (Lentferink et al. 2017; Noorbergen et al. 2019). Self-tracking data of stress can provide the first step towards behaviour change, namely, awareness about the personal level and causes of stress. Subsequently, this continuous stream of self-tracking data can be used by the automated eCoach to send personalised suggestions with effective coping strategies. The sending of personalised suggestions based on the collected data via self-tracking comprises the automated eCoaching in this study. An important advantage of the combination of self-tracking and automated eCoaching is that it enables us to reach the user at any moment with any type of message, i.e. just-in-time (JIT). JIT is often described as providing the user with the right (number of) support at the right moment (Nahum-Shani et al. 2018).

Intervening at moments when it is most needed can have a positive effect on behaviour change as it can prevent the user from performing adverse health behaviour at an early stage (Nahum-Shani et al. 2018). An example of a JIT-message for stress-management is that an automated eCoach can suggest to say 'no' to a certain request

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from a colleague when a self-tracking device classifies a stress reaction as determined by, for example, a dramatic increase in heart rate without accompanying physical exertion (Nahum-Shani et al. 2018). The suggestion to perform an adaptive coping strategy (saying 'no'), can eliminate a dysfunctional stress reaction at an early stage and, therefore, disrupt the process towards a prolonged stress reaction and prevent stress from harming the employees' health and wellbeing (Nahum-Shani, Hekler, and Spruijt-Metz 2015; Nahum-Shani et al. 2018).

The sending of JIT-messages can be highly impactful (Hardeman et al. 2019) but it is only effective when someone is also receptive to the JIT-message (Nahum-Shani et al. 2018). Receptivity is a related concept that anticipates a user's subjective overall reaction towards an interruption (Fischer et al. 2010). In this study, we are looking for the receptivity of the user to (1) take in the message or (2) act upon a request in the message. To our knowledge, little is known about the factors that determine the employee's receptivity to JIT-messages during their daily lives in the context of stress management. Previous work mainly focusses on the receptivity towards JIT messages among the general population (Noorbergen et al. 2019; Nahum-Shani et al. 2018; Fischer et al. 2010; Sano, Johns, and Czerwinski 2017). However, the disrupting of employees takes place in a specific context that may require a different approach. Bad timing among employees can reduce productivity and even increase stress and frustration (Sano, Johns, and Czerwinski 2017). The study of Sano and colleagues did focus on the receptivity of employees for eCoaching messages throughout the day and led to valuable suggestions for improvement. These suggestions are included in the section on possible influential factors on receptivity. However, the study of Sano et al. did not focus on the receptivity of self-tracking messages. Opportune timing for self-tracking messages could differ from opportune timing for automated eCoaching messages as different actions are requested from the user as follow-up (Lentferink et al. 2020). Also, Sano et al. focused on predicting the most opportune moments to send messages but it remains unknown how the predictors found in their study influenced the receptivity according to employees. To improve the uptake and impact of eHealth technology on stress management among employees, the present study aims to explore what factors, and how these factors, influence the receptivity of employees to just-in-time self-tracking and automated eCoaching for stress management.

Below, we describe the pathway towards prolonged stress to determine the most ideal situations to intervene just-in-time via self-tracking and automated eCoaching. The pathway includes the distal outcome, which is the ultimate goal of the application – the prevention of prolonged stress –, and proximal outcomes, which are the short-term goals of the application (Nahum-Shani, Hekler, and Spruijt-Metz 2015). Thereafter, we describe possible influential factors on the receptivity of employees to JIT-messages in the context of stress management based on our expectations and earlier research in other contexts.

1.1. Just-in-time self-tracking and eCoaching messages for stress management

A proximal outcome in the pathway towards prolonged stress, that can be used as a trigger for the sending of JIT-messages for self-tracking, is *emotional arousal*. Emotional arousal is one of the ways stress expresses itself. Arousal entails 'a state of heightened physiological activity' which, for example, includes an increased heart rate and a fast breathing pace' (Lazarus and Folkman 1987). Awareness of emotional arousal is a prerequisite for a person to activate themselves to do something about the situation (Lazarus and Folkman 1987; Mattila et al. 2007). Moreover, awareness of the emotional arousal due to a positive emotional valence is also of value as the experience of positive emotions enhances the ability of a person to be resilient in moments when a stressor is experienced (Ong et al. 2006). The employee's capacity for resilience entails 'the ability to bounce back after adversity' (Portzky et al. 2010). Besides, previously experienced positive emotions diminish the stress reaction, including the emotional arousal as a result of a stressor (Ong et al. 2006). Self-tracking via wearable devices can measure the physiological changes related to emotional arousal and notify the user when a change in, e.g. heart rate is detected (Myrtek, Aschenbrenner, and Brügner 2005). Once awareness about the emotional arousal is created, questions via ecological momentary assessment (EMA), i.e. assessing experiences in close occurrence to the event in the user's natural environment (Burke et al. 2017), can stimulate the person to perform reflection on the experienced emotional state and the cause of the emotion in order to understand what situations, conditions, or persons affect their emotional state.

After becoming aware of the emotional state and the cause of the emotion, the individual evaluates which coping strategies are available, the expected effectiveness of the coping strategy, and the perceived self-efficacy to perform the coping strategy (Lazarus and Folkman 1987). The decision process of choosing a coping strategy can result in the proximal outcome of *adaptive coping*. The moment when the user *decides upon a coping*

strategy can be used as a trigger for sending JIT-messages for eCoaching. An automated eCoach can stimulate the choice for an adaptive coping strategy by sending personalised suggestions based on the input from self-tracking via the smartwatch and EMA questionnaire, which is the specific emotional state (positive or negative) and the cause of the emotion.

The sending of JIT-messages during high emotional arousal, for the awareness process, and during the decision for a coping strategy, to decrease the stress reaction, was supported by stakeholders participating in a needs assessment on self-tracking and eCoaching for stress management (Lentferink et al. 2020). This needs assessment led to the development of the Resilience Navigator application and is used in this study's set-up. The app is described in more detail in the Methods section.

1.2. Possible influential factors on receptivity among employees

To be able to effectively intervene, we need to know if the moments for JIT-messages based on the proximal outcomes also represent moments in which users are receptive to do something with the eHealth technology. A complicating factor in the process of stress management is that there may be a mismatch between the moment when intervening is most needed versus most wanted among individuals experiencing stress (Lentferink et al. 2020; Crane et al. 2019). Based on the earlier conducted needs assessment on self-tracking and automated eCoaching for stress prevention among employees (Lentferink et al. 2020), earlier research on the general population, not necessarily in the context of stress prevention, and the research done by Sano and colleagues (Sano, Johns, and Czerwinski 2017) on receptivity among employees, we identified three categories of possible influential factors, namely: (1) emotional state, (2) events or conditions, and (3) the content of the message. Earlier research on the general population is used here as the best alternative due to limited available research on the topic among employees.

On the one hand, the experience of an intense negative *emotion* indicates an 'unsafe' situation that interferes with personal goals and values and requests action for change, thus the relevance of receiving an eCoaching message is high (Crane et al. 2019). At the same time, the negative emotion may lead to a limited cognitive capacity to pay attention to anything else than the negative emotional state (Fredrickson 2004, 2013).

Besides, certain events or conditions may affect the receptivity of employees. For example, JIT-messages could annoy stressed individuals as it distracts them from work (Sano, Johns, and Czerwinski 2017; Lentferink et al. 2020; Mehrotra et al. 2016). A scan of current literature found the following factors related to *events and conditions* as possible influential for the receptivity to JIT-messages: (1) the activity the user is involved in (Nahum-Shani et al. 2018; Fischer et al. 2010; Sano, Johns, and Czerwinski 2017; Mehrotra et al. 2016; Künzler, Kramer, and Kowatsch 2017; Mark et al. 2016), (2) the time of the day, for example during natural breaks (Fischer et al. 2010; Sano, Johns, and Czerwinski 2017; Künzler, Kramer, and Kowatsch 2017; Mark et al. 2016; Ahtinen et al. 2013), and (3) the number of earlier received messages during the day (Nahum-Shani et al. 2018; Sano, Johns, and Czerwinski 2017; Künzler, Kramer, and Kowatsch 2017).

In addition, factors that concern the *content of the message* have been found to influence the receptivity in other contexts, such as (4) the appeal of the message (Fischer et al. 2010), (5) the perceived relevance of the message (Fischer et al. 2010; Künzler, Kramer, and Kowatsch 2017; Mark et al. 2016; Petty and Cacioppo 1986), and (6) the amount of effort that is requested from the individual (Lentferink et al. 2020). Also, the different factors might interact. For example, when more effort is requested but the perceived relevance of the message is appropriate, the user might be receptive to act immediately upon the requested action in the message.

The receptiveness towards JIT-messages in the context of stress and among the population of employees is likely to be different because of intense emotional states during stressful events and the competition between demands from work and dealing with the stressful event. The objective of this study is to explore how employees react to JIT-messages in the context of stress to intervene as early as possible in the process of stress using the proximal outcome of emotional arousal and the moment of deciding upon coping strategies as triggers for the sending of JIT-messages. Answering the following research question can lead to implications for the future design of stress management apps for the working population: *How is the employee's receptivity to just-in-time messages for self-tracking and eCoaching affected by factors related to (1)* ***emotional states,*** *(2)* ***events or conditions****, and (3)* ***the content of the message*** *for stress management via a smartphone application?*

2. Methods

2.1. General procedure

The 17 participants were invited to use a simplified but working prototype of the Resilience Navigator app for

two weeks (described in more detail below). This prototype consists of two apps: (1) the Sense-IT app (Derks et al. 2017, 2019) for sending a signal via a smartwatch when changes in physiological parameters for emotional arousal are detected, and (2) the Incredible Intervention Machine (TIIM) app for collecting subjective measures of the emotions and causes of the emotions using EMA and sending personalised eCoaching messages. When participants received a signal from the Sense-IT app, they were triggered to fill in a short EMA questionnaire in the TIIM app asking about their emotional state (positive, neutral or negative) and the cause of the emotion. Based on this input, an eCoaching message was sent with a suggestion for a coping strategy. Besides, the TIIM app was used to collect additional measurements for research purposes (e.g. the factors of interest). After the two-week study period, participants were interviewed about their experiences regarding the ease of use of the Resilience Navigator app and their receptivity to JIT-messages, that is, to take in and act upon the JIT-messages for self-tracking and eCoaching.

A mixed-methods approach was applied to answer the research question. Quantitative data, collected via the TIIM app, enabled us to collect data on the constant changing state of the factors of interest in the natural environment of the employees. Qualitative data, collected via semi-structured interviews, enabled us to obtain an in-depth understanding of the user's experience concerning the receptivity towards the JIT-messages and factors affecting the receptivity. The qualitative data were seen as the main source of data to answer the research question as it provided us with a rich view on the topic and enabled us to study the experience on a more detailed level. Subsequently, the quantitative data was used to confirm and/or explain the findings from the qualitative data, making it a convergent mixed-methods design (Creswell and Clark 2017). The intent for this mixed-method design was 'to obtain different but complementary data on the same topic' (Morse 1991) in order to obtain a more complete understanding of the problem (Creswell and Clark 2017).

More information on how the Sense-IT and Resilience Navigator app are developed, by whom, and the rationale behind the apps according to the CONSORT e-Health reporting guidelines (Eysenbach 2011) can be found in Appendix 1. The TIIM app is not described in full detail as the app is used as a tool to build in the content of the Resilience Navigator app. In short, the TIIM app can be used to perform interventions and send questionnaires to a group of participants. The content of messages and questionnaires can be determined by the researchers and are sent to the smartphone of the participant on predefined moments. Notifications can be sent when messages are available. The TIIM app is developed by the Behavioural, Management and Social sciences Lab (BMS lab) from the University of Twente (BMS lab 2020). The applications and the content in the TIIM and Sense-IT app were frozen during the study period.

2.2. Resilience navigator app

The prototype version of the Resilience Navigator app was developed based on the results of previously conducted research (Lentferink et al. 2017, 2018, 2020) by some of the authors of this study (AL, HKE, HV, and LVG) during which we have followed the CeHRes roadmap (Centre for eHealth and Wellbeing research roadmap), a roadmap for the development of eHealth applications with a high focus on involving all important stakeholders and principles from business modelling (van Gemert-Pijnen et al. 2011). A prototype version was used as this study is part of the development process of the Resilience Navigator app. The central research question in this study came from the earlier conducted research and results on this question can lead to improvements for design and can increase chances for successful uptake and impact of the Resilience Navigator app. More information on the prototype version of the Resilience Navigator app can be found in Appendix 1.

In short, the Resilience Navigator app uses JIT-messages to activate the user to become aware of emotional arousal and causes of the emotion, via self – tracking, and provides personalised suggestions for a coping strategy, via eCoaching. See Figure 1 for a visual representation of the self-tracking (Sense-IT display on the smartwatch and EMA questionnaires via TIIM) and the eCoaching part (via TIIM) of the Resilience Navigator app. The Sense-IT collects heart rate measurements via a smartwatch, operable with all Android Wear 2.0 smartwatches. When a significant increase in heart rate is detected with respect to a personalised baseline, in the absence of vigorous physical activity of the subject, it is presumed that the increase in heart rate is associated more with emotional than physical arousal (Derks et al. 2019). This substantial heart rate change is the trigger to send a JIT-notification via vibrations by the smartwatch. The physiological measurement of emotional arousal should be combined with psychological measurements as emotions are expressed via physiological and psychological responses (De Witte, Buyck, and Van Daele 2019). Therefore, the user receives a pop-up from the Sense-IT to fill in an EMA questionnaire in the TIIM app to reflect upon

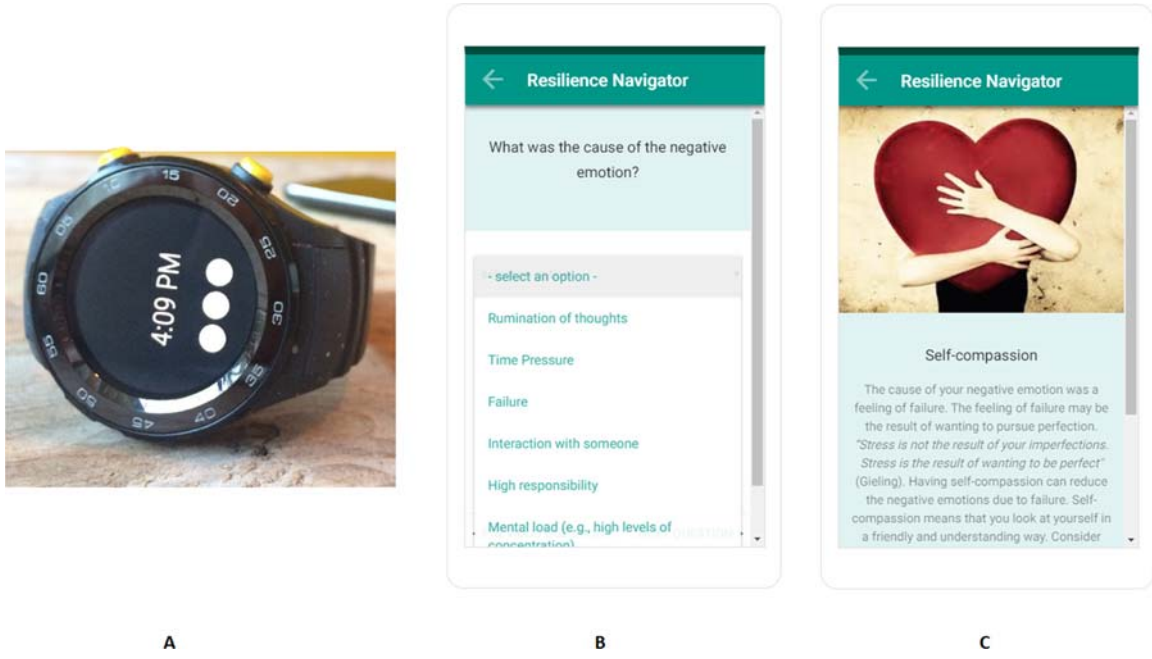

Figure 1. Self-tracking and eCoaching via the Resilience Navigator app.
Notes: self-tracking: (a) Sense-IT display on the smartwatch, and (b) EMA questionnaire via TIIM. eCoaching: (c) personalised eCoaching message via TIIM.

the emotional valence and subjective emotional arousal, based on the circumplex model of affect (Posner, Russell, and Peterson 2005), and cause of the emotion, including the following questions: (1) 'Do you experience a positive, neutral, or negative emotion?', (2) 'How strong is the emotion you are experiencing on a scale from 1 to 10?', and (3) 'What was the cause of the experienced emotion?' (drop-down menu). The latter two were only asked when a positive or negative emotional valence was reported. eCoaching messages consisted of sending out a personalised suggestion for a coping strategy based on the reported emotion and cause of the emotion, in the context of work or private life. A detailed description on the set-up of the notifications and the EMA questionnaires, based on the report checklist from Berkel and colleagues (2018), can found in Appendix 1 as well. The suggested coping strategies came from existing literature and therapies on stress management and resilience training (the positive psychology approach, time management, ACT, and CBT) (Butler et al. 2006; Covey 1989; Hayes et al. 2006; Seligman and Csikszentmihalyi 2014).

Participants could personalise the sending of JIT-notifications via the smartwatch to some extent. They could change settings in (1) sensitivity (low, normal, high), and (2) the interval in seconds for the comparison between the current heart rate and the personal baseline. This personalisation was added by the developers of the Sense-IT app to adjust the triggering of notifications that fits better with the user's perceived emotional arousal than the set values (Derks et al. 2019). The personal choices in settings also provided us with relevant information concerning the receptivity and was a topic during interviews.

2.3. Participants

Participants were recruited via the personal network of the research teams via flyers at the University of Twente and the Hanze University of Applied Sciences. We chose this sampling method based on our aim of the study, which is to explore the phenomenon of receptivity for triggers in order to integrate the findings into the design of the Resilience Navigator app (Onwuegbuzie and Collins 2007). Our aim is not to generalise findings to the full working population. Both the University of Twente and the Hanze University of Applied Sciences have about 3000 employees. The employees are working as a researcher and/or lecturer, or support staff. Their work activities consist mainly of intensive cognitive tasks or administrative tasks behind the computer, participating in meetings, and lecturing in front of small or large groups of students.

Eligible employees were (1) employees working most of their time behind a digital screen (e.g. more than 4 h during a working day of 8 h) to be able to have long stretches of time with limited physical exertion, and (2) employees who have affinity with using eHealth technology to involve only potential end-users. The University of Twente Ethics Committee BMS approved

the research set-up (application number: 17778). Participation in the study was voluntary.

2.4. Data collection

2.4.1. Before the start of the study

Before the start of the study, participants were invited for a one-on-one meeting with the researcher. They received information about the aim of the study, the storage of their collected personal data, how to use the apps and were asked to sign informed consent. The apps were downloaded on the personal device of the participant, or, when not in possession of an Android smartphone, on a borrowed device. The participants were instructed to wear the smartwatch with the Sense-IT application between waking up and going to sleep.

Via the TIIM app, participants were asked to fill in questions regarding demographic characteristics (gender, age, level of education) and three validated questionnaires, namely, (1) the perceived stress scale (PSS) (Cohen, Kamarck, and Mermelstein 1983; Korten et al. 2017; LASA 2018), (2) the brief resilience scale (BRS) (Portzky et al. 2010; Smith et al. 2008, 2013), and (3) the Toronto Alexithymia Scale (TAS) (Bagby, Parker, and Taylor 1994). Scores on the TAS provide information on how well users are able to recognise emotions and deal with emotions. Scores on these quistionnaires were used to gain insight into the characteristics of the study population.

2.4.2. During the study period

Following recommendations for studies involving EMA, a study period of two weeks was chosen (Van Berkel, Ferreira, and Kostakos 2018). During the study period, participants received questions via the TIIM app whenever they responded upon a JIT-message for self-tracking or eCoaching regarding (1) the receptivity and factors related to (2) emotional state, (3) events and conditions, and (4) the content of the message. Questions were set-up by the authors of this study and the full study set-up was tested, including clarity and ease of filling in the questionnaires, by two potential participants, leading towards small adjustments in the wording of the questions. Receptivity was measured by users scoring the receptivity on a scale 1–10 to fill in an EMA questionnaire after receiving a notification from the smartwatch and during the moment of processing the eCoaching message. Two factors were collected concerning *emotional state*: emotional valence (negative, neutral, positive) and emotional arousal (scale 1–10). Factors collected concerning *events and conditions* were: the activity the user was involved in just before filling in the EMA questionnaire or processing the eCoaching message (in key words), number of earlier filled in questionnaires or eCoaching messages per day (via log data), and time of day when the notification from the smartwatch or the eCoaching was processed (morning, afternoon, evening via log data). Additionally, for the receptivity to eCoaching, the following factors were collected related to the *content of the message*: requested effort (an action was requested or not), appeal of the message (scale 1–10), perceived relevance of the message (scale 1–10), and perceived effectiveness of the eCoaching message (improved wellbeing yes or no). See Table 1 for an overview of the collected variables. Moreover, to obtain an understanding about the experiences with the app, log data was used to calculate how many times participants completed the EMA questionnaire, completed eCoaching messages, and how many days users continued using the app (using unique dates from the received EMA questionnaires and completed eCoaching messages).

Table 1. Overview of the collected variables.

Variable	Measurement level
Receptivity	
Self-reported receptivity for self-tracking or eCoaching	Scale 1–10
Emotional status	
Emotional valence	Positive, Neutral, Negative
Emotional arousal (Total, Positive, Negative)	Scale 1–10
Events or conditions	
Activity	Report in keywords
Number of earlier questionnaires or eCoaching messages	Number per day
Time of day	Morning (0.00–11.59), Afternoon (12.00–17.59), Evening (18.00–23.59)
Content of the message (only for eCoaching)	
Effort	Yes or No
Appeal	Scale 1–10
Relevance	Scale 1–10
Effectiveness	Yes or No

2.4.3. After the study period – semi-structured interviews

Semi-structured interviews were conducted one on one by one interviewer (AL) to obtain more in-depth insights if and how factors were experienced as influential on the receptivity. In addition, citations of the respondents could reflect possible interactions between factors and their influence on the receptivity. The interview data in combination with the quantitative data revealed confirmation and explanations of the associations found.

Topics during the interviews included all factors for which quantitative data was collected (see Table 1). Moreover, topics included the perceived relevance and the requested effort to complete the EMA-

questionnaires and its effect on receptivity to JIT-messages. The factors *relevance* and *effort* in relation to the receptivity for self-tracking were only analysed via qualitative data. In addition, topics included the general experience regarding the use of the Resilience Navigator app (usability) and the experiences with the notifications for self-tracking and eCoaching during the day. These topics were included to relate the observed associations, from both qualitative and quantitative analysis, to the experiences with the app. Appendix 2 includes the full interview scheme. The interviews were audiotaped and recordings had a duration between 26 and 57 min.

2.5. Data analysis

2.5.1. Qualitative data analyses

All transcriptions were uploaded in the statistical software package for qualitative research Atlas.ti version 8 (Scientific Software Development GmbH, Berlin). A first version of the coding scheme was created using sensitising concepts from the literature on possible factors that could influence the receptivity of self-tracking and eCoaching, and open coding. The intercoder agreement was performed by two researchers (AL and MLN) via independently coding of two transcripts and discussing the disagreements in codings. This resulted in (1) joint refinement of the descriptions of codes to increase unambiguous interpretation of codes and (2) a simplification of the coding scheme as the level of detail in the coding scheme led to the missing of codings to quotations. During selective coding, important themes and subthemes were identified, special attention was placed on finding contradicting quotations, and we strived for the identification of relationships between themes (e.g. activity and relevance).

Table 2. Demographic characteristics.

Characteristic	Mean (SD)
Age	43.1 (7.9)
Perceived Stress Scale	11.1 (4.9)
Characteristic	*n* (%)
Gender	
Male	3 (17.6)
Female	14 (82.4)
Gender neutral	0
Level of education	
Low	0
Medium	1 (5.9)
High	16 (94.1)
Brief Resilience Scale	
Low	1 (5.9)
Medium	13 (76.5)
High	3 (17.6)
Toronto Alexithymia Scale	
Non-alexithymia	16 (94.1)
Possible alexithymia	1 (5.9)
Alexithymia	0

In addition, the reported activities they were involved in before responding upon JIT-messages in the TIIM app were analysed via open coding, leading to categories of activities. These activities represent moments after which users are receptive to act upon notifications for self-tracking or eCoaching.

2.5.2. Quantitative data analyses

All data from the TIIM app including the EMA-questionnaires and log data were transported into SPSS (IMB SPSS Statistics version 25). The TIIM app generated a personal identifier number per participant to anonymize the data. The personal identifier numbers are stored at the BMS lab server of the University of Twente and is certified with ISO 27001 and NEN 7510. Descriptive statistics were used to describe the demographic characteristics and to calculate mean scores on the PSS, BRS, and TAS. Repeated measures linear mixed effect models were used to study the associations between the factors and the perceived receptivity. This analysis method accounts for within-subject correlations and can deal with a different number of observations per participant (Twisk 2006). Compound symmetry was used for all models as this gave the best fit. Due to the small sample size, the restricted maximum likelihood procedure was chosen, and the statistical significance was set at a liberal $p < 0.10$.

2.5.3. Mixed-methods analyses

First, the two types of collected data were analysed separately. Then, the identified content areas from quantitative data were compared with the results from the qualitative data to identify discrepancies and similarities between the results of the two types of methods (Creswell and Clark 2017). This approach led to stronger evidence when, for example, a positive association was found between a positive emotional valence and receptivity in the quantitative analyses and this association was also described by participants during the interviews. Besides, it led to relevant implications for further research when the results of the two methods did not match.

3. Results

The 17 participants consisted of 14 females (82.4%), were on average 43.1 (SD 7.9) years old, and almost all had a high educational level (94.1%). PSS scores were on average 11.1 (SD 4.9). On the BRS, 76.5% of the participants had a medium score and 17.6% had a high score. One participant was categorised as 'possible alexithymia' based on the TAS-scores. See Table 2 for a

representation of the demographic characteristics of the study population.

3.1. General experience

Participants started using the app with a certain curiosity and interest in the app. Most participants reported that the self-tracking part of the app made them aware of their emotional state and half of the participants said the notifications triggered to self-regulate their emotions. The receiving of JIT-eCoaching messages was perceived as logical during a stressful situation and the messages reactivated their knowledge about stress management among half. 34% of the processed eCoaching messages (n = 85) were experienced as effective to improve their emotional wellbeing.

At a certain point, a sum-up of difficulties experienced with the early prototype version of the app affected their willingness to continue. An important difficulty was uncertainty if the smartwatch was still connected with the mobile phone and if the measurements were performed. This sometimes led to the missing of measurements over a certain period. In the end, participants used the app for a duration of 5.2 days (SD: 2.1) on average. Half of the participants adjusted the sensitivity and interval of the sending of notifications resulting in a decrease in notifications. Reasons to adjust the settings were that (1) the interval between two notifications was experienced as too short, or (2) the sensitivity for the detection of a change in emotional state did not match their perception.

> No matter how positive you are in it, if things don't go quite that easy, you quickly get the urge to think 'well, that's that. (employee #6)

3.2. Receptivity to just-in-time messages

The result section is structured as follows: Firstly, we describe the count of processed messages and the average perceived receptivity. Secondly, the results of the qualitative data are described separately for the receptivity to JIT self-tracking messages and receptivity to JIT eCoaching messages. These sub-paragraphs are structured according to the categories of factors: (1) emotional state, (2) events or conditions, and (3) content of the message. Then, the results are presented from the quantitative data analyses with a focus on the confirmation or explanation of the qualitative data. Appendix 3 includes an overview of factors that seemed to affect the receptivity to take in and act upon a message for self-tracking and eCoaching based on an integration of the qualitative and quantitative results, and how these factors seem to affect the receptivity based on the qualitative results. To provide a quick overview of the results, Figure 2 includes a visual presentation of the factors affecting receptivity.

The 17 participants filled in a total of 196 questionnaires (3–42 questionnaires per participant) after receiving a notification from the smartwatch that a substantial heart rate change was detected. The daily average was 3.7 (SD: 2.9). The mean receptivity to self-tracking messages was 5.39 (SD: 2.42) on a scale from 1 to 10. In 54% of the received questionnaires, the filling in of the questionnaire was within 5 min after receiving a notification.

The participants processed a total of 85 eCoaching messages (0–18 per participant), of which 17 could not be linked to a questionnaire caused by a bug in the system sending an extra eCoaching message after completing the original eCoaching message. The daily average was 2.4 (SD: 1.2). The receptivity to eCoaching messages scored on average 5.69 (SD: 2.27) on a scale from 1 to 10. In 34% of the received eCoaching messages, participants dealt with the eCoaching message within 15 min after receiving a notification from the smartwatch (15 min was the longest duration of a suggested coping strategy).

3.3. Receptivity to JIT self-tracking messages (qualitative results)

3.3.1. Factors related to emotional states

Emotional valence: During the interviews, respondents mentioned they were more receptive towards a notification for self-tracking during a positive emotional valence in comparison to a negative emotional valence, although the necessity to fill in a questionnaire was perceived higher during a negative emotional valence. Their explanation for a better receptivity during a positive emotional valence was that positive emotions are more pleasant to reflect upon, while during a negative emotional valence there is no room to pay attention to anything else. Therefore, a certain time period between the emotion with a negative valance and the filling in of the questionnaire was believed beneficial by some participants for an effective reflection.

Emotional arousal: The few quotations on this topic indicated that the higher the emotional arousal, the more willing the users were to fill in an EMA questionnaire due to an increased perception of relevance.

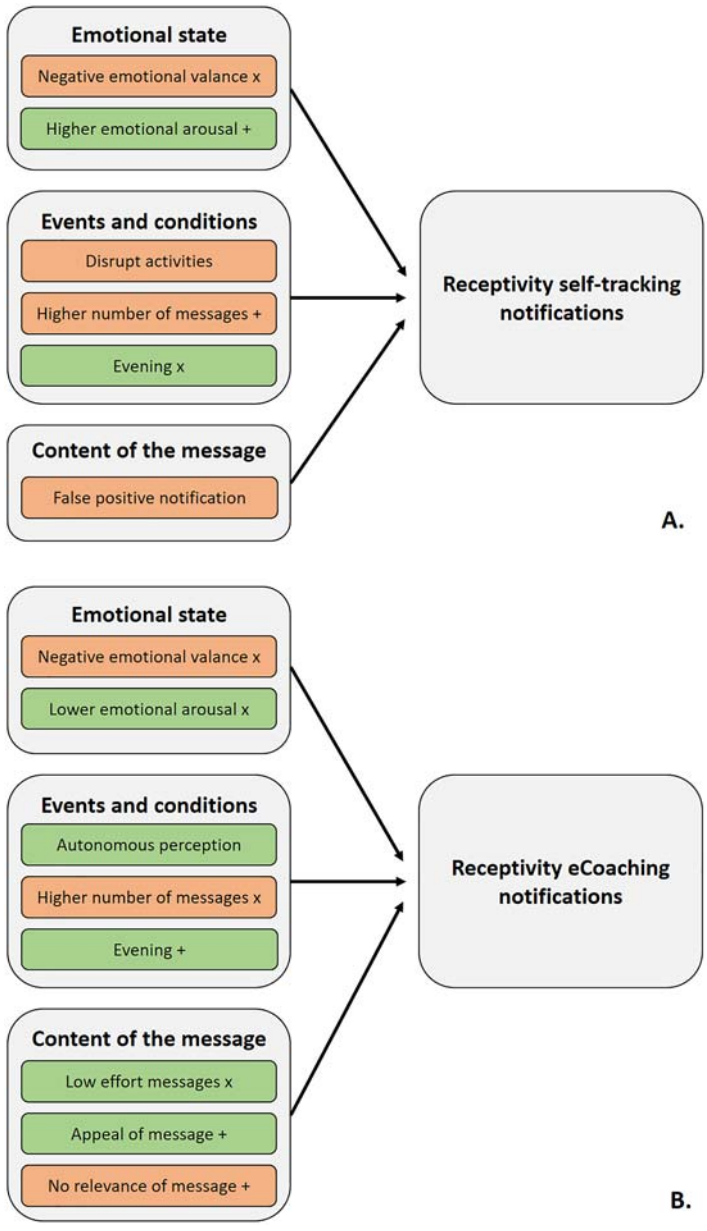

Figure 2. Visual presentation of the factors affecting the receptivity to self-tracking notifications (Figure 2a) and eCoaching notifications (Figure 2b).

Notes: The factors presented in the figure are based on the qualitative results. Orange: negative association. Green: positive association. The symbols indicate if the results are confirmed by the quantitative analysis. +: a significant association was found, x: no significant association was found. No symbol indicates that this factor was not analysed using quantitative data.

3.3.2. Factors related to events and conditions

Activity: The activity was an important topic of discussion. Two subtopics emerged from the data: internal locus of control (the user experiences control to decide that it is (not) convenient to interrupt the activity) and external locus of control (the user experiences no control as the user believes it is (not) accepted or (not) possible to interrupt the activity). During a state of *internal locus of control*, half of the users mentioned that they found it burdensome to interrupt the activity they were involved in to fill in the questionnaire, especially during tasks involving some level of concentration. However, as can be established from the self-reported activities by the user in the EMA-questionnaires, respondents were able to fill in a questionnaire after such a task. During a state of *external locus of control*, the notifications by the smartwatch were experienced by more than one third as a mandatory request to fill in the questionnaire and caused a negative initial response.

> Someone is interfering with my life. (employee #1)

A difficulty observed by participants was that days involving a lot of social interaction and a busy schedule increased the relevance to act upon the notification, as more emotions are expected during such days, but decreased the receptivity. For social interaction, one participant explicitly mentioned that paying attention to emotions would influence the work-related conversation in a negative way.

> Some aspects of the work affect me. And you do not want anyone else to see that it affects you because you actually want to stay neutral. (employee #7)

Number of messages per day: Half of the respondents said that their receptivity towards self-tracking messages decreased when the number of earlier filled-in questionnaires was higher. According to some respondents, the association between receptivity and number of received questionnaires can be negatively influenced by a shorter time period between the filling in of questionnaires due to higher chances that the notification relates to the same situation.

Time of the day: The evening and fixed times during the day were mentioned as the most convenient moments during the day to respond to notifications from the smartwatch. A certain time between the notification and the filling in of the questionnaire is mentioned by a few as beneficial for the reflective process due to having more time to overthink the situation. In addition, some respondents specifically mentioned that they did not mind being interrupted by the notifications from the smartwatch during the day.

3.3.3. Factors related to the content of the message

Effort: Opinions were somewhat divided about the effort that it took to fill in the questionnaire. Participants who found it effortful mentioned that the questionnaire could be made more user-friendly to fill in. Also, they mentioned that it required some time to overthink the situation. Of the respondents who found it quick and easy, half gave priority to the activity they were involved in. The actual number of questions to complete per notification did not seem important to the user as long as it was user-friendly and fitted into their schedule.

Relevance: When coherence was experienced between the notification and the emotion, they were more willing to respond upon a request to fill in the questionnaire. Fourteen out of seventeen respondents experienced a coherence between the notified heart rate changes and their emotional state at least once, of which twelve more than one time, and was experienced as very insightful. The coherence was most often experienced during a negative emotional valance. However, in the vast majority of situations participants did not experience a coherence between the notification and their emotions. Then, the notification was the result of physical activity or they had difficulties explaining the cause of the notification, which led to a feeling of worry among a few respondents. At first, the many false-positive notifications regularly created a feeling of annoyance. As the users' experiences with the app evolved, the false-positive notifications had a negative impact on the perceived level of relevance of the notifications and users tended to ignore the notifications resulting in the loss of its trigger function.

> That the same message has a different meaning is confusing and, I believe, that is why you subconsciously start to ignore it a bit, also because it just happens too often. (employee #17)

3.4. Receptivity to JIT eCoaching messages (qualitative results)

3.4.1. Factors related to emotional states

Emotional valence: Same as for the receptivity to self-tracking messages, many participants saw the dilemma that the receptivity towards an eCoaching message was better during a positive emotional valence, although the necessity was higher during a negative emotional valence. During the experience of negative emotions, the eCoaching message elicited sometimes a negative reaction, of which a few explained this by experiencing the eCoaching message as paternalistic.

> Are you really going to tell me what to do?! (employee #7)

Opinions were divided about the relevance of receiving an eCoaching message during a positive emotional valance. Again, a certain time period between emotions with negative valence and the eCoaching message was experienced as positive for the reflection process.

Emotional arousal: During a less intense emotion, respondents believed that they could better overthink how the eCoaching could be relevant for their specific situation as the eCoaching was experienced as rather general by one third.

3.4.2. Factors related to events and conditions

Activity: Participants found it important to choose autonomously when it is convenient to process the eCoaching message appropriately. Moreover, opinions were divided about what is more important in relation to the receptivity of the eCoaching message: the relevance or the activity. Three respondents believed that the relevance was more important:

> When the suggestion is relevant, you will follow-up. (employee #11)

Five others believed that the activity was more important.

> If it concerns a situation in which you try to catch the train, you are stressed because of a deadline, or you get annoyed by an e-mail. Whatever situation you can think of, those moments are often not the moments in which you think 'Let's do some eCoaching'! (employee #2)

Number of messages per day: A few respondents mentioned that the more eCoaching messages received, the less effort was spent in processing the eCoaching message.

Time of the day: The evening was mentioned as the most welcome moment to process an eCoaching message. Half of the respondents mentioned that eCoaching requires time and space to process which was not experienced in the daytime. The second-best option according to participants was on fixed moments during the day that are reserved beforehand.

3.4.3. Factors related to the content of the message

Effort: Participants reported that low effort eCoaching messages positively influences the receptivity to process eCoaching messages right away. When respondents chose to process the eCoaching right away, which often involved lack of time and space, they caught themselves processing the message less intensively.

Appeal: A few participants reported that when the eCoaching messages were appraised as appealing, the eCoaching message was processed in a better way and was remembered for a longer period.

Relevance: Negative responses towards the eCoaching messages occurred among three respondents during a mismatch between the suggested coping strategy and the cause of the emotion. Also, many respondents were already familiar with the content of most eCoaching messages. This provoked two types of reactions: (1) the participant experienced a lack of challenge which did not motivate them to act upon the eCoaching message; or (2) the participant experienced the eCoaching message as a refresher of their known coping strategies.

Effect: Some participants experienced the eCoaching messages as too general to be effective which affected their receptivity in a negative way. By contrast, a few other participants did believe that the eCoaching messages could be effective although this did not always lead to following-up the suggestion.

3.5. Receptivity to JIT self-tracking messages (quantitative results)

The results from the mixed effect models analyses for results on the receptivity to self-tracking messages can be found in Table 3.

A positive, significant association was found between the estimated marginal means for positive emotional arousal and the receptivity to self-tracking messages (both on a scale from 1 to 10) ($\beta = 0.49$, 90%CI: 0.15; 0.82, $p = 0.019$). This positive association was also observed for emotional arousal in general ($\beta = 0.40$, 90%CI: 0.16; 0.65, $p = 0.008$) but not for negative emotional arousal ($\beta = 0.41$, 90%CI: −0.08; 0.90, $p =$ 0.163). This is in line with the few comments made on the topic of emotional arousal during interviews,

Table 3. The influence of factors on the perceived receptivity to self-tracking messages.

		Receptivity to filling in a questionnaire (scale 1–10)	
Determinant	*N*	*β* (90%CI)	*P*-value
Total	196		
Emotional valence	190		
Positive	67	.60 (−.16; 1.36)	0.195
Neutral	85	.06 (−.66; .79)	0.883
Negative (ref.)	38		
Emotional arousal	104	.40 (.16; .65)	0.008
Emotional arousal positive valence	66	.49 (.15; .82)	0.019
Emotional arousal negative valance	38	.41 (−.08; .90)	0.163
Number of received questionnaires	196	.16 (−.03; .29)	0.047
Time of day	195		
Morning	76	−.15 (−1.07; .77)	0.789
Afternoon	97	−.22 (−1.11; .67)	0.680
Evening (ref.)	22		

Notes: *N* = number of responses to the notification send via the smartwatch from the participants in total. The results presented in this table represent single mixed effect model analysis per factor in relation to receptivity.

Table 4. The influence of factors on the perceived receptivity to eCoaching messages.

		Receptivity to eCoaching messages (scale 1–10)	
Determinant	*N*	*β* (90%CI)	*P*-value
Total	85		
Emotional valence	84		
Positive	36	.15 (−.86;1.16)	.807
Neutral	20	.57 (−.68;1.82)	.446
Negative (ref.)	28		
Emotional arousal	71	.10(−.21;.40)	.604
Emotional arousal positive valence	35	.61 (.05;1.17)	.075
Emotional arousal negative valence	28	−.33 (−.90;.24)	.333
Number of eCoaching messages	85	.40 (−.01;.81)	.111
Effort (yes vs. no)	85	−.31 (−1.21;0.59)	.569
Experienced effect (yes vs. no)	83	1.48 (.51;2.46)	.014
Appeal of the eCoaching messages	84	.36 (.13;.59)	.013
Relevance of eCoaching messages	84	.26 (.05;.48)	.047
Time of Day*	85		
Morning	33	−1.50 (−2.75; −.25)	.050
Afternoon	34	−.26 (−1.54;1.02)	.735
Evening (ref.)	18		

Notes: *N* = number of responses to the processed eCoaching messages from the participants in total. * = a significant difference was observed between morning (ref.) and afternoon ($\beta = 1.24$, 90%CI: 0.27; 2.21, $p = 0.036$). The results presented here represent single mixed effect model analysis per factor in relation to receptivity.

although no statements reflected that this accounted only for positive emotional arousal.

Moreover, a significant positive association was found between the number of received questionnaires and the scores on receptivity to self-tracking messages ($\beta = 0.16$, 90%CI: −0.03; 0.29, $p = 0.047$). This is not in line with the results from the qualitative data as a few participants mentioned that the higher the number of received questionnaires, the lower the receptivity. No other significant associations were found.

In line with answers given during the interviews, although non-significant, the evening obtained the highest estimated marginal mean for receptivity in comparison to the morning and afternoon. However, the evening was not the most frequent moment of the day to act upon the self-tracking questionnaires (afternoon ($n = 97$), morning ($n = 76$), evening ($n = 20$)).

3.6. Receptivity to JIT eCoaching messages (quantitative results)

The results from the mixed effect models analyses for results on receptivity to eCoaching messages can be found in Table 4.

A significant positive association was found between the receptivity to JIT eCoaching messages and the factors positive emotional arousal ($\beta = 0.61$, 90%CI: 0.05; 1.17, $p = 0.075$), experienced effect ($\beta = 1.48$, 90%CI: 0.51; 2.46, $p = 0.014$), appeal of the message ($\beta = 0.36$, 90%CI: 0.13; 0.59, $p = 0.013$), and relevance of the message ($\beta = 0.26$, 90%CI: 0.05; 0.48, $p = 0.047$) (all measured on a scale from 1 to 10 with exception of effect, which was measured dichotomously 'yes' or 'no'). From the above-described factors, quotations from participants reflected a positive association between receptivity and the factors 'relevance' and 'appeal'. Statements on emotional arousal are not fully in line as respondents mentioned the higher the arousal the lower the receptivity to process the message. In addition, no clear statements were made on the effectiveness of the eCoaching message and the receptivity.

In addition, a significant negative association was found for the receptivity to eCoaching messages during the evening in comparison to the morning ($\beta = -1.50$, 90%CI: −2.75; −.25, $p = 0.050$) and a positive association between the afternoon in comparison to the morning ($\beta = 1.24$, 90%CI: 0.27; 2.21, $p = 0.036$). From interviews, the evening was also mentioned as the most opportune moment to process an eCoaching message during the day. However, the least coaching messages were processed during the evening ($n = 18$) in comparison to the morning ($n = 33$) or afternoon ($n = 34$).

4. Discussion

This study's main aim was to explore how the employees' receptivity to JIT self-tracking and eCoaching messages in the context of stress management was affected by factors related to (1) emotional states, (2) events or conditions, and (3) the content of the message. Below we will discuss the most apparent results per category of factors.

4.1. Receptivity and emotional states

An important factor that seemed to affect the user's receptivity to both self-tracking and eCoaching negatively, is the presence of emotions with a negative valence. For self-tracking, users experienced a lack in the ability to pay attention to anything else than the emotion during a negative emotional valence. For eCoaching, the negative emotional valence can cause a negative initial response towards the eCoaching message. The participants believed that a decrease in the intensity of the negative emotional valance positively affects their ability to perform the reflection necessary for self-management via self-tracking and eCoaching. Although the receptivity appeared to be lower during a negative emotional valence in comparison to a positive emotional valence, the relevance for self-tracking and eCoaching was perceived higher.

From stress management literature, relevance is often mentioned as an important factor to activate the user in changing the situation (Crane et al. 2019; Gross 2015). An emotion with a negative valance indicates an 'unsafe' situation that interferes with personal goals and values and requests action for change (Crane et al. 2019). Two possible explanations were found in literature about why the relevance during a negative emotional valence was often not the dominant factor to beat low receptivity. First, according to Evers et al., emotions can bring about fast and unconscious autonomic responses, such as the initial negative response towards the notification, and/or slower and conscious reflective responses (Evers et al. 2014), such as evaluating if the emotional valence is intense enough to act upon (Gross 2015). For this study, the initial negative autonomic response may have overwhelmed the user too much in order to evaluate the relevance of the situation consciously (Evers et al. 2014) and can be related to the quotations from participants about not being able to pay attention to anything else then the emotional state. Moreover, acting just-in-time upon the slower and conscious reflective response may be more difficult for employees in comparison to the general population due to a lack of time and space during

the working day to perform reflection properly, experienced by this study's participants. Besides, the initial negative reaction can be advantageous, and is experienced as such by the participants in this study, as problem-solving abilities are negatively affected by emotions with a negative valence, and thus could result in the performance of maladaptive coping (Fredrickson 2004, 2013).

The second explanation is 'attention deployment' (Gross 2015). For example, after the user becomes consciously aware of the negative emotion, he/she chooses the coping strategy to suppress the negative emotion or reappraise the emotion later on. This can be an adaptive coping strategy, especially when the user consciously chooses to give priority to a more important goal to attain than to deal with the emotion in that specific situation (Gross 2015), which for employees might be completing a task. In such situations, employees can benefit from the acute stress reaction as it can bring about a higher level of concentration and focus (Michie 2002).

Contradictory in the results was that high emotional arousal seemed to affect the receptivity for JIT self-tracking messages positively and, although based on limited available data, affect the receptivity for JIT eCoaching messages negatively. This may be explained by the factor of relevance. Relevance was found in previous literature as an important factor for the receptivity of JIT messages (Noorbergen et al. 2019; Sano, Johns, and Czerwinski 2017; Mehrotra et al. 2016). Participants in this study perceived higher relevance of a JIT self-tracking message during high emotional arousal in comparison to low emotional arousal. In addition, one third of the participants experienced low relevance of the eCoaching messages as they were too generic. An in-depth reflection was necessary to find the added value of the eCoaching message for them personally. However, during high emotional arousal, participants were not able to search for this added value.

4.2. Receptivity and events or conditions

An autonomous perception was found an important factor in the receptivity towards self-tracking and eCoaching notifications. Without an autonomous perception to decide when to act upon the notification, the notification for self-tracking led to an initial negative response. Moreover, when employees felt forced to act upon the eCoaching message, they experienced difficulties to take in the eCoaching message appropriately and discover the added value of the eCoaching message. Although smartphones have high potential to stimulate the self-management of the user, and self-management is all about increasing the individual's autonomy, studies on user experiences regularly found a loss of the perception of autonomy during smartphone usage (Harmon and Mazmanian 2013). Lukoff and colleagues found that a loss of autonomy was especially experienced when the smartphone-activities were perceived aimless (Lukoff et al. 2018). It might be that the high number of false-positive notifications resulted in a perception that their attention was caught, i.e. attention theft (Wu T 2019), but that they did not get anything in return.

In addition, activities were a big topic of discussion during the interviews. A constant competition was observed between the perceived level of *relevance* to deal with the message and the *activity* the user was involved in. The activity often seemed to be the factor with priority. Different from our results, earlier research on the general population found relevance as more predictive for receptivity in comparison to the activity (Fischer et al. 2010; Mehrotra et al. 2016; Vastenburg, Keyson, and De Ridder 2004). A possible explanation for these differences in results can be that employees prioritise work-related activities over dealing with emotions (Sano, Johns, and Czerwinski 2017), as they appear to be more in line with their goals and values in the work context. One participant explicitly mentioned that dealing with emotions during work was perceived as dysfunctional. Sano and colleagues, who focused on the receptivity among employees, agree that the activity is an important factor for receptivity, especially when the activity is characterised by high levels of engagement and challenge (Sano, Johns, and Czerwinski 2017). This is consistent with our finding that disrupting activities requiring high concentration levels should be avoided. When someone is highly concentrated on a task, he or she might be more susceptible to notify the notification due to the alert state involving such tasks (Mehrotra et al. 2016). This disruption may lead to high levels of frustration (Mehrotra et al. 2016; Mark et al. 2016) as it interferes with their work-related goals (Crane et al. 2019).

As can be observed in the quantitative data, the least JIT-messages were processed during the evening although participants mentioned the evening as the most opportune moment during the day to act upon the self-tracking and eCoaching notifications. this discrepancy in results found in this study may be explained by measuring the concepts on different levels. That is, the qualitative result indicates a belief about the most opportune moment to act upon the message, whereas the quantitative result indicates the actual behaviour 'act upon the message' (Creswell and Clark 2017).

This indicates a gap between a perceived high state of receptivity and actually following-up the JIT-message and could be compared to the traditional gap between intention and real behaviour change (Sheeran and Webb 2016).

4.3. Receptivity and the content of the message

When a coherence was experienced between the notification via the smartwatch and an emotional state, the user was more receptive to self-tracking and eCoaching. However, the receptivity of the users to notice the notifications for self-tracking consciously was affected by the loss of relevance by the many false-positive notifications sent by the smartwatch. Explanations for this vigilance decrement in acting upon the notifications can be found in *the sensitivity hypothesis*, in which users are less likely to discriminate relevant and irrelevant notifications after a period of time as not all notifications from the smartwatch asked their follow-up, and *the arousal hypothesis*, in which the level of alertness of the user decreases due to perceptual habituation (Stone et al. 2017).

The perceived relevance and appeal of the eCoaching message were observed as factors that can positively influence the receptivity in this study and are in line with earlier research (Fischer et al. 2010; Mehrotra et al. 2016). From our results, the factors relevance and appeal positively influenced the receptivity to take in the message but did not have the upper hand in influencing the receptivity towards acting upon the message, based on the superiority of other factors observed in this study, such as the emotional valence or the activity the user is involved in.

4.4. Implications for future design

The results of this study provide many opportunities to improve the impact and uptake of eHealth technologies utilising JIT notifications for stress prevention. We will focus our implications for future design on the factors that seemed to be dominant in the receptivity for notifications among employees, which are: (1) the experience of negative emotional valence, (2) an autonomous perception when to take in and act upon the notifications, and (3) the activity the employee is involved in. With the widespread opportunities for data collection via sensors in smartphones, wearables, and home automation, it is possible to consider the associated factors with receptivity to self-tracking and eCoaching messages.

Firstly, to improve the ability of the employee to perform reflection and choose an adaptive coping strategy in close occurrence to the experience of an intense negative emotional valance (Fredrickson 2004, 2013), the current study results suggest to send a notification when heart rate has returned to baseline values (Gross 2015). Sending a notification when the intensity has diminished decreases the chance of initiating a negative initial response towards the notification (Evers et al. 2014) and improves the employee's cognitive capacity to perform reflection (Crane et al. 2019) while not postponing the notification too far away from the intense negative emotion and increase problems with recall.

Secondly, an autonomous perception when to take in and act upon the notifications could be increased by improving the perceived usefulness of the eHealth technology (Harmon and Mazmanian 2013; Lukoff et al. 2018). Perceived usefulness can be improved by decreasing the number of false-positives. For this study, the Sense-IT application was used to detect emotional arousal based on a substantial increase in heart rate without accompanying physical exertion. The many false-positive notifications can be explained by how, and how often the baseline of an individual was established. The Sense-IT is designed to be a platform that allows individual users to establish their own baseline with varying lengths and with different activities that are or are not part of the baseline. For example, one could decide to measure a baseline of 60 min that includes sitting, walking, working alone and having a team meeting. Alternatively, the baseline could be the same but without the (social) team meeting. These kinds of choices strongly influence the extent to which the Sense-IT will or will not trigger an individual in a variety of settings. In this study, we instructed participants to perform their baseline measure during a period in which they mostly performed tasks sitting behind a desk. This may have introduced many notifications during days that involved other work activities, such as team meetings or walking to appointments. Some of the false-positives might be eliminated by performing the baseline measure during a period that better matches the employee's daily work activities. Moreover, in the period that this study took place, the Sense-it application was working on improving the algorithm for sending JIT messages based on the physical activity the user was involved in, such as cycling or walking. Users could indicate when they not wished to receive notifications based on physical activity. As this was a new feature, the algorithm was not at its most optimal state of functioning in recognising these activities. Improving the algorithm for detecting physical activity may decrease the many false-positives.

Finally, a challenge for future design is dealing with the unwanted interruptions of activities. The design of the Resilience Navigator app is based on the principle

that by connecting the emotion to a specific situation, the user is able to identify the cause of the emotion, which will increase chances of choosing an adaptive coping strategy (Crane et al. 2019). A compromise might be to avoid the interruption of activities but still notify the user in close occurrence to the situation that caused the emotion. Various sensory data or other types of data can be connected to enable interrupting during the early stages of tasks, which was found a good predictor for appropriate timing of JIT messages (Sano, Johns, and Czerwinski 2017; Mehrotra et al. 2016), or postponing the notification after the completion of an activity. Examples are a connection with the outlook-schedule, for job-related tasks, or auditory data reflecting that the user is involved in a conversation and, thus, identify social interaction. Moreover, the employee can be interrupted when they open the door of their office (Künzler, Kramer, and Kowatsch 2017) or, for office workers, data can be used from their mouse and keyboard to indicate that he/she is in-between tasks (Sano, Johns, and Czerwinski 2017). These suggestions can also be a solution for the mismatch between low perceived receptivity to JIT-messages during days involving many social interactions and busy schedules, but high perceived relevance of reflecting on such moments.

4.5. Implications for future research

With the qualitative data as the main source for answering the research question, we were able to obtain a detailed view of the concept of receptivity and the factors affecting receptivity for JIT self-tracking and eCoaching messages among the population of employees in the context of stress prevention. However, the quantitative data fall short to confirm the findings and study the interaction between factors. Therefore, a general implication for future research is to apply more robust quantitative data collection and analysis. Such findings might fine-tune the sending of just-in-time messages and increase the effectiveness of JIT intervention designs. For example, via fractional factorial designs for the testing of multiple combinations of factors to find the most optimal condition (on an individual level) (Sieverink et al. 2018). Via fractional factorial design, we can test the effectiveness of the suggested implications for future design on receptivity in comparison to the original design used in this study:

(1) Unusually strong heart rate rises without accompanying physical exertion are detected vs. when heart rate is returned to the baseline heart rate.
(2) Fine-tuning the algorithm to detect physical activity vs. the original algorithm
(3) Using additional data to detect that the employee is just starting a new task or is in-between tasks (yes or no)

Next to fine-tuning the current algorithm, designing an appropriate and detailed usage protocol to set baseline values can diminish the false-positives and should be part of follow-up studies.

Besides testing the effectiveness of the implications for future design, it is worthwhile to further explore how and why certain factors affect receptivity among employees. Of special interest, future research can focus on finding stronger evidence that the receptivity is of higher importance during a negative emotional valence than the perceived relevance for self-tracking or eCoaching. This can be done by involving a higher number of subjects to improve quantitative data analysis and requesting a more in-depth reflection on this topic during interviews with employees using the Resilience Navigator app. Moreover, a higher number of subjects and subjects from different work settings can generalise the explorative results found in this study to the larger working population and will enable us to study the receptivity towards notifications in different work settings. The latter is relevant because it is likely to expect that the receptivity is different in other jobs as we found specific aspects of the job, such as activities, affecting the receptivity. Another topic of interest is to find an explanation for the discrepancy between qualitative and quantitative results on the evening as a convenient moment to follow-up JIT-messages by testing the concept on the same level with qualitative and quantitative data (Creswell and Clark 2017).

4.6. Strengths and limitations

A strength of this study was the mixed-methods set-up. The use of EMA questionnaires and log data relates to real-life experiences and limits problems with recall bias as they are collected in close occurrence to the related situation (Sieverink et al. 2018). The comparison between quantitative results and qualitative results enabled us to find confirmation for factors that affect the receptivity among employees. Also, the qualitative data was used to explain how these factors affect the receptivity according to employees. The latter revealed new insights in comparison to previous literature on the topic and these results enabled us to suggest concrete implications for future design to improve the impact of self-tracking and eCoaching notifications for stress management in the context of the workplace.

Firstly, our study was meant as an explorative study on how employees react to notifications in the workplace and stress management context. Our sampling

method was chosen based on this explorative nature (Onwuegbuzie and Collins 2007). Although explorative objectives are common in early-stage eHealth development (Burns 2018), we describe the sampling method's limitations for generalisation to the full working population as our study population was characterised by high educated female employees working in a scientific and educational work setting. On the one hand, some level of transferability of the results is expected as many jobs have similar characteristics in comparison to the scientific and educational work setting, such as activities involving high levels of concentration or presenting for large groups. The gender imbalance could have been the result of females being more likely to opt-in eHealth interventions (Tavares and Oliveira 2016), and, thus, reflects real-life situations. On the other hand, females have different biological responses to stress than male workers. It seems that males have higher acute activation of the sympathetic nervous system than females after exposure to a stressor (Verma, Balhara, and Gupta 2011), i.e. the acute emotional arousal is higher, which may affect the receptivity to notifications.

Secondly, we cannot make firm statements based on the quantitative results due to the relatively small number of observations for multilevel analysis and the skewed distribution of the number of observations per participant (Twisk 2006;Onwuegbuzie and Collins 2007)In addition, the interactions between factors could not be tested via quantitative analyses because of issues with power.

Thirdly, due to the use of the early prototype version of the app in this study, a lot of attention from participants was lost because of the experienced technical and usability difficulties. This resulted in none of the participants adhering to the intended use of interacting with the Resilience Navigator app during a period of 14 days. Although, it also revealed relevant results for the associations between factors and the impact on receptivity, such as the effect of many false-positives on the receptivity. The aspect of false-positives is likely to be present during the use of other consumer wearable technology, although to a lesser extent, as the validity is never 100% (Kooiman et al. 2015; Stahl et al. 2016).

Fourthly, to obtain results that closely match real-life use of the application, we instructed participants to act upon the notifications whenever they felt like doing so. This resulted in skewed distributions on the number of observations per participant and may have led to results on receptivity that are presented as too positive. Data on situations in which users did not act upon notifications might have provided more insights on the effect of factors during low receptivity. At the same time, these skewed distributions are proof that personalisation of the technology is needed. Besides, as both qualitative and quantitative data included results on low receptivity, the effect of this systematic bias may be limited.

Finally, one way or another, the collection of data on receptivity to eCoaching messages was never really satisfactory. The notification for eCoaching came after the user filled in the questionnaire. The fact that the user filled in a questionnaire was already a moment when they were receptive to the processing and acting upon the message. To ensure that we could perform an analysis between emotional state and the receptivity, we decided to collect data on receptivity during the moment the eCoaching message was processed instead of collecting data during the notification for eCoaching after the completing the self-tracking questionnaire (we did not have data on the emotional state during filling in of the self-tracking questionnaire). As one-third of the eCoaching messages were processed after a notification from the smartwatch, the quantitative results on associations between factors for eCoaching and receptivity could still reflect reliable results for JIT eCoaching.

5. Conclusion

With this study, we added knowledge to the existing literature on factors that affect the receptivity to JIT-messages. We focused on the receptivity towards JIT-messages for self-tracking and eCoaching in the context of stress management and the workplace. Results show that the receptivity in the context of stress management and the workplace requires special rules for the sending of JIT-messages. It seems that factors are often intervening with each other resulting in a clash between the most important moments to send JIT-messages and the highest receptivity to take in and act upon a JIT-message. In the context of stress management, in which emotional states are important triggers for JIT change, we observed that the detrimental effect of a negative emotional valence on receptivity seems more important than the experienced relevance during such an emotional state. Moreover, in the workplace, the goal of dealing with emotions obtains lower priority than a work-related goal, as the activity seems to be more dominant in relation to receptivity than the relevance to deal with the emotional state. In addition, findings indicate the importance of an autonomous experience in deciding when to process and/or act upon a JIT-message. As a final major finding, a loss of relevance due to many false-positives can lead to a loss of the original function of JIT self-tracking messages: creating awareness. As technology has high potential to pinpoint the exact moment when the user is both receptive towards a message and when a message is needed to be able to

intervene just-in-time, we advocate that this topic of study will be expanded more in future research.

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Disclosure statement

MLN, RK, and YD are involved in the development process of the Sense-it app. Moreover, AJL, HKE, HV, and LVGP were involved in the development process of the prototype of the Resilience Navigator app. The authors declare that their involvement in the development process did not influence the results of this study in any way.

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Appendices

Appendix 1. Sense-IT and Resilience Navigator app description according to CONSORT guidelines.

Sense-IT

Subitem CONSORT reporting eHealth guidelines (Derks et al. 2017)

i *Mention names, credential, affiliations of the developers, sponsors, and owners (if authors/evaluators are owners or developer of the software, this needs to be declared in a 'Conflict of interest' section).*

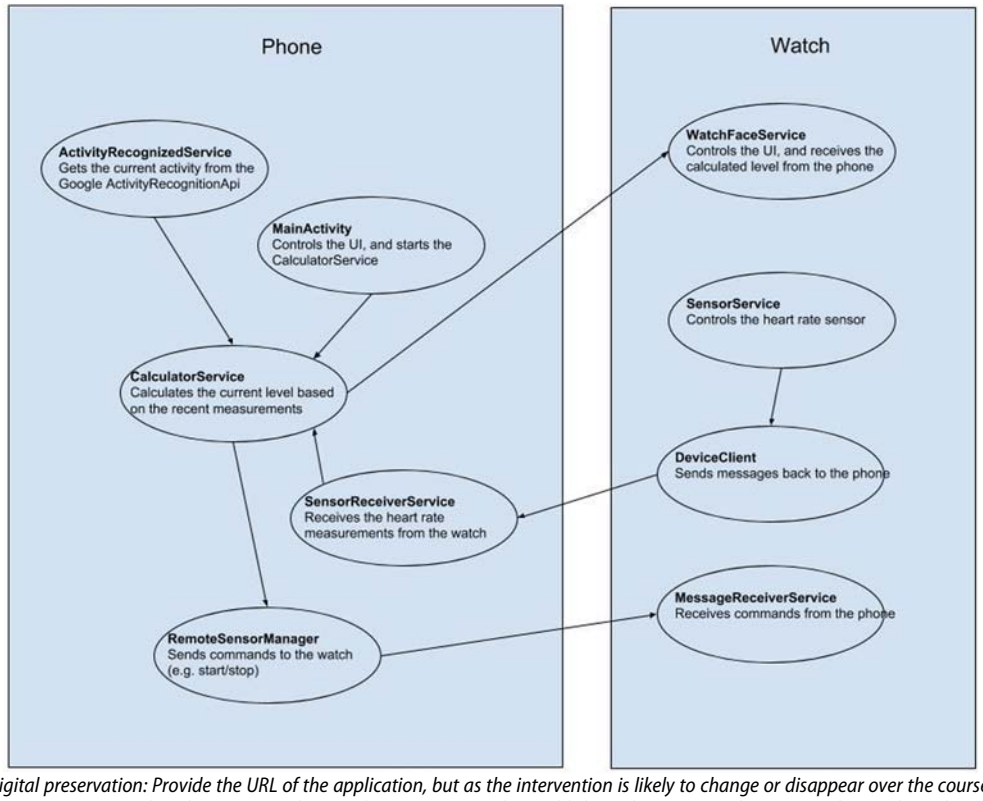
ii *Describe the history/development process of the application and previous formative evaluations (e.g. focus groups, usability testing), as these will have an impact on adoption/use rates and help with interpreting results.*The Sense-IT application is developed by following an iterative, co-creative user centred design method. This included a series of development and testing cycles with prospect users and experts: patients in mental health care, mental health care professionals, and researchers with an expertise in UXD. Main stakeholders were identified via after initial scoping research. Development continued with contextual inquiry, identification of values of main stakeholders and consequent specification of needs and requirements, and mental models of prospect users of the desired app structure and flow. For this purpose, a custom UX-framework was created in which two validated design frameworks were combined: the CeHRes Roadmap (van Gemert-Pijnen et al. 2011) and The Five Elements of UX by Garrett (2011). First prototypes were built on the basis of identified needs, requirements and mental models by patients and mental health care professionals. The framework was coined the Elements-Methods-Products (EMP) framework. Main methods employed were semi-structured interviews, use of paper prototypes, card sorting, personas, task scenarios, cognitive walkthroughs, a systems usability scale and real life prototype testing. The initial prototype was programmed and pilot tested with patients. Based on the findings from pilot testing, further iterative development followed in serial cycles with patients, mental health care professionals and UX experts. Two papers on the development process have been published in peer-reviewed journals (Derks et al. 2019; Derks et al. 2017).

iii *Revisions and updating. Clearly mention the date and/or version number of the application/intervention (and comparator, if applicable) evaluated, or describe whether the intervention underwent major changes during the evaluation process, or whether the development and/or content was 'frozen' during the trial. Describe dynamic components such as news feeds or changing content which may have an impact on the replicability of the intervention (for unexpected events see item 3b).*
In this study a stable version of Sense-IT applications (smartphone and smart watch, version April 2018) was used. The application and the content were frozen during the study. Both applications do not make use of dynamic components other than biofeedback related components.

iv *Provide information on quality assurance methods to ensure accuracy and quality of information provided, if applicable.*
We assured the quality of the application in the way the application is developed. The application is designed following the Model View Controller (MVC) design pattern. This decouples the major components; model – responsible for managing the data of the application and its intelligence, view – presentation of the model in a format, and control – responds to the user input and performs interactions on the data model objects. MVC makes it easier to adapt parts of the system without changing or affecting other parts of the application to increase stability.
The code of the application is reviewed and inspected by a colleague computer scientist from the University of Twente who was not involved in designing and developing the application. Several stress tests (Bluetooth connections, different hardware configurations and different versions of the Android OS) were performed with this version of the Sense-IT application by the different researcher involved in this research.

v Ensure replicability by publishing the source code (preferably as open source), and/or providing screenshots/screen-capture video, and/or providing flowcharts of the algorithms used.
Replicability (i.e. other researchers should in principle be able to replicate the study) is a hallmark of scientific reporting.
The source code is not open source yet, but access to the git repository is possible on request. Please find below a flowchart of the Sense-IT application.

vi



Digital preservation: Provide the URL of the application, but as the intervention is likely to change or disappear over the course of the years, also make sure the intervention is archived (Internet Archive, webcitation.org, and/or publishing the source code or screenshots/videos alongside the article). As pages behind

login screens cannot be archived, consider creating demo pages which are accessible without login.
The source code is available on a git repository and access can be given on request. The apk files are distributed by the researcher via email. Instructions for installation on smartphone and smart watch were given face-to-face.

vii *Access: Describe how participants accessed the application, in what setting/context, if they had to pay (or were paid) or not, whether they had to be a member of specific group. If known, describe how participants obtained 'access to the platform and Internet'. To ensure access for editors/reviewers/readers, consider providing a 'backdoor' login account or demo mode for reviewers/readers to explore the application (also important for archiving purposes, see vi)*.
Participants received written instructions after selection to participate in the study. The instructions contained URLs to download the application for the smartphone and smart watch. Installation instructions were given on paper. Participants could use their own Android smartphone and Android Wear OS smart watch. If participants did not have any of those devices, we provided the devices when needed.

viii *Describe mode of delivery, features/functionalities/components of the intervention and comparator, and the theoretical framework used to design them (instructional strategy, behaviour change techniques, persuasive features, etc., see e.g. for terminology). This includes an in-depth description of the content (including where it is coming from and who developed it), 'whether [and how] it is tailored to individual circumstances and allows users to track their progress and receive feedback'. This also includes a description of communication delivery channels and – if computer-mediated communication is a component – whether communication was synchronous or asynchronous. It also includes information on presentation strategies, including page design principles, average amount of text on pages, presence of hyperlinks to other resources etc*.
The Sense-IT application collects heart rate measurements via a smartwatch, compatible with all Android Wear 2.0 smartwatches. When a substantial increase in heart rate is detected with respect to a personalised baseline, in the absence of vigorous physical activity of the subject, it is presumed that the increase in heart rate is associated more with emotional than physical arousal (Derks et al. 2019) (inspired by the idea of Additional Heart Rate, Myrtek [Myrtek et al. 2000; Brouwer et al. 2018]). 'Substantial' is specified here as a set deviation from a user's personal average heart rate. The 'deviation' is customisable by the researcher/supervisor of the app, standard setting is one standard deviation from the personal average heart rate. The personal average heart rate is determined in a baseline measurement done before actual use (standard: 300 measurements over a period of approximately an hour). This substantial l heart rate change is the trigger to send a JIT-notification via vibrations via the smartwatch. Substantial heart rate changes are also stored and displayed in the smartphone application. A timeline with changes is available. By clicking on one of the events, users can add written text (e.g. personal notes) to this event.
Participants can personalise the sending of JIT-notifications via the smartwatch to some extent. They can change settings in (1) sensitivity (low, normal, high), and (2) the interval in seconds for the comparison between the current heart rate and the personal baseline. This personalisation was added by the developers of the Sense-IT app to adjust the triggering of notifications that fits better with the user's perceived emotional arousal then the set values (Derks et al. 2019). All communication between the application(s) and the user were digital and without interference of a human experiment leader.

ix *Describe use parameters (e.g. intended 'doses' and optimal timing for use). Clarify what instructions or recommendations were given to the user, for example, regarding timing, frequency, heaviness of use, if any, or was the intervention used ad libitum*
The Sense-IT application provides real-time biofeedback. Users were instructed to use and wear the application between waking up and going to sleep.

x *Clarify the level of human involvement (care providers or health professionals, also technical assistance) in the e-intervention or as co-intervention. Detail number and expertise of professionals involved, if any, as well as 'type of assistance offered, the timing and frequency of the support, how it is initiated, and the medium by which the assistance is delivered'. It may be necessary to distinguish between the level of human involvement required for the trial, and the level of human involvement required for a routine application outside of an RCT setting (discuss under item 21 – generalizability)*.
The experiment leader (AL) was only involved with the intake of the participant. The experiment leader and participant together installed the application on the smartphone and smart watch. Assistance was available on request during the experiment.

xi *Report any prompts/reminders used: Clarify if there were prompts (letters, emails, phone calls, SMS) to use the application, what triggered them, frequency, etc. It may be necessary to distinguish between the level of prompts/reminders required for the trial, and the level of prompts/reminders for a routine application outside of an RCT setting (discuss under item 21 – generalizability)*.
Prompts, or notifications were generated based on personal parameters (such as average heart rate and standard deviation) and the current heart rate. The algorithm constantly compares the current heart rate and the personal average. Substantial heart rate changes can trigger notification.

xii *Describe any co-interventions (including training/support): Clearly state any 'interventions that are provided in addition to the targeted eHealth intervention', as eHealth intervention may not be designed as standalone intervention. This includes training sessions and support. It may be necessary to distinguish between the level of training required for the trial, and the level of training for a routine application outside of an RCT setting (discuss under item 21 – generalizability)*.
The Sense-IT application was used in combination with the TIIM application to collect qualitative data

Resilience navigator app

Subitem CONSORT reporting eHealth guidelines (Derks et al. 2017)

i *Mention names, credential, affiliations of the developers, sponsors, and owners (if authors/evaluators are owners or developer of the software, this needs to be declared in a 'Conflict of interest' section)*.

ii *Describe the history/development process of the application and previous formative evaluations (e.g. focus groups, usability testing), as these will have an impact on adoption/use rates and help with interpreting results*.
The prototype version of the Resilience Navigator app is developed following the CeHRes Roadmap, a roadmap for the development of eHealth with a high focus on involving all important stakeholders and the principles from business modelling (van Gemert-Pijnen et al. 2011). Earlier research included a scoping review to identify critical success factors for self-tracking and persuasive eCoaching (Lentferink et al. 2017) and a needs assessment among employees and HR advisors by means of interviews (Lentferink et al. 2018) and focus groups among all identified key stakeholders using a business modelling approach (Lentferink et al. 2020). The identified key stakeholders were employees, employers, representative councils within organisations, HR advisors, product owners, company doctors and business analysts (Lentferink et al. 2020). This study is part of the design phase of the CeHRes Roadmap and includes testing a first prototype of the Resilience Navigator app using two existing apps: The Sense-IT app and the TIIM app. Results can lead to the revision of earlier identified values and requirements or the discovery of new values and requirements to improve the current design.

iii *Revisions and updating. Clearly mention the date and/or version number of the application/intervention (and comparator, if applicable) evaluated, or describe whether the intervention underwent major changes during the evaluation process, or whether the development and/or content was 'frozen' during the trial. Describe dynamic components such as news feeds or changing content which may have an impact on the replicability of the intervention*.
In this study, a first prototype of the Resilience Navigator app was tested (version April 2018). The Resilience Navigator app is in technical readiness level three 'Proof of concept' (European Commission 2019). The applications and the content in the TIIM and Sense-IT app were frozen during the study. The applications did not make use of dynamic components other than biofeedback related components from the Sense-IT app.

iv *Provide information on quality assurance methods to ensure accuracy and quality of information provided, if applicable*.
The Resilience Navigator app was pretested by two persons before the app was used in the study. This resulted in including an instruction to users that they only had to fill in a questionnaire when they believed that the signal by the Sense-IT app was the result of an emotion and not because of physical activity, due to the experience of the tester that many reminders were the result of physical activity. In addition, clear instructions were necessary why similar questions were asked during the self-tracking and eCoaching elements of the TIIM app for research purposes. Moreover, some adjustments were

made to the questions: (1) the question regarding the receptivity was not clear, and (2) open-ended questions were limited as the typing in of text was experienced as time-consuming in the TIIM app.
In addition, the developers of the Sense-IT app and the TIIM app were available for assistance during the experience of difficulties by the users of the apps.

v *Ensure replicability by publishing the source code (preferably as open source), and/or providing screenshots/screen-capture video, and/or providing flowcharts of the algorithms used.*
Replicability (i.e. other researchers should in principle be able to replicate the study) is a hallmark of scientific reporting.
The source code is not open source. The source code from the Sense-IT app can be accessed via a git repository on request. A demo-version of the app via the TIIM app can be accessed via https://app.tech4people-apps.bms.utwente.nl/preview/Mlb1t/1283.

vi *Digital preservation: Provide the URL of the application, but as the intervention is likely to change or disappear over the course of the years, also make sure the intervention is archived (Internet Archive, webcitation.org, and/or publishing the source code or screenshots/videos alongside the article). As pages behind login screens cannot be archived, consider creating demo pages which are accessible without login.*
The source code from Sense-IT is available on a git repository and access can be given on request. The apk files from the Sense-IT are distributed by the researcher via email. The webpage with the demo version of the Resilience Navigator app via the TIIM app is archived via http://archive.today/vPWl6.

vii *Access: Describe how participants accessed the application, in what setting/context, if they had to pay (or were paid) or not, whether they had to be a member of specific group. If known, describe how participants obtained 'access to the platform and Internet'. To ensure access for editors/reviewers/readers, consider providing a 'backdoor' login account or demo mode for reviewers/readers to explore the application (also important for archiving purposes, see vi).*
Participants from the University of Twente and the Hanze University of Applied Sciences could opt-in. They were recruited via flyers. Eligible employees were (1) employees working most of their time behind a digital screen (e.g. more than 4 h during a working day of 8 h) to be able to have long stretches of time with limited physical exertion, and (2) employees who have affinity with using eHealth technology to involve only potential end-users.
Participants received written instructions after selection to participate in the study. The instructions contained URLs to download the application for the smartphone and smart watch. Installation instructions were given on paper. Participants could use their own Android smartphone and Android Wear OS smart watch. If participants did not have any of those devices, we provided the devices when needed.

viii *Describe mode of delivery, features/functionalities/components of the intervention and comparator, and the theoretical framework used to design them (instructional strategy, behaviour change techniques, persuasive features, etc., see e.g. for terminology). This includes an in-depth description of the content (including where it is coming from and who developed it), 'whether [and how] it is tailored to individual circumstances and allows users to track their progress and receive feedback'. This also includes a description of communication delivery channels and – if computer-mediated communication is a component – whether communication was synchronous or asynchronous. It also includes information on presentation strategies, including page design principles, average amount of text on pages, presence of hyperlinks to other resources etc.*
The Resilience Navigator app is a prototype that consists of two apps: (1) the Sense-IT app and (2) the TIIM app. The Sense-IT app is described above and is used in its full form as designed by the developers of the Sense-IT app. As described, the content of the TIIM app can be adjusted by the designers. A concise description of the Resilience Navigator can be found in the method section of the article. Here we will describe some components of the app in more detail:
Participant could choose the cause of the emotion from a drop-down menu. This drop-down menu was the result of a scan of the literature and a discussion with two occupational psychologists who reviewed the list. The list of causes for positive emotions consisted of: pleasant working atmosphere, social interaction, receiving appreciation, enthusiastic about task, task completed, receiving help during task, personal growth/development, relaxing activity (including physical activity), pleasant moment in general, other (private cause), and other (work-related cause).
The list of causes for negative emotions consisted of: rumination of thoughts, time pressure, emotional burden, high cognitive load (e.g. high level of concentration), little control over work tasks, interaction with someone, not being able to say 'no', high responsibility, exciting activity, having no overview, failure, wrong balance work and private life, other (private cause), and other (work-related cause).
After the reporting of the cause of the emotion, a coaching message was send. In some situations, the coaching message matched with the cause of the emotion. Other coaching messages were randomly selected. This was done to collect data on the level of relevance. The personalised coaching message were expected to be of higher relevance than the non-personalised messages. The relevance was measured on a subjective level. The suggested coping strategies came from existing literature and therapies on stress management and resilience training (the positive psychology approach, time management, ACT, and CBT) [Butler et al. 2006; Covey 1989; Hayes et al. 2006; Seligman and Csikszentmihalyi 2014].**Examples of coaching messages**
Personalised (high cognitive workload):
'You were experiencing a negative emotion due to high cognitive workload. Did you know that we can best perform when we take a short break, 'a microbreak', after a period of 45 min high cognitive workload (Zacher et al. 2014)? Not taking microbreaks can have a negative impact on our energy level during the workday. Standing up to get a cup of coffee or have a quick chat with one of your colleagues helps you to reload for a new period of 45 min of high cognitive workload.
Exercise 'Microbreak'
Perhaps this is a moment to take a microbreak. Invest 90 s time in yourself multiples times per day and you will end the day with more vitality!'
Not personalised:
'During the self-measurement of emotions, you may have noticed that you often experience a negative emotion. That is not surprising, because we tend to notice negative emotions better than positive emotions. Positive emotions are often more subtle. However, experiencing positive emotions often can serve as a buffer during periods of when things are not going well for a while.
Exercise 'Pay more attention to positive emotions'
Try to be more alert for the experience of positive emotions and spend some more time noticing the positive feeling accompanying the little things in life, such as a ray of sunshine or a good cup of coffee or tea. Enjoy!'
EMA-questionnaires
Information on the EMA-questionnaires are based on the checklist provided in the article by Van Berkel and colleagues (Van Berkel, Ferreira, and Kostakos 2018):

- Inter-notification time: the standard setting for minimum time in-between two notifications for self-tracking was 20 s. Participants could adjust this to 60 s. In addition, participants were instructed to act upon one signal from the smartwatch per 15 min. This resulted in a minimum time-in-between two notifications for eCoaching of 15 min.
- Notification expiry: Notifications did not expire during the study period.
- Inquiry limit: No maximum number of notifications was established.
- Participants did not receive a reward for their participation.
- EMA question: See below.
- Rich media collection: The input from participants on the EMA questionnaires were text, yes/no answers or scores on scale.
- Validated questionnaire adaptation: EMA questions were not validated questionnaires. The EMA questions for emotions were based on the circumplex model of affect (Posner, Russell, and Peterson 2005), EMA questions for the causes of the emotions are described above, and the rest of the EMA questions did not have a basis in literature but were pretested with two study-subjects (see described below).

EMA questions self-tracking:

1. Did you experience a positive, neutral, or negative emotion during the signal from the smartwatch?

2. How strong was the experienced positive (or negative) emotion during the signal from the smartwatch? (scale 1–10)
3. What was the cause of the positive (or negative) emotion? (dropdown-menu)
4. How appropriate was the timing of the notification from the smartwatch to fill in a questionnaire? (scale 1–10)
5. What was the time of the signal from the smartwatch? (time 00:00)
6. What were you doing just before filling in this questionnaire? (text)

EMA questions eCoaching:

1. Did you opened up this coaching message directly after filling in the questionnaire? (yes/no)
   If yes, then the coaching message was revealed and after the processing of the coaching message, question 7 till 12 were asked.
2. Do you experience a positive, neutral, or negative emotion at this moment?
3. How strong is the experienced positive (or negative) emotion at this moment? (scale 1–10)
4. What were you doing just before opening the coaching message? (text)
5. Coaching message is shown (no input from user)
6. Possible suggestion is shown (no input from user)
7. To what extent did you find the coaching message appealing? (scale 1–10)
8. To what extent did you find the coaching message relevant?
9. How appropriate was the timing to process the coaching message at this moment? (scale 1–10)

Questions only asked when the coaching included a suggestions to follow-up:

1. Did you followed up the suggestion? (yes/no)
2. How appropriate was the timing of the coaching message to follow-up the coaching message? (scale 1–10)
3. Did the coaching message helped you to improve your emotional state? (yes/no)

ix *Describe use parameters (e.g. intended 'doses' and optimal timing for use). Clarify describe what instructions or recommendations were given to the user, for example, regarding timing, frequency, heaviness of use, if any, or was the intervention used ad libitum*
Participants were instructed to use the Sense-IT application between waking up and going to sleep. Whenever they received a prompt from the smartwatch, they were instructed to fill in a EMA-questionnaire for self-tracking. In addition, they were instructed to use the app whenever a coaching message became available.

x *Clarify the level of human involvement (care providers or health professionals, also technical assistance) in the e-intervention or as co-intervention. Detail number and expertise of professionals involved, if any, as well as 'type of assistance offered, the timing and frequency of the support, how it is initiated, and the medium by which the assistance is delivered'. It may be necessary to distinguish between the level of human involvement required for the trial, and the level of human involvement required for a routine application outside of an RCT setting (discuss under item 21 – generalizability).*
The experiment leader (AL) was only involved with the intake of the participant. The experiment leader and participant together installed the application on the smartphone and smart watch. In addition, participants received oral and written instructions from one of the researchers (AL) before using the app. The instructions included a description of the Resilience Navigator app, the installation of the apps (during the face-to-face meeting), to use the app between waking up and going to sleep, to interact with the app as they would normally interact with an app, and instruction were provided on possible difficulties when using the app. These included how to limit battery-use due to the apps, how to resolve the absence of notifications from the smartwatch, to fill in one questionnaire when multiple notifications were received during a period of 15 min, how to adjust the sensitivity when too many notifications were received, to only fill in a questionnaire when the notifications was the result of an emotion, instructions on similar questions during the coaching element in comparison to the self-tracking element, and what to do when no new questionnaires appeared in the TIIM app. Finally, instructions were given to fill in questionnaires whenever it suited them. If this meant that questionnaires had to be filled in at a later time, the could check the exact time of the moment the notifications from the Sense-IT was received and they were instructed to keep a note in the TIIM app about this specific time.
Assistance was available on request during the experiment by mail or phone by the experiment leader. The intervention was executed without human involvement.

xi *Report any prompts/reminders used: Clarify if there were prompts (letters, emails, phone calls, SMS) to use the application, what triggered them, frequency, etc. It may be necessary to distinguish between the level of prompts/reminders required for the trial, and the level of prompts/reminders for a routine application outside of an RCT setting (discuss under item 21 – generalizability).*
From the Sense-IT, users received reminders when a substantial increase in heart rate was detected. From the TIIM app, users received reminders whenever a coaching message was available. The coaching message became available after reporting a cause of a negative or positive emotion.

xii *Describe any co-interventions (including training/support): Clearly state any 'interventions that are provided in addition to the targeted eHealth intervention', as eHealth intervention may not be designed as standalone intervention. This includes training sessions and support. It may be necessary to distinguish between the level of training required for the trial, and the level of training for a routine application outside of an RCT setting (discuss under item 21 – generalizability).*
The prototype of the Resilience Navigator app consisted of The Sense-IT application in combination with the TIIM application.

Appendix 2. Interview scheme resilience navigator app

Topic	Questions
General experience	1. How long do you believe you would like to use the Resilience Navigator app? 2. Were there any specialties during the two-week study period that might have influenced usages? 3. Did you adjust settings in the Sense-IT?
Value of measurements with the Sense-IT app	1. How did you experience the association between heart rate measurements and the experienced emotions? Did this experience influence the usage of the app? 2. How did you experience the filling in of the questions after you received a signal that your heart rate was increased? a. To which extent did you find it relevant to reflect on the emotions and the causes of the emotions? b. Was that different during certain emotional statuses? c. Was that different during certain causes of emotions?

(*Continued*)

Continued.

Topic	Questions
	1. In case of delaying the filling in of the questionnaire, how difficult/or easy was it for you to recall the emotion that was experienced during the moment of the signal?
Effort self-tracking	1. How many questions were you prepared to answer after a signal that your heart rate was increased? How much time would you spend on filling in the questions? 2. How many times during a day were you willing to answer the questions?
Receptivity JIT self-tracking	1. What were convenient moments to fill in the questions after a signal from the smartwatch? a. During which activities did you find it most convenient to fill in questionnaires? b. During which hour of the day? 2. Did your emotional status influence your willingness to directly filling in the questionnaire after a signal? If yes, how did it influence your willingness? 3. What was the most positive aspect that you experienced due to the notifications from the smartwatch during the day? 4. What was the most negative aspect that you experienced due to the notifications from the smartwatch during the day? 5. Did the filling in of earlier questionnaires influence your willingness to fill in the next questionnaire after a signal? In what way?
Effort eCoaching	1. When exercises were suggested by the eCoach, how many minutes were you willing to spend on the performance of the exercise during the day?
Receptivity JIT eCoaching	1. During which moments were your willing to process an eCoaching message? a. During which activities did you find it most convenient to process an eCoaching message? b. During which hour of the day? 2. Did your emotional status influence your willingness to directly processing an eCoaching message? If yes, how did it influence your willingness? 3. What was the most positive aspect that you experienced due to the notifications with the eCoaching messages during the day? 4. What was the most negative aspect that you experienced due to the notifications with the eCoaching messages during the day? 5. Did the dose of previously processed eCoaching messages influence your willingness to process a new coaching message? In what way? 6. Did the level of relevance of the content of the message influence your receptivity to process an eCoaching message? In what way? 7. Did the level of appeal of the content of the message influence your receptivity to process an eCoaching message? In what way? 8. During which moments were you prepared to follow-up a suggestion? a. During which activities did you find it most convenient to act upon a suggestion? b. During which hour of the day? 9. Did your emotional status influence your willingness to directly act upon the suggestion in the eCoaching message? If yes, how did it influence your willingness? 10. Did the level of relevance of the suggestion influence your receptivity to act upon an eCoaching message? In what way? 11. Did the level of appeal of the suggestion influence your receptivity to act upon an eCoaching message? In what way? 12. Did the dose of earlier received suggestion influence your willingness to act upon an eCoaching message? In what way? 13. What was the most important reason to not act upon a suggestion?
Other	1. Are there any additional things that you noticed during the study period/you would like to discuss?

Appendix 3. Summary table of results

Factor	Self-tracking (indicated by a = quantitative data, b = qualitative data)	Grounded	eCoaching (indicated by a = quantitative data, b = qualitative data)	Grounded
Emotional valence				
Take-in the message	The receptivity towards the notification seems higher during a positive emotional valence in comparison to a negative emotional valence (a, b)	3	The receptivity towards the eCoaching message seems higher during a positive emotional valence in comparison to a negative emotional valence (b)	7
	During a negative emotional valence, there is no room to pay attention to anything else than the emotional state (b)	9	During a negative emotional valence, eCoaching messages may elicit a negative response (b)	6
	A positive emotional valence can initiate a positive initial response towards a notification as it is perceived as more pleasant to reflect on emotions with positive emotional valence (b)	2		
Act upon the message	Most relevant to overthink situations that involve emotions with negative emotional valence, followed by a positive emotional valence, and least relevant during a neutral emotional valence (b)		eCoaching messages were perceived most relevant during a negative emotional valence in comparison to a positive emotional valence (b)	5
	The time between the emotion and the filling in of the questionnaire is perceived as beneficial for the reflection process as the negative valence needs to diminish before experiencing the time and space to overthink the situation (b)	4	Opinions were divided about the relevance of an eCoaching message during a positive emotional valence (b)	
Emotional arousal				
Take-in the message			The receptivity towards an eCoaching message seems higher among emotions involving a higher positive emotional arousal (a*)	
Act upon the message	The receptivity to act upon the notification seems higher among emotion involving a higher (positive) emotional arousal (a*) due to a higher perceived level of relevance (b)	4	A certain time between the intense emotion is needed to better overthink how the rather general suggestion in the eCoaching message could be relevant for their specific situation (b)	6
Activity				
Take-in the message	In general, users did not perceive it as convenient to interrupt any activity to fill in a questionnaire (b)	8	Choose autonomously to process the message during a moment when there are time and space necessary to appropriately take-in the message (b)	7
	An autonomous perception to decide when to act upon the notification is necessary to avoid a negative initial response (b)	7		
	Users do not perceive it as convenient to interrupt activities that involve some level of concentration and might cause a negative initial response towards the notification (internal locus of control) (b)	4		
Act upon the message	Users believe that during social interaction, others do not find it acceptable that the activity will be interrupted for self-tracking (external locus of control) (b)	12		
	Users do not experience the ability to fill in a questionnaire during days characterised by a busy schedule (external locus of control) (b)	7		
Number of earlier messages				
Take-in the message			A higher number of earlier processed eCoaching messages decreases the effort spend in processing the message (b)	2
Act upon the message	Results were divided with the qualitative data reflecting a decrease in receptivity caused by a higher number of earlier filled in questionnaires (b) and the quantitative data reflecting an increase in receptivity caused by a higher number of earlier filled in questionnaires (a*).	7	Not perceived as relevant to receive eCoaching after every single emotional state (b)	3

(*Continued*)

Continued.

Factor	Self-tracking (indicated by a = quantitative data, b = qualitative data)	Grounded	eCoaching (indicated by a = quantitative data, b = qualitative data)	Grounded
	A higher number of earlier filled in questionnaires affected the effort the user spend in filling in the questionnaire (b)	2		
	A shorter period between the filling in of two questionnaires can negatively affect the receptivity towards self-tracking due to higher chances that it relates to the same situation (b)	4		
Time of the day				
Take-in the message			The processing of eCoaching messages requires time and space which was often not experienced in the daytime (b)	7
			Results on the best time of the day to process an eCoaching message were not decisive. The evening and afternoon scored significantly better on receptivity in comparison to the morning (a*), with the evening being mentioned as the most opportune moment during interviews (b). However, the evening was not the most frequent moment to process an eCoaching message.	9
			Fixed moments during the day were experienced as opportune moments to process eCoaching messages as respondents reserve time on forehand (b)	6
Act upon the message	Results are conflicting about the evening as the most receptive moment during the day to act upon a notification. During the evening the receptivity was higher in comparison to the morning or afternoon (a, b) due to having the time and space to overthink the situation and/or respondents liked to look back on how their day evolved (b). However, the evening was not the most frequent moment to act upon a notification (a).	5		
	Fixed moments during the day were perceived as opportune moments to act upon a notification because respondents can account for such moments on forehand (b).	5		
	A certain time between the notification and the filling in of the questionnaire was mentioned as beneficial for the reflective process due to having more time to overthink the situation (b).	2		
Effort				
Take-in the message	–		When participants processed the eCoaching message right away, involving a lack of time and space, they processed the message less intensively (b).	7
Act upon the message	Problems with the usability of the system made it more effortful to act upon the notification and affected the receptivity (b).	4	The less effort is required, the higher the chance to deal with the eCoaching message right away (b)	6
	It requires some time to overthink the situation (b).	4		
Appeal				
Take-in the message	–		The receptivity to eCoaching messages was better when users appraised the message as more appealing (a*,b)	3
			eCoaching messages that appealed to the user were remembered longer (b)	3
			eCoaching messages with a positive framing affected the receptivity positively (b)	4
Act upon the message	–			
Relevance				
Take-in the message	Many false-positive notifications can lead to ignorance of the notifications (b)	8	A mismatch between the coping strategy and the cause of the emotion evoked a negative initial response (b)	3
Act upon the message	Coherence experienced between heart rate and the emotional state increases the willingness to fill in a questionnaire because of the higher	8	The higher the perceived relevance of the eCoaching message, the higher the receptivity (a*)	

(*Continued*)

Continued.

Factor	Self-tracking (indicated by a = quantitative data, b = qualitative data)	Grounded	eCoaching (indicated by a = quantitative data, b = qualitative data)	Grounded
	perceived relevance of filling in a questionnaire (b)			
	When no coherence was experienced, the notification could be annoying (b)	7	When the eCoaching message is already known to the user, the participant experienced a lack of challenge which did not motivate them to act upon the eCoaching message (b)	5
	When no coherence was experienced, it was sometimes still perceived as relevant to overthink what is going on in the situation (b)	6	When the eCoaching message was already known, the participant experienced the eCoaching message as a refresher of their known coping strategies (b)	3
	When no coherence was experienced, it felt artificial to search for emotions as the additional heart rate was in essence caused by an increase in physical activity (b)	4		
	Repetition of filling in the same information for notifications related to similar situations affected their tolerance towards filling in the questionnaire (b)	5		
Effectiveness				
Take-in the message			Messages that were experienced as effective scored higher on receptivity than messages that were not experienced as effective (a*)	
			Some participants experienced the eCoaching messages as too general to be effective which affected their receptivity in a negative way (b).	4
Act upon the message			A few other participants did believe that the eCoaching messages could be effective although this did not always lead to following-up the suggestion (b).	2
Interactions between variables				
Activity vs. relevance	More relevant on days involving a lot of social interaction and a busy schedule although less receptive during such days. ***Activity is mentioned to be more important*** (b)	3	Opinions were divided about what factor was more decisive for the receptivity: the relevance of the eCoaching messages or the activity the user is involved in during the moment of the notification. Somewhat more participants gave priority to the activity instead of the relevance. Thus, **activity seems to be more important (b).**	3 relevance vs. 5 activity
Activity vs. effort	The activity the user was involved in was perceived as more important than the acceptable effort requested to fill in a questionnaire for self-tracking***Activity seems to be more important (b)***	3		
Relevance vs. emotional valence	Although relevance is perceived higher during a negative emotional valence in comparison to a positive emotional valence (b), the receptivity seems lower (a,b). ***Level of receptivity during emotional valence seems to be more important than the relevance (b)***	8 emotional valence vs. 5 relevance	Although relevance is perceived higher during a negative emotional valence in comparison to a positive emotional valence (b), the receptivity seems lower (b). The fact that the emotional state does not make them able to act upon the coaching properly, ***the level of receptivity due to the emotional valence seems to be more important (b).***	7 emotional valence vs. 5 relevance

Notes: a* = significant association between the receptivity and the factor of interest.