

INSTITUT FÜR INFORMATIK
der Ludwig-Maximilians-Universität München

IMPACT OF VISUAL FEEDBACK AND RECOMMENDATIONS ON STRESS AWARENESS AND COPING

Design, Implementation and
evaluation of the Stila web app

Kevin Hartwig

Master Thesis

Supervisor Prof. Dr. François Bry
Mentor Yingding Wang

Abgabe am 15. Juli 2021

Erklärung

Hiermit versichere ich, dass ich die vorliegende Arbeit selbständig verfasst habe und keine anderen als die angegebenen Hilfsmittel verwendet habe.

München, den 15. Juli 2021

Kevin Hartwig
11318950

Abstract

Stress is a global problem that affects more and more people. However, various studies show that stress is not solely negative but can also have positive effects. With an optimal stress level and awareness about the intensity and origin of stress, health and productivity can be improved. On the contrary, too much stress can trigger severe physical and mental illnesses, like depression, which frequently emerge in our contemporary society.

This master thesis aims to increase stress awareness among students and professionals by creating a web app that provides visual information about short and long-term stress levels. Additionally, recommendations in the web app are intended to support users in developing helpful stress coping strategies. Therefore, all recommendations were selected and formulated based on a literature review examining publications researching stress coping strategies. Furthermore, the web app's graphical user interface was developed following a user-centered design process and persuasive systems design guidelines to increase the persuasive effect of the web app.

A prestudy, which examined wireframes of the envisioned web app, was used to evaluate the navigation and arrangement of elements at an early stage. Subsequently, taking into account the findings from the prestudy, digital prototypes were developed from the wireframes, which served as the basis for implementing the web app. Finally, the web app was used and evaluated in a field study by students and professionals.

Zusammenfassung

Stress ist ein globales Problem, das immer mehr Menschen betrifft. Verschiedene Studien zeigen jedoch, dass Stress nicht ausschließlich negativ ist, sondern auch positive Auswirkungen haben kann. Mit einem optimalen Stresslevel und dem Bewusstsein über die Intensität und Herkunft von Stress können Gesundheit und Produktivität verbessert werden. Andererseits kann zu viel Stress schwere körperliche und psychische Erkrankungen, wie Depressionen, auslösen, die in unserer heutigen Gesellschaft häufig auftreten.

Diese Masterarbeit zielt darauf ab, das Stressbewusstsein von Studenten und Berufstätigen zu erhöhen, indem eine Web-App erstellt wird, die visuelle Informationen über kurz- und langfristige Stresslevel liefert. Zusätzlich sollen die Empfehlungen in der Web-App die Nutzerinnen und Nutzer bei der Entwicklung hilfreicher Stressbewältigungsstrategien unterstützen. Daher wurden alle Empfehlungen auf Basis einer Literaturrecherche ausgewählt und formuliert, die Publikationen zur Erforschung von Stressbewältigungsstrategien untersucht. Darüber hinaus wurde die grafische Benutzeroberfläche der Web-App nach einem nutzerzentrierten Designprozess und persuasiven Systemdesign-Richtlinien entwickelt, um die persuasive Wirkung der Web-App zu erhöhen.

In einer Vorstudie wurden Wireframes der angedachten Web-App untersucht, um die Navigation und Anordnung der Elemente frühzeitig zu evaluieren. Anschließend wurden unter Berücksichtigung der Erkenntnisse aus der Vorstudie aus den Wireframes digitale Prototypen entwickelt, die als Grundlage für die Umsetzung der Web-App dienten. Abschließend wurde die Web-App in einer Feldstudie von Studenten und Young Professionals genutzt und evaluiert.

Acknowledgments

First, I would like to thank Prof. Dr. François Bry, for giving me the opportunity to write this master thesis. He supported me with his indispensable expertise, which helped me take my work to a higher level.

I would also like to thank my mentor, Professor M. Sc. Inform. Yingding Wang. He provided helpful feedback to both my writing and programming during this thesis. Additionally, he was always available for regular meetings and to answer my questions.

Lastly I also want to thank all the participants of the user study, who showed great motivation and performed their tasks conscientious.

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1.1 Background

Stress is a significant problem in our whole society. However, students and professionals, in particular, are under constantly increasing pressure to deliver outstanding performance in their learning or work. Many of them already use fitness trackers or smartwatches to log daily activities and measure physiological data. These records, meaningfully aggregated and analyzed, can be useful in drawing attention to potential stressors and ensuring better management of stress. Since there is a lack of mobile applications doing precisely that, the *Stila* project was launched to provide students and professionals with an increased stress awareness and recommendations to improve their performance while learning or working. *Stila* is a research project of the Institute of Informatics at the Ludwig-Maximilian University of Munich. Currently, it offers a mobile application developed for Android that won the *Android Developer Challenge* by Google in 2020.

The app displays the user's stress-level scores and offers the possibility to enter activities throughout the day while assessing both mood and self-reported stress feelings. Therefore, heart rate data is recorded using a fitness tracker or smartwatch in a non-invasive way. *Stila* calculates the computed stress-level score using the heart rate variability, the variation of time between two consecutive heartbeats, in 10-minute time segments to determine whether the user is experiencing stress or not. Usually, a low heart rate variability indicates acute stress, while a high heart rate variability implies a low stress-level [34].

Since stress causes not solely adverse effects and should therefore not always be unconditionally prevented, it can be categorized into positive stress (eustress) and negative stress (distress). Eustress, for example, can drive people to increase their productivity or help in situations like presentations at work or exams at university, whereas negative stress leads to the opposite and can also trigger serious illnesses [33]. Therefore, *Stila* uses a classifier to distinguish between these two categories of stress. The user's heart rate variability is processed together with the user's assessed activities to train the classifier that divides the linked data into eustress and distress. With more and more data collected, the final goal is to enable the classifier to decide whether it was positive or negative stress without additional user input [12].

1.2 Motivation

Stress is considered to be one of the biggest global threats to people's mental and physical health [16]. Especially with the advent of the COVID-19 pandemic, this problem was further intensified as people are exposed to additional stressors. These can include the fear of becoming infected or suffering under the socio-economic consequences of the pandemic [36]. According to Lazarus and Folkman's Cognitive Stress Theory, a person may suffer mental and physical health problems if they negatively evaluate the stress that affects them and do not have adequate coping skills to alleviate their stress [18]. Stress can harm health directly or indirectly. The direct influence is caused by autonomic and neuroendocrine responses, while the indirect influence is through deteriorations in health behaviors, such as a decrease in health [24]. Demographic groups particularly affected are students and professionals. Mosley et al. [21] have found that students who feel the most stress have the highest levels of depression and most physical complaints. Constructive stress coping strategies are needed to prevent the harmful impacts of stress [32]. However, it can be challenging to convince people who already have stress coping strategies, that do not necessarily need to be constructive, to adopt other or new mechanisms [22]. In this respect, this master thesis is intended to suggest comprehensible and acceptable stress coping strategies that help reduce the users' stress levels in the long run to prevent the negative consequences of stress, including serious mental or physical illness.

In addition, this master thesis aims to increase users' stress awareness, as many students want to have a better overview of their health state, especially in terms of stress management [20]. Increased stress awareness can encourage people to reflect on their behavior and consider coping strategies by supporting the re-calling of experiences to identify stressors [22]. In a study by Sano et al., more than half of the participants found it helpful to have an increased stress awareness [31].

As part of this master's thesis, a web app was developed to increase the user's stress awareness by visualizing their stress data in a clear yet detailed manner. This kind of interaction turns the intangible stress measurements into tangible and modifiable subjects. In this way, the perception of the user's stress level is provided playfully. The web app was designed following principles for persuasive system design by Kukkonen to motivate the user in using the app often, as this should increase stress awareness more effectively [25]. This was done in a user-centered design process including a prestudy and following the golden rules of interface design by Shneiderman [35]. The web app offers the ability to monitor long-term stress levels, a timeline of the user's activities, and the possibility to compare computed stress data over weeks and months. The web app also provides its users with recommendations on mitigating stress to equip them with valuable stress coping strategies. The recommendations were selected after a literature review and are presented in the form of a recommendation board. The web app is written in Angular and uses the data provided by the existing Stila backend. Wireframes were evaluated in a prestudy to derive digital prototypes which were used as a basis for the implementation. Even if long-term overviews of data can be presented more easily on large displays, an essential part of the thesis was designing a responsive user interface since many users mainly or exclusively use mobile phones.

Several scientific papers and even more health apps deal with improving the user's health using non-invasive measurement technology. However, few of them focus on increasing stress awareness by visualizing measured physiological data or improving stress coping strategies, let alone a combination of both. Especially, there is limited literature exploring the effectiveness and acceptability of software for improving stress awareness.

2.1 Software Supporting Health Behavior Change

Researchers' interest in using technology, like smartphone apps, to present behavioral interventions in the health sector keeps increasing. Dennison et al. have found that certain principles should be followed in these interventions to promote regular and effective use. Key factors were, for example, the accuracy and legitimacy of data and their evaluation, the security of the user data, the effort required to obtain information, and the immediate impact of the application [7]. Especially security and privacy seem to be disregarded by many applications in the health area, although providers should pay more attention to this while dealing with these sensitive user data [27]. Furthermore, Gowin et al. found that users prefer health and fitness apps that are free, have an easy-to-understand user interface design, provide hints, and incorporate gamification. If apps meet these criteria, they can help maintain established behavior or support the adoption of new behavior [11]. Lee et al. studied increasing the motivation of regular fitness and diet app use. They found that activities and data have to be easily trackable, and the information offered must be reliable and comprehensive [19]. The social component of apps in this area is controversial. Some studies suggest that this has a valuable benefit [19], and some studies contradict this [11, 7].

2.2 Stress Awareness

Several studies regarding stress monitoring in controlled laboratory conditions were conducted, but there is a limited number of studies researching stress monitoring in daily life.

In a literature review, Can et al. examined studies that addressed stress detection under laboratory conditions and in everyday life. They found that there is a need for improvement in daily life stress detection, especially since the accuracy lags behind laboratory conditions [6]. Since there is a lack of studies researching stress detection in real life, and accuracy is not as high as desired, there are also not many studies that investigate how to visualize stress levels to increase stress awareness. Healey et al. measured and evaluated physiological data of drivers solving real world driving tasks to conclude on their stress level. They have found that stress is best measured with heart rate metrics and skin conductivity [13]. Boateng et al. visualized participants' stress levels in graphs after measuring them with unobtrusive wearables. Based on the participants' feedback, they concluded that there is interest in stress monitoring and that this form has the potential to be used [4].

2.3 Stress Coping

Zuckerman and Gagne made a distinction between adaptive and maladaptive coping strategies. While self-help, approach, and accommodation have a greater positive outcome and are thus adaptive coping strategies, self-punishment and avoidance are maladaptive strategies because of their more negative outcome [38]. Therefore, according to Zuckerman and Gagne, adaptive coping strategies should be part of recommendations for stress coping. There are even differences between genders, how stressors are evaluated and which coping strategies are used. Brougham et al. investigated the connection between different stressors, coping strategies and gender based on the use of the 5-factor revised COPE model. They found some support, that male college students have lower overall levels of stress than female college students and female college students use more emotional coping strategies like self-help and self-punishment. The other three coping strategies of the 5-factor revised COPE model are accommodation, approach and avoidance [5].

Stress coping strategies

Hatunoglu et al. found that participating in social events and maintain social contacts can be an effective coping strategy for students. Physical activity can also be a helpful way to reduce stress [37]. Although people often practice sports in larger groups or teams, it can also be done well alone or in pairs. Sano et al. found that participants favored physical exercise, breathing, and stretching among all recommendations and rated them as most effective in reducing stress [31]. Akçay et al. have studied how the outbreak of the corona pandemic affects stress levels for people in Turkey. They discovered that, especially among women and young adults, stress levels increased and physical activity decreased [2]. Additionally, mindfulness can play an important role while coping with stress. In conjunction with physical activity, yoga can be an effective strategy [29], but also simple meditation-based stress management can reduce stress [26]. Finally, the U.S. Department of Health & Human Services' Centers for Disease Control and Prevention recommends staying away from drugs and alcohol, eating healthy, and taking a break from the news when events cause stress, among other suggestions [10].

Studies of recommendation usage in stress management apps

Some of the above stress coping strategies have also been studied in the context of mobile applications. Paredes et al. investigated the potential of mobile applications as stress therapy. They found that users can be persuaded to adopt constructive coping strategies using machine learning algorithms in web apps. However, here the users were not shown their

actual stress data and these were not used for the selection of recommendations, but parameters such as the number of calendar entries or GPS data. [28].

A study combining recorded physiological data with advice against stress was conducted by Sano et al. However, the focus was not only on stress but also on sleep, diet, and exercise. They found that participants experiencing higher stress levels were more open-minded towards stress interventions and that tracking physiological data improved stress awareness [31].

2.4 Insights

Considering the related work, it becomes evident that few studies deal with app-based stress management and that this topic still requires much research. Additionally, none of the studies considered guidelines of user interface design and persuasive system design. Also, gamification in stress management apps was only examined by Hoffmann et al. [15]. Therefore, in the next chapter, *Theoretical frameworks*, the basics of user interface design, persuasive systems design, and gamification will be presented.

3.1 Persuasive Systems Design

In order to create impactful software that aims to change user behavior, persuasive system design principles must be followed in the development process. Therefore, Kukkonen et al. provided 28 design principles categorized into primary task, dialogue, system credibility, and social support categories. According to Kukkonen et al., a persuasive system can have three positive outcomes: reinforcement, change, or shaping. The first outcome, reinforcement, means that existing attributes or behaviors of users are reinforced against changes. The second one, change, refers to a change in problematic attributes or behaviors. Lastly, shaping means providing users with novel patterns for various situations. Shaping seems to have the best chance of success [25].

Analyzing the Persuasion Context

An important and inevitable step in developing a persuasive system is the analysis of the persuasion context. This includes capturing the intention of the persuasion, understanding the persuasion event, and defining the strategies used.

Users utilize software tools for different purposes, such as changing their daily behavior or other autogenous motivation. Persuasive software should include mechanisms that motivate users to long-term and regular use. Endogenous intention is originating from the producers, so it should be considered that the usage by users is on a voluntary basis. Finally, the sources of exogenous intention are the distributors of the technology. Here, functionality that allows users to personalize the assigned objectives is important.

In order to analyze the persuasion event, **use context** and **user context** must be analyzed. For this purpose, the characteristics of the problem domain must be explored first. Along with this, the goals of the users and their current state of progress must be analyzed. In addition, due to the constantly changing technology, the **technology context** should also be evaluated in order to identify opportunities and problems of new technologies.

Defining the persuasion strategies depends on the message and on the route. The message

has to be chosen carefully, since there is a fine line between persuasion and conviction. The route can either be direct or indirect. A direct route should be used, if the user is able to comprehend it. However, if the user is overwhelmed by an information overflow, an indirect route is the better choice. Nevertheless, the direct route seems to be the more lasting one. [25]

Designing the system features

With his functional triad and design principles, Fogg laid the foundation for the work of Kukkonen et al. [9]. However, he failed to define prerequisites for persuasive software, which is why Kukkonen et al. adopted and modified them to create a guideline for implementing these features. The principles in this guideline are divided into four categories.

The principles in the first category, *primary tasks*, cover the execution of the user's primary tasks. First of all, users have to be able to carry out complex tasks quickly and easily (*Reduction*). They also need to be guided on their way to their behavior change (*Tunneling*). Furthermore, the information a system provides to its users should be tailored to them (*Tailoring*) and even be personalized (*Personalization*). Users should also be able to check on the current progress they have made constantly (*Self-monitoring*). Last, providing simulations gives users additional motivation (*Simulation*) and a regular rehearsal of target behavior makes it easier for users to change it for real (*Rehearsal*).

The second category, *dialogue support*, covers principles about feedback to users. Firstly, a system should praise and reward its users for achievements to gain better persuasion (*Praise, Rewards*). Furthermore, users should constantly be reminded about their target behavior to make it easier for them to consolidate it (*Reminders*). The system should also provide relevant recommendations (*Suggestion*) and imitate its target group (*Similarity*). Finally, the software should be designed to the target groups liking (*Liking*) and offer a social component, e.g., in the form of a virtual assistant (*Social role*).

The credibility that users attribute to a system plays a significant role in the persuasive effect. For this reason, the third category, *system credibility*, includes principles that increase the system's credibility. A system should be perceived as trustworthy (*Trustworthiness*) and present information about the expertise with which it was built (y), e.g., by showing the people behind it (*Real-world feel*), preferably people with authority (*Authority*). This should all be apparent at first glance (*Surface credibility*). Additionally, the system should provide endorsements from third parties (*Third-party endorsements*) and an easy possibility to verify all of its content (*Verifiability*).

A social component can also help the persuasive effect. Therefore, Kukkonen et al. listed some principles under the category of *social support*. To make it easier for users to adopt a certain behavior, it can be helpful, to watch other people perform it (*Social learning*). It is also more motivating for users if they can compare their progress to other users (*Social comparison*) or see, that other users are on the same journey at the same time (*Social facilitation*). Furthermore, peer pressure can be used, to motivate users into perform target behaviors (*Normative influence*). Both working together (*Cooperation*) and competing with each other (*Competition*), can have a positive impact on the persuasive effect. Finally, systems should also promote public recognition for successful users (*Recognition*). [25]

3.2 User Interface Design

Designing user interfaces of software that are easy to use and learn is a non-trivial task. As technology is taking over more and more parts of our lives, humans and computers' interaction also gets more attention, resulting in the advent of the scientific field Human-Computer Interaction [8]. The following section covers guidelines and heuristics for creating easy to use user interface designs and gives an overview about the user centered design process.

3.2.1 Shneiderman's Eight Golden rules

With his golden rules, Shneiderman has developed eight key principles that should be followed when designing interactive systems to produce a user interface that is easy to use and quick to understand. The following list specifies Shneiderman's principles [35].

- **Strive for consistency.** It is essential to have consistent colors and elements, like fonts, throughout the whole design. Furthermore, in situations that are similar to each other, the same steps of actions should always have to be performed by the users. Variations in consistency should be used in a limited way and only to draw attention to something important.
- **Seek universal usability.** Since the demands on a user interface strongly depend on the user, the second principle requires that the design also offers functions for different user groups. Age differences of users should also be considered as well as disabilities, but also the different levels of experience. Beginners should thus be able to learn the interface quickly, and experienced users should be able to work productively.
- **Offer informative feedback.** Interactivity can be confusing or overwhelming for some users. The third principle requires that the interface provide feedback for each interaction that users perform. This feedback should be subtle for regular interactions but more noticeable for unusual interactions.
- **Design dialogs to yield closure.** Difficult or more complex sequences of actions should be grouped together and provide feedback at the end that they have been completed. Compliance with this fourth principle gives the user the satisfaction of having achieved something.
- **Prevent errors.** The fifth principle focuses on error prevention. The interface should not allow the user to make mistakes that have a significant impact. This is achieved by allowing the user to perform only those actions that are appropriate at the time.
- **Permit easy reversal of actions.** Referring to the previous principle, the sixth principle requires that any action taken by the user must be reversible. This ensures that the user can operate the interface confidently without fear of making mistakes.
- **Keep users in control.** The interface should be not only easy to use for beginners but also efficient to use for experts. The seventh principle requires the interface to stick to typical behavior, so experienced users feel in control.
- **Reduce short-term memory load.** Lastly, the interface should ensure that users do not have to keep too much information in their memory since the human capacity for information processing is limited. A screen must not require remembered information from a previous screen.

3.2.2 Nielsen's Usability Heuristics for User Interface Design

Nielsen has also established general principles to be followed in interaction design. He called them heuristics since they are not exact specifications but only general guidelines. These have some overlap with Shneiderman's eight golden rules but also provide additional information. The following table lists Nielsen's Heuristics.

- **Visibility of system status** The first heuristic claims that users should always be aware of what state the system is in. This helps users learn what consequences follow their interactions and thus plan their next steps.
- **Match between system and the real world** Concepts that are obvious to designers or developers can often be unclear to users. Therefore, according to the second heuristic, the system world should resemble the real world to enable users to create abstractions (natural mapping).
- **User control and freedom** The third heuristic overlaps with Shneiderman's sixth principle. It states that users must be able to undo any action they take to not get frustrated or stuck.
- **Consistency and standards** Jakob's Law states that users spend most of their digital usage in other apps or on other websites. Therefore, the fourth heuristic requires that the interface meets certain expectations that users already know from other products. If this is not followed, the cognitive load of the users could increase and thus overwhelm them.
- **Error prevention** The fifth heuristic overlaps with Shneiderman's fifth principle. Users should be prevented from making serious errors. These can, in general, only be committed if there is a mismatch between the mental model and the interface design.
- **Recognition rather than recall** Interfaces should promote recognition rather than recall, because users have a limited short-term memory. Every important information needs to be available at any time. This also overlaps with Shneiderman's last principle.
- **Flexibility and efficiency of use** The interaction with users should be tailored to their need. This is achieved by offering flexible interaction possibilities that can be personalized by users, e.g., with shortcuts.
- **Aesthetic and minimalist design** All elements in the interface should focus on supporting the users in achieving their primary goals. Therefore, the eighth heuristic states that interfaces should not show information or elements that are irrelevant.
- **Help users recognize, diagnose, and recover from errors** Many users are often overwhelmed by cryptic error messages containing only codes that they cannot understand. Following the ninth heuristic by Nielsen, error messages are always formulated so that all users understand them and find an easy way out of their situation.
- **Help and documentation** Lastly, even after implementing all the above mentioned heuristics, it can happen, that users come to a point, where they do not know what to do. For this case, according to the tenth heuristic, precise and brief documentation should be provided.

Nielsen's heuristics have existed more or less unchanged since 1994 and are often cited, applied and verified in user studies. Accordingly, they should form the basis for good interaction design. [23]

3.2.3 User-centered design process

Since the design of user interfaces is not a trivial task that often leaves users sitting frustrated in front of the final product, a user-centered design approach is often chosen to prevent this. There are many methods to accomplish a user-centered design process. However, the main concept is that the user is somehow involved in the design process rather than just seeing the final product.

Users are involved at an early design stage to evaluate interactions or layouts. This is done in an interactive iterative process that allows designers to have their designs evaluated without costly production of finished products and before it is too late. Therefore, paper prototypes or wireframes are often used for this purpose. This process enriches previous analyses and observations with information that would not have been obtainable without involving eventual users.

An essential step in the user-centered design process is the evaluation of user feedback. This provides information about how efficiently a design can be used, whether it satisfies the users and how easy it is to learn how to use it. After the evaluation, the designers should adapt their design accordingly and test it again in a user study until all deficiencies are eliminated. [1]

3.3 Gamification

Gamification refers to using game elements, like points, badges, or leaderboards, in contexts that have nothing to do with games, like education or health apps. It is used to increase users' motivation in different areas by using the motivational influence of games. Sailer et al. defined three main components that must be considered while using gamification in a non-game context. The first component is the person that is using the product. The gamification should always be targeted to the user. The second component is the product itself, which uses gamification and the evaluation, which motivation should be fostered. The third component is the context of the situation in which the gamification is used [30].

Sailer et al. also found that different game elements appeal to different motivational mechanisms. For example, *points* can be used to foster learning motivation, since they provide immediate positive reinforcement after completing a task. On the other hand, *Badges* can be used as virtual representations of achievements. They give users the feeling of having achieved a status symbol or of being competent. There are many more game elements that can be used, all addressing different motivational mechanisms. They can even change the motivational mechanism by being combined with one another. In summary, before using specific game elements, it should be evaluated in which context they will be used and which motivational mechanism should be addressed [30].

Hoffmann et al. studied the usage of gamification in stress management apps. They came to the conclusion, that as of right now, gamification is not used in stress management apps and the potential of using gamification in the context of behavior change theory has not yet been explored. However, they suggest that stress management apps should use gamification, since its positive effect on motivation and engagement [14]. They later confirmed their suggestion by conducting a study where they used gamification a stress management app [15].

This chapter covers the benchmarking, preparation, and evaluation of the prestudy conducted with wireframes derived from the previously discussed theoretical frameworks. It also presents the resulting digital prototypes and methods used to develop the web app. Furthermore, the recommendation board is discussed as well as the implementation of theoretical frameworks.

4.1 Benchmarking

Benchmarking is a method of improving a product by identifying the best industry practices of competitors [3]. This section covers the benchmarking of the most popular fitness and health apps that focus on users' awareness of their data. From this, best practices for designing functionalities and interfaces for (web) apps in this area will be derived. Since it is expected that a large proportion of users will use the Stila web app via a smartphone, not only classic web portals but also apps will be included in the benchmarking. This will help identify best practices for designing these kinds of applications for mobile devices. The review will cover the following areas: Functional scope, user interface design, and usability.

4.1.1 Analysis of existing web portals and apps

Fitbit web portal The web portal's dashboard (see Figure 4.1) is divided into numerous tiles, which each contain various user data (e.g., sleep, activities, and heart rate). When hovering some of the tiles, they reveal additional information. Users can also click on the tile to open an overlay that offers the possibility of accessing a detailed view or changing the settings for the tile's content. In addition to displaying the data, the Fitbit web portal provides some functionalities worth highlighting. First, users can show or hide selected tiles of the dashboard. Furthermore, the portal offers help for more complex tiles using a question mark icon that, when clicked on, opens a popup explaining the content or providing instructions on using the input fields. The portal does not provide support for use on mobile devices as the dashboard is not built responsive. For Fitbit users to view their data on mobile devices, they need to use the Fitbit app. Even though the design is very clear, some dashboard functionalities are hidden so that users cannot discover them at first glance.

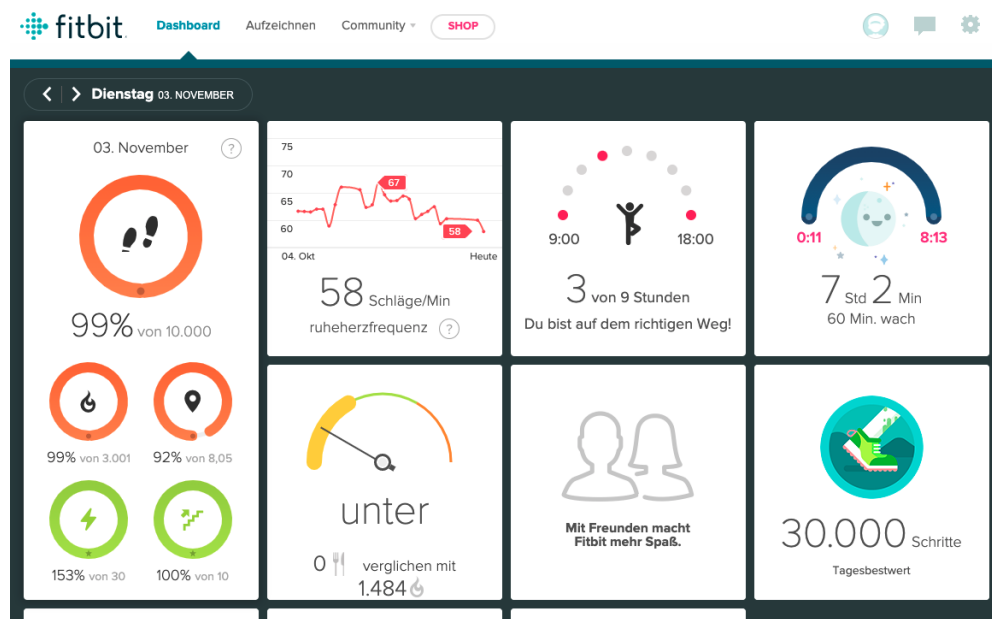


Abbildung 4.1: Fitbit web portal's dashboard

This concerns the additional information in the tiles, as well as the navigation to the detail pages.

Fitbit app In September 2020, Fitbit released a smartwatch that offers stress management tools via the Fitbit app. Using this smartwatch, the Fitbit app calculates a stress management index, which comprises various data recorded by the watch: Heart rate, heart rate variability, electrodermal activity, workout data, and sleep analysis data. Worth highlighting is the comprehensive information offered by the app to explain the individual values and the given advice for better stress management. Additionally, the app offers the possibility to create a mood diary to identify correlations between mood and the daily stress management index. Beyond stress management, the Fitbit app offers additional functionalities relevant for benchmarking in the field of fitness and health apps. For example, users can view their sleep data in detail in a chart that shows the course of sleep, depending on the phase, in different colors. The exact times of the sleep phases and explanations of the data shown are listed below the chart.

Apple Health Upon opening, the Apple Health app shows tiles containing data worth highlighting (e.g., an above-average number of steps) on the summary page (see Figure 4.2), which acts as the start screen. Below are the favorites: user-selectable tiles that display various information, such as sleep data or activity data. Users can click on a tile on the summary page to get a detailed view of the respective data. The data can be explored by day, week, month, or year. Worth highlighting are the understandable explanations that Apple includes with the charts to help the user interpret the data correctly.

Google Fit Google Fit is an app provided by Google to track and view health data like sleep data, steps, heart rate, blood pressure, and weight. The app uses sensors of smartphones or wearables to track the user's data. The app's main page shows a list containing the different categories of data with a link to a detail page. There the user can see a chart



Abbildung 4.2: Apple Health app

displaying a weekly overview with the respective data. By clicking on a corresponding day, the detailed view of the daily values opens dynamically. Users can also view the data in a monthly overview. The size and transparency of a colored dot in a calendar view indicate how many activities (e.g., steps) are available for the respective day.

Garmin Connect Garmin offers a comprehensive dashboard that has a recognizable structure. On the left side is the navigation bar, and on the right side, the tracked information is displayed in tiles (see Figure 4.3). The dashboard is customizable. Each tile can be shown, hidden, and repositioned individually. Also, the user can customize the level of detail of the information per tile. The dashboard is fully responsive. Depending on the display size, the arrangement of the tiles changes. If the display size falls below a certain value, the navigation bar is hidden and can be accessed by clicking on the menu icon. Garmin uses gamification. The user can earn numerous badges by solving tasks, such as tracking a certain number of activities in a given period of time. Overall, Garmin's dashboard looks cluttered since many tiles are to be seen at the beginning. The number of tiles can be adjusted and reduced, but the navigation bar cannot. It consists of 15 navigation points, some of which even can be expanded. Using the data that Garmin tracks with its wearables, a stress level is calculated as well. The recorded time is divided into four zones (rest, low, medium, high), and it is displayed how much time the user spent in which zone.

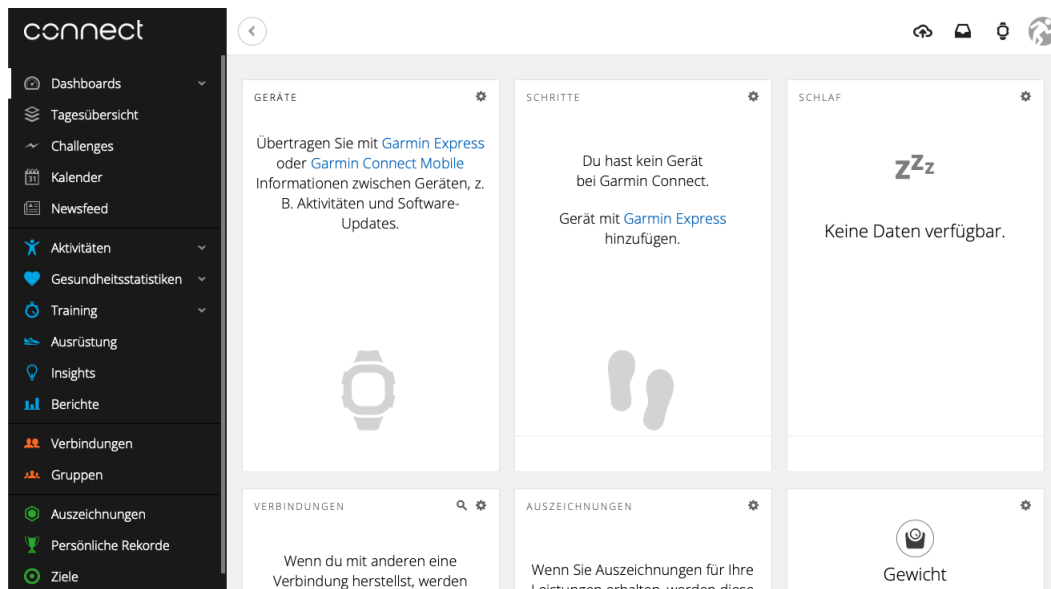


Abbildung 4.3: Garmin Connect

4.1.2 Required functionality

All of the reviewed web apps and smartphone apps use a dashboard as a home page to provide users with an overview of their data. Clicking on the corresponding tile or item in the navigation bar displays more details. A majority of apps, such as Apple and Fitbit, show users additional information to explain their data. This helps users understand how their data was calculated and how to interpret it. Also, many apps offer the setting to individualize the visualized data, for example, by showing and hiding tiles. The design is often kept very minimalistic so that users can quickly find their way around. Colors are usually only used as a means to highlight important aspects. The benchmarking also showed that a responsive design is indispensable today. Either there is no desktop version at all (Google Fit), the web app is fully responsive (Garmin), or if the web app is not responsive, a corresponding smartphone app is offered (Fitbit).

4.2 Prestudy with wireframes

After considering the related work, guidelines for persuasive system design and user interface design, and also benchmarking several health and fitness apps, the wireframes (see Figure 4.4) were designed. In a prestudy involving ten participants, the wireframes were evaluated. The prestudy's focus was on verifying and improving the navigation around the web app and the arrangement and proper sizing of the user interface elements. Evaluating the wireframes was also intended to collect ideas for additional features. As responsive web design is one of the main tasks of this thesis, the wireframes were created and examined in two screen sizes: desktop and mobile.

4.2.1 Structure of the Prestudy Prototype

To evaluate the wireframes in a prestudy, they were merged into an interactive and clickable prototype consisting of three screens. The entry screen is a **dashboard** (see Figure 4.4), which consists of a sidebar containing the navigation items and several tiles showing user

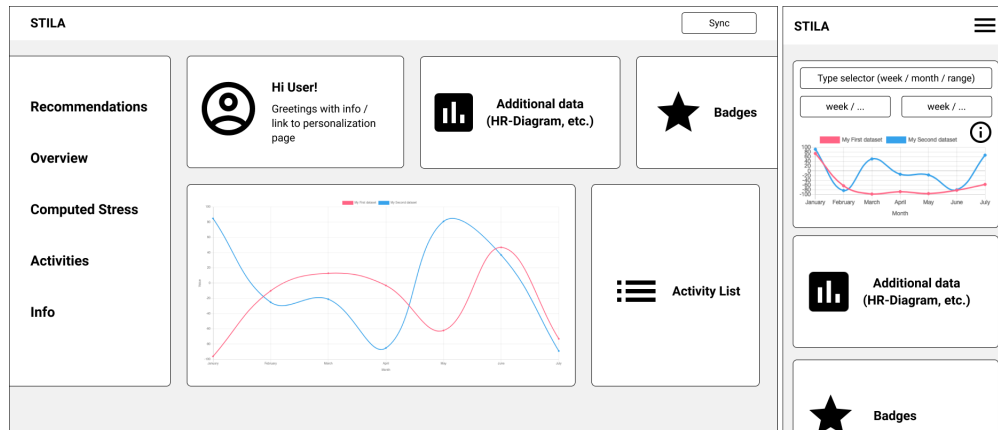


Abbildung 4.4: Wireframes for desktop and mobile screens showing the dashboard

data like current stress level or heart rate in graphs. The second screen, the **comparison screen**, presents the user's stress level graph with the ability to adjust the time periods of the displayed stress level and compare it to other time periods. The last page, the **recommendations page**, shows a *recommendation board* consisting of three different sections (*my recommendations*, *my achievements* and *my strategy*). The user could assign his displayed recommendations to the different sections or delete and restore the recommendations.

4.2.2 Study design

When conducting the study, participants sat in front of a computer and were shown the wireframes. The duration of the study was about ten minutes. It was kept as short as possible to keep the participants engaged and focused. Therefore six participants tested the desktop version, and four participants tested the mobile version of the wireframes. The prestudy consisted of three parts:

1. The study participants had to look at the first screen, the dashboard, and guess which purpose the web app would serve.
2. The participants were given tasks that they had to solve using the wireframes of the screens mentioned above. They had to perform various use case scenarios and evaluate them with a Likert scale (1: easy - 5: complicated) after completing them.
3. They should assess using a 5-point Likert scale (1: absolutely - 5: not at all) whether they believe that the examined web app could increase their stress awareness and lower their distress level.

4.2.3 Results

The prestudy had ten participants with an average age of 26.3 and a gender distribution of 60% male and 40% female. Four participants were evaluating the mobile version of the wireframes, and six participants the desktop version.

1. First impression

The participants could specify what purpose they thought the app would serve after first looking at the dashboard. Thereby, a large part of the participants recognized that it is an

app that displays and monitors vitality values. However, only one participant recognized that it is an app for stress management.

2. Tasks

As part of the prestudy, the participants had to solve various tasks concerning the navigation around the app and then evaluate how well they found their way around using a 5-point Likert scale (1: easy - 5: complicated). During the first tasks, the participants had to navigate to the stress comparison page and then compare the stress level for different time periods. The average of the ratings on the Likert scale was around 1.5, so there were no troubles in solving that tasks.

The next task was to get additional information about the computed stress graph. The intention behind this task was to find out if users would find the information button easily. The average of the ratings on the Likert scale was a 3.3.

Participants then had to navigate to the recommendations page (desktop: 1.0, mobile 2.0) and solve some tasks like moving, deleting, or restoring recommendations. All of these tasks were rated as very easy except for moving recommendations on a mobile screen. The average of the ratings for this task was a 2.5 on the Likert scale.

3. Participants' expectation

Finally, participants were asked if they thought this web app could increase their stress awareness. This question was rated 1.5 for desktop and 1.75 for mobile on average on the Likert scale. The question of whether the participants believe that the web app can also lower their stress level was rated similarly, although slightly lower (desktop and mobile: 2.0).

4.2.4 Evaluation

During the prestudy, the participants filled out a questionnaire. The evaluation of this questionnaire was used to find flaws in the wireframes. These flaws had to be identified and resolved before the digital prototypes could be created.

Since only one of the participants recognized the app as a stress management app, additional labels had to be placed on the dashboard to explain the content at first glance. These labels act as headlines for the graphs or tiles, so users do not have to guess which content they are viewing. Furthermore, the participants had difficulties finding the information button that belongs to the computed stress graph. Therefore, the information button must be made more noticeable and placed closer to the associated graph.

Another issue was the slightly worse rated easiness of navigating between the pages on mobile (desktop: 1.0, mobile: 2.0). However, due to the limited placement options of the navigation on small screens and the frequent general use of collapsed menus in other apps or websites, no changes were made here. It can be said that despite the slightly lower score on mobile devices, the participants rated the navigation through the app very positively.

Since the design on the mobile screen also made it difficult to move the recommendations between columns, adjustments had to be made here as well. The arrangement of the

columns was changed from horizontal to vertical, and the buttons for moving the recommendations were made more obvious.

Finally, the participants could provide a comment at the end of the study with additional notes or requests. First, some participants in the desktop study requested that a drag and drop feature be added to the recommendation board to make it easier to move recommendations from one column to another. Second, a few participants pointed out that it is confusing to have the more recent date on the left side of the pre-filled dates on the stress comparison page.

4.3 Recommendation board

In order to recommend useful stress coping strategies to the users of the web app and provide them with the opportunity to organize them, the web app provides a recommendation board. The selection and wording of the recommendations suggested to the web app users and thus to the study participants was based on a literature review. Due to the current corona pandemic, the participants cannot realize some recommendations, so they are adapted to the ongoing limitations. To contain the spread of coronavirus, restrictions are in place in Germany and much of the world at the time of the study. These may include the prohibition of large events and private meetings with more than two different households. These restrictions are dependent on country and incidence. However, it is not possible to predict which regulations a study participant is currently undergoing. Therefore, all recommendations will be feasible alone or with little social contact. It could be argued that recommendations might increase stress for stressed users, as they impose additional requirements (e.g., doing sports). However, studies show that users with high stress levels like recommendations with stress coping strategies [31]. It may even result in participants not only adapting the suggestions but also being inspired to find their own new ways to deal with stress [28].

4.3.1 Recommendation board functionality

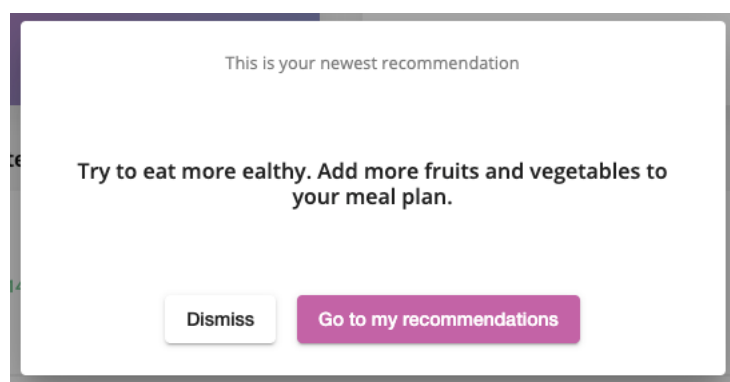


Abbildung 4.5: Digital prototype of a popup for a new incoming recommendation

Each time a user logs in for the first time on a given day, a new recommendation is displayed in a pop-up (see Figure 4.6). The user can either dismiss this pop-up or navigate directly to the recommendation board. Users have access to a board based on a Kanban

board on the recommendations page in terms of structure and design. This board shows all active recommendations. They are divided into three categories. New recommendations land in the first category *My recommendations*. The users then have the option to move the recommendations to any location on the board. They can either move them in their prioritization in the same category or assign them to another category. The second category on the board is *My achievements*. Here, users can place all the recommendations that they have fulfilled. From this point on, an activity recorded in Stila can be linked with the recommendation (e.g., a jogging session with "Do some sports, like jogging or fitness exercises"). Recommendations that users feel have helped them cope with stress can be moved to the third category *My strategy*. If users feel stressed and need a recommendation that has already helped them, they can come back to the board and look at their strategy to choose one. Recommendations can also be hidden if users do not like them or can be restored if they change their minds. As soon as there are no more new recommendations in the pool, the helpful ones are repeatedly displayed to the users as a pop-up.

4.3.2 Recommendations selection

Based on the literature review in chapter 3, the following recommendations are displayed to study participants in the web app. The wording is intended to make concrete suggestions that can be carried out directly but also leave room for the users' own ideas.

- "Do some sports, like jogging or fitness exercises." [37]
- "Get together with a friend or family member." [37]
- "Go outside and take a walk." [31]
- "Do some physical exercises like stretching while working or studying." [31]
- "Meet a friend outside and grab a coffee or tea." [31]
- "If something bothers you, concentrate on dealing with your problem." [38]
- "If something bothers you, talk to someone about it." [38]
- "Try guided meditation. There are free videos on YouTube.
(e.g., <https://www.youtube.com/watch?v=ez3GgRqhNvA>)" [26]
- "Do some yoga. There are free videos on YouTube.
(e.g., <https://www.youtube.com/user/yogawithkassandra>)" [29]
- "Try to avoid alcohol, if you feel stressed. It is not an effective coping strategy." [10]
- "Try to eat more healthily. Add more fruits and vegetables to your meal plan." [10]
- "Take a break. If news events are causing your stress, don't listen to or watch the news for a while." [10]

4.4 Digital prototype specification

The digital prototypes were created using the insights gained from benchmarking existing fitness and stress apps from manufacturers such as Fitbit or Apple and evaluating the prestudy that examined the wireframes for the web app. Furthermore, guidelines for persuasive system design and user interface design were followed in the conception and implementation. To simplify the design and implementation and to support compliance



Abbildung 4.6: Current Stila color scheme

with the guidelines for persuasive system design and user interface design, components from the Google Material Design Library¹ were used. The digital prototypes were designed with Figma². The colors used in the design were provided by the current color scheme of the Stila web app (see Figure 4.6).

Navigation Bar

On the left side of the web app's layout is the navigation bar. It contains the links to all the pages that make up the web app. Additionally, the link to the current page is highlighted in the primary color #C363A6 (see Figure 4.6). On mobile screens, the navigation bar is hidden to provide space for the other content. The navigation bar can be accessed by tapping on the menu icon.

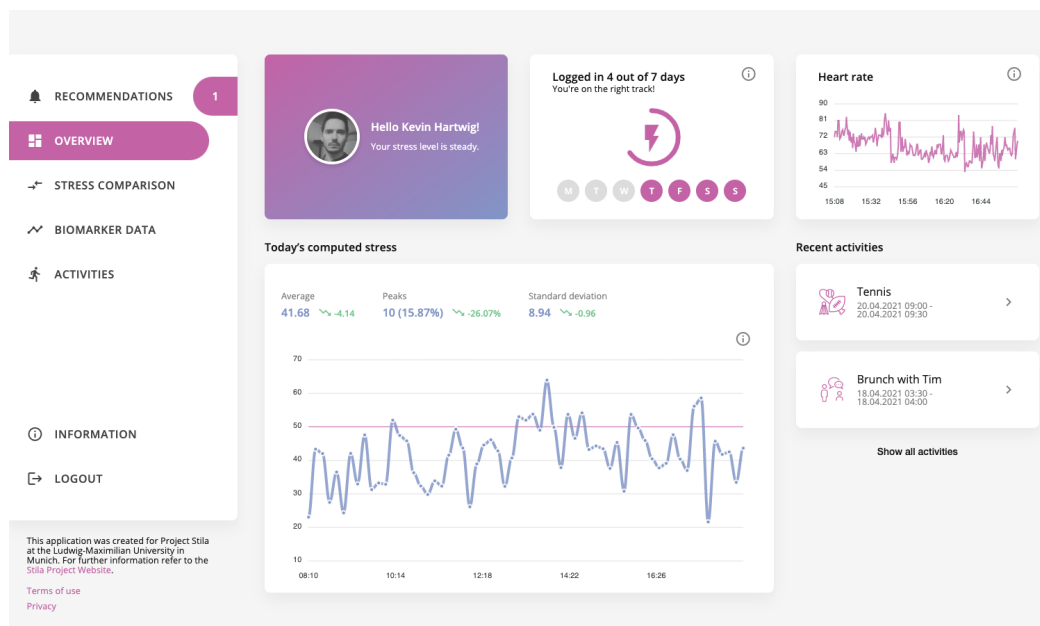


Abbildung 4.7: Digital prototype of the dashboard

Dashboard

After logging in, the first screen that users see is the dashboard (see Figure 4.7). This is in

¹<https://material.io/design>

²<https://www.figma.com>

line with all market-leading fitness apps and compliant with guidelines suggesting that the most important information must be instantly available. To display all important information, the dashboard is composed of two rows containing various tiles.

The upper row is divided into three tiles. The first tile on the top left corner shows a welcome tile for the current user. It shows both a greeting with the user name and information on how the user's current stress level develops. It can be either increasing, steady or decreasing. Next to the welcome tile, the user is presented with a gamification element in the form of a login streak. It contains information on how often the user logged in within the last seven days. The corresponding days on which the user was logged in are highlighted. In addition, a circle fills around a streak icon, which is closed as soon as the user has logged in seven days in a row. In the top right corner, the user's heart rate data of the last two hours before login is displayed in a graph.

On the left side of the bottom row is the most important tile of the dashboard. It contains the graph that shows the users' computed stress level of the current day. At the top of the tile is an information bar showing the daily computed stress level average, the peaks, and the standard deviation of the data. *Peaks* are data points that are above the stress threshold of 50. From the value 50, the stress level is evaluated by the Stila classifier as "stressed". The standard deviation gives users a hint on how much the user's stress level fluctuates throughout the day. All values in the information bar are compared to the values of the day before to provide users with better awareness of the development of their stress levels.

The right side of the bottom row contains a list of the recent activities that the user has entered in the Stila Android app. A list item consists of an assigned icon and the title and date of the activity. On click, the associated activity detail page opens, which is described below.

In the mobile design, the layout of the tiles on the dashboard had to be changed to fit the screen. Therefore, the tiles are arranged one below the other in the order described above. The width of the tiles adapts according to the available screen size.

Comparison of computed stress data

The stress comparison page (see Figure 4.8) shows one big tile containing all elements. There are three input fields in the upper part that allow users to choose which data they want to compare. The input field in the upper left corner is used to select which time units are to be compared. Either two days can be compared, or custom time ranges. The specific days or custom time ranges can be selected with the two input fields in the upper right corner.

Below the input fields are two charts showing the computed stress data for the selected time units. Like the dashboard, an information bar shows the associated average, peaks, and standard deviation of the data. The upper chart shows the users computed stress data in detail. The data points can be hovered or tapped to reveal more information like the specific value and time. A legend below this chart clarifies which line belongs to which time unit. Finally, a navigation chart is provided at the bottom of the page, which contains an abstraction of the data shown above to enable the user to scroll and zoom on the upper chart.

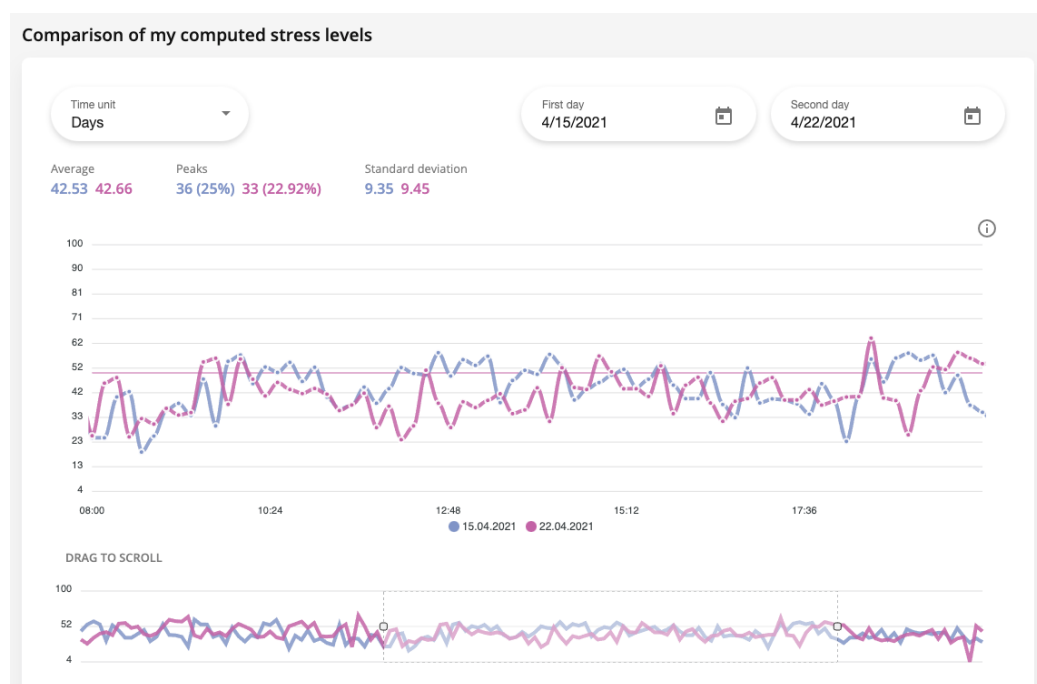


Abbildung 4.8: Digital prototype of the computed stress level comparison page (the navigation bar on the left side is not shown)

Biomarker data

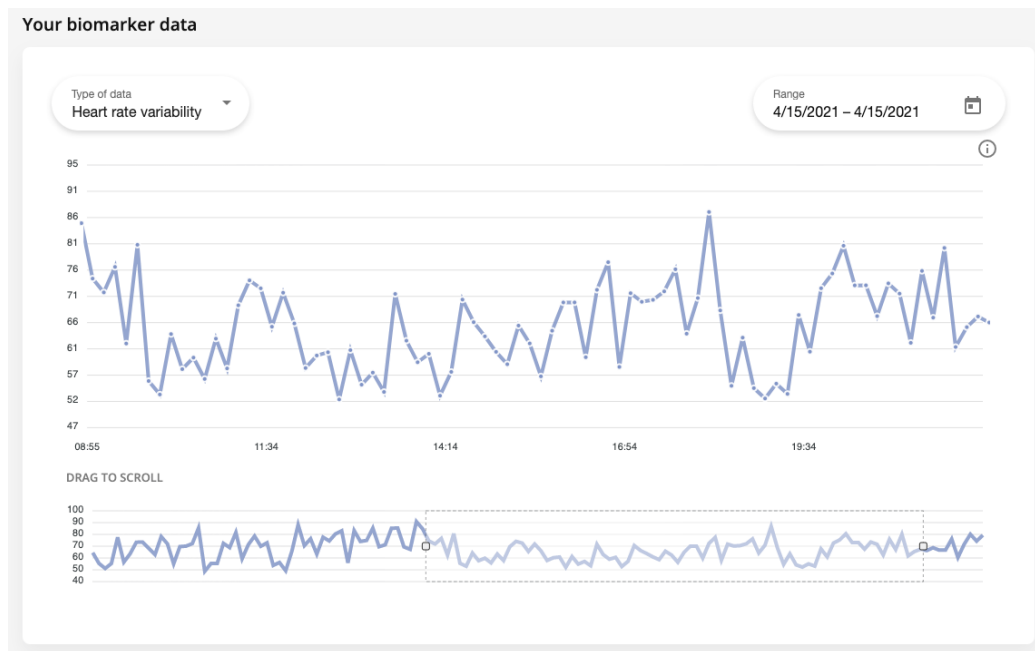


Abbildung 4.9: Digital prototype of the biomarker data page (the navigation bar on the left side is not shown)

The biomarker page is similar to the stress comparison page (see Figure 4.9). An input field is placed in the top left corner, giving users different options to select which kind of data they want to view. They have the choice between *heart rate data*, *heart rate variability*, *computed stress data* and *data features*. The input field in the top right corner is used to select the desired time range for the displayed data. Also similar to the stress comparison page, below the input fields is the chart showing the data with a navigation chart below.

Activity page

On the activity page, as on the dashboard, all activities that the user enters in the Stila Android app are displayed. Clicking on an activity opens the corresponding detail page (see Figure 4.10). There, the user can see the computed stress data for the corresponding period of the activity and the average, peaks, and standard deviation.

Information page

The information page provides the user with a list containing questions with corresponding answers like "How is the computed stress data calculated?" and "What is the motivation behind Stila?". It also shows an email address where users can send additional questions.

Recommendation board page

The recommendation board has its own page and offers various functionalities (see Figure 4.10). The three columns *my recommendations*, *my achievements* and *my strategy* are displayed side by side and contain the respective recommendations assigned by the user. On mobile,

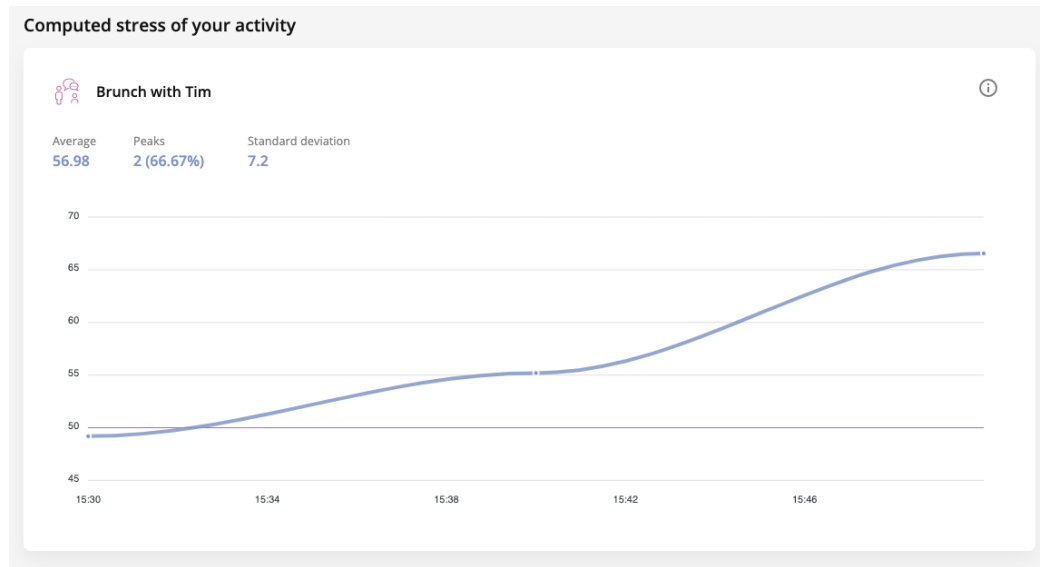


Abbildung 4.10: Digital prototype of the activity detail page (the navigation bar on the left side is not shown)

the columns are displayed one below the other. New recommendations inside the column *my recommendations* have a border in the web app's primary color to attract the user's attention. The recommendation cards contain the recommendation itself, an info button to get more information, and two buttons. The left button is used to hide the recommendation, and the right button is used to move the recommendation one column to the right. Therefore, on the *my strategy* column, there is no right button. In addition, the cards in the columns *my achievements* and *my strategy* contain a select field to link the user's activities with the recommendations. The recommendation board is also equipped with a drag-and-drop feature. All recommendations can be dragged and dropped into the different columns with a mouse.

At the top of the page, there are two buttons. By clicking on the left button, the user can request a new recommendation, which will then be displayed in a popup. The right button is used to hide all active recommendations and only shows those that the user hid before.

4.5 Implementation of theoretical frameworks

4.5.1 Kukkonens Persuasive Design Principles

The web app aims to help users improve their stress awareness and eventually lower their distress level. To achieve this, the user interface design should have a persuasive effect. Therefore some of the previously presented design principles by Kukkonen et al. [25] were taken into account in the conception of the system features and interface design after analyzing the persuasion context (see Figure 4.12). As the web app intends to be a lifestyle-changing persuasive intervention, the review by Kelders et al. was also taken into account when selecting the design principles. They especially suggested *tailoring* and *rehearsal* as essential points for the design of a web intervention. Reminders were also emphasized as a relevant principle by Kelders et al., which is why they are prominently displayed in the

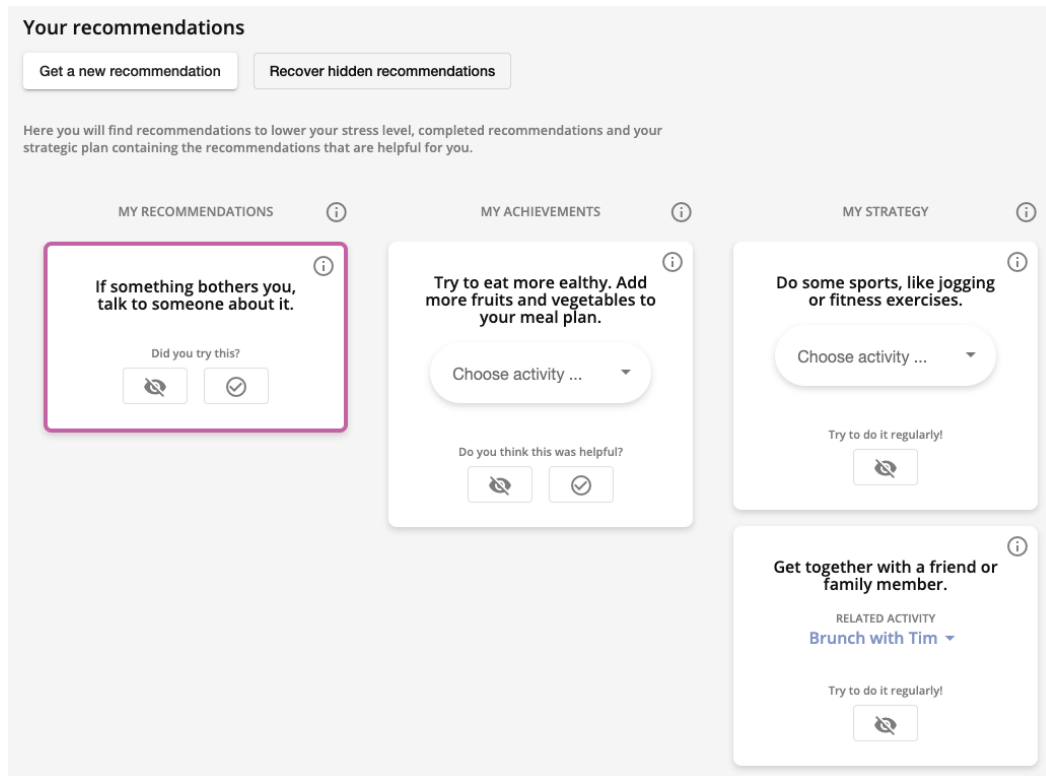


Abbildung 4.11: Digital prototype of the recommendation page (the navigation bar on the left side is not shown)



Abbildung 4.12: Generic Steps in Persuasive System Development from [25]

web app in the form of the recommendation board [17].

The following list describes how selected design principles by Kukkonen et al. [25] have been implemented.

- **Reduction:** The system has a minimalist and clear design. The most frequently used functions are easy to reach, and input fields for data are reasonably pre-filled, for example, with the current day's date.
- **Tailoring:** The system is tailored for student's and young professional's needs. It is optimized for use on smartphones, and the selection for creating activities has tailored templates like exams or work.
- **Personalization:** The greeting on the overview page and the data displayed there are customized. In addition, recommendations can be organized in a personalized way and linked to user-created activities.

- **Self-monitoring:** The web app offers multiple ways for users to track their stress levels, recommendations, and activities. They can observe their stress levels on the overview, comparison, and biomarker data pages. Recommendations can be categorized into three sections: *My Recommendations*, *My Achievements*, and *My Strategy*. All user activities are pulled from the user's calendar, can be evaluated, and are then always available with detailed stress levels.
- **Rehearsal:** The web app implements gamification in the form of a badge that motivates users to log in every day and check their stress levels, thus increasing their stress awareness. Furthermore, all recommendations that users moved into their strategy are repeatedly shown to encourage them to repeat the target behavior that helped them to lower their stress level.
- **Praise / Rewards:** Users would get a badge if they logged in every day in a seven-day streak. This should motivate users to log in every day to increase their stress awareness.
- **Reminders / Suggestion:** The web app is showing a new recommendation every day when users are logging in. They can also request a recommendation at any time, which is then delivered directly and can be organized in the user's recommendation board. An indicator in the navigation bar always reminds users if they have new recommendations they have not tried yet.
- **Trustworthiness / Expertise:** In the footer of the web app, one can see that the app originates from a research project of the Ludwig-Maximilians University in Munich. There is also an information page that describes how the stress level data is calculated. In addition, there is an info button for each functionality of the web app, which displays an explanation of the respective functions or data when clicked.

4.5.2 User Interface Design

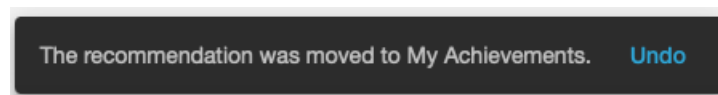


Abbildung 4.13: Example of snackbar in Stila web app

As stated in chapter 3, Shneiderman constituted eight golden rules for designing interactive user interfaces. In addition, Nielsen formulated ten usability heuristics for interaction design. It is also important that the interface is designed well to be used as easily as possible. Therefore the following golden rules of interface design by Shneiderman were followed [35]. Due to the limited development capacity within the scope of this master thesis, not all guidelines could be considered. In addition, following some points was not necessary given the limited functionality of the web app.

- **Strive for consistency.** All users of the Android Stila App will be familiar with the colors and the web app's design as this is very much based on the design of the Android app. Additionally, the standard material design icons from Google, which users know from various websites and apps, were used. This consistency ensures that users can apply knowledge from other applications without learning new representations for the same actions.

- **Offer informative feedback.** Every component in the web app showing user data is linked to an information modal that provides additional information about the structure and computation of the data.
- **Design dialogue to yield closure.** The most complex task users can do in the web app is the handling of their recommendations. Managing recommendations are grouped from start to end. Users get their newest recommendation when logging in on the dashboard in a popup. From this popup, they can go directly to the recommendation board. There all tasks can be done directly on one page. Additionally, users get feedback for every action they do on the board.
- **Permit easy reversal of actions.** The only place where users can edit the database and thus perform actions that need to be reversible is the recommendation board. Here, users can get feedback about what they just did and the possibility to revert their action in the form of a so-called *snackbar* (see Figure 4.13).
- **Reduce short-term memory load.** The web app provides all related information on a single screen for every functionality, so users do not have to transfer information from one screen to another.

The list below describes the implementation of selected Nielsen's heuristics, excluding those that overlap with Shneiderman's principles (see chapter Theoretical Framework) [23].

- **Visibility of system status** Users of the web app can always perceive the current state of the system. Firstly, spinning loading circles indicate components that are currently loading their data. If the data is successfully loaded, the data is displayed. If there is no data available for the chosen date, a corresponding information message is displayed. Furthermore, the user data is visually connected to dates, so users always know the period that a chart belongs to. Additionally, desktop users can see which page they are on by the highlighting in the navigation bar. Mobile users can use the page title for this purpose.
- **Consistency and standards** The web app's interface was designed using Google's Material Design Components for Angular and Google's Material Icons. Many other apps and websites are using these, hence many users should be familiar with the look and feel of the interface.
- **Flexibility and efficiency of use** The web app meets this guideline in two ways. First, the app is fully usable on both desktop and mobile without any restrictions. Second, the recommendation board is equipped with a drag and drop function after incorporating the pre-study results. Users can, therefore, either use the drag and drop function or the operation via buttons.
- **Aesthetic and minimalist design** The interface of the web app is limited to displaying only the most necessary elements. In addition, the use of Google Material Design components supports an aesthetic and minimalistic design.
- **Help users recognize, diagnose, and recover from errors** All error or information messages in the web app are formulated to be easily understood by users. The messages also contain suggestions on preventing this message from showing like "There is no stress data for today. Please go to the Stila Android app and sync your data!".

4.5.3 Gamification

Since Hoffmann et al. confirmed gamification has a positive effect on motivation and engagement [15], it is also implemented in this web app. The first step in selecting the correct gamification elements was to evaluate the three main components defined by Sailer et al. [30]. The first aspect to consider is the person that is using the web app. In this case, the target groups are students and young professionals. Based on the age structure, it can be assumed that the target group either has experience with games or that, at least most of them, are open to gamification elements and used to them from the usage of other apps. The second aspect that needs to be evaluated is the gamification environment, i. e., the goals to be achieved using gamification. For this, Sailer has provided a list that specifies various game elements and their effects [30]. Using gamification in this web app should primarily motivate users to log in as often as possible to cause better stress awareness. Furthermore, it would be beneficial if users spend much time with the web app to explore all functionalities, intensively study their physiological data and use the recommendation board accordingly. The last aspect to consider is the *context*, in which gamification is used. This web app is designed to improve the user's health by evaluating and displaying physiological data. In this context, users must find the web app trustworthy. Therefore, an excess of game elements should be avoided, and these measures should only be used in a very particular way.

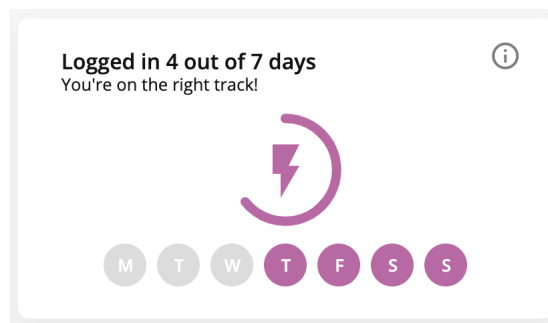


Abbildung 4.14: Login badge used in the Stila web app

Considering the above evaluation and the limited development capacity within the scope of this master thesis, the choice of the game element fell on a login badge (see Figure 4.14). Badges can meet the users' demand for success and can act as virtual status symbols. They can also help people in setting goals and give a feeling of competence [30]. The login badge used here is intended to increase the motivation of users to log in daily to achieve a better increase in stress awareness. Users can achieve a streak, a concept many popular apps use if they log in every day. However, the streak breaks if a user does not log in for a day. In this case, the streak must be rebuilt. If the user logs in seven days in a row, he achieves a complete streak.

4.6 Technologies used

After the digital prototype was designed, the basis for the programming of the web app was established. The web app is based on a client-server model. A REST API is used to communicate between the server and the client. This chapter describes which technologies were used for programming the web app and how the code is structured.

4.6.1 Frameworks and libraries used

The following section describes the frameworks used for the frontend development, the design framework, and visualizing the user data in charts.

Frontend framework

The backend for the web app was provided ready to use, so the thesis' programming task was focused solely on the frontend. To meet the requirements of modern web development, Angular 10³, a component-based framework for building scalable and progressive web applications by Google, was used. The technologies for building web applications with Angular 10 are HTML, CSS, and Typescript. For developing this web application SASS was used, which is a CSS preprocessor that helps with structuring CSS files.

Design library

To facilitate compliance with some guidelines for user interface design and persuasive design systems and provide a simple, easy-to-use user interface design, Google's Material Design System and Material Design Icons were used. Material Design inherently uses best practices for user interface design and is used by many apps and websites. Therefore, it also supports Nielsen's *consistency and standards* (see chapter 4) heuristics. Additionally, Google offers an Angular Material UI component library, which was used to implement date pickers, snackbars, drag and drop columns, and other components.

Chart library

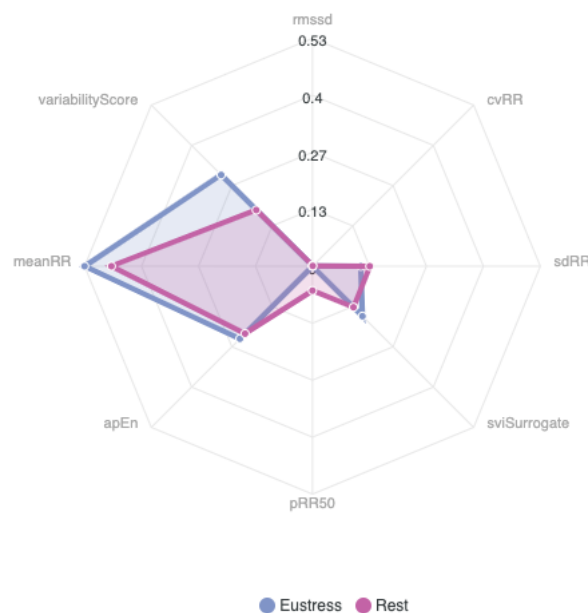


Abbildung 4.15: Feature chart of the web app implemented with ApexCharts.js

³<https://angular.io/>

For visualizing the user data, ApexCharts.js⁴ was used. This library offers a variety of different chart types. In the web app, mostly line charts were used, but also radar charts (see Figure 4.15), which were used to visualize feature data. Furthermore, ApexCharts provides interactivity, so users can hover or tap on the chart to get additional information about specific data points. Additionally, users can navigate and zoom the chart displaying their data with the help of a so-called *brush chart*, that is synced with the main chart (see Figure 4.9).

4.6.2 Code structure

The code of an Angular web app is typically divided into components. This creates the advantage that the web app is scalable and individual components can be easily replaced. Another advantage is the encapsulation of the different code parts per component. This means that users only have to load the code for the components that they actually view in their browsers.

Structure of the Stila web app components

All pages in the logged-in state have the same basic layout. Therefore, they are based on a layout file that contains the code for the navigation bar and a so-called *router-outlet*. The router-outlet displays content based on the route that the user has currently accessed. Angular uses a routing module to determine the respective content to the current route. The consequence of this is that the navigation bar is visible on every page, but the content changes depending on the route.

An Angular component is divided into three files. The HTML-file is used to specify the template for the respective component. Next, the corresponding CSS-file is responsible for the styling of the template. Finally, the Typescript file contains all the data that is displayed in the component and is responsible for initiating API calls and, if necessary, provide methods for interactivity.

A data service is used to define and wrap all API calls that the web app is using. Here, all get and post functions are provided to allow the components to use the API easily. Therefore, the data service combines the parameters that the components give to the API calls into a URI understandable to the REST API. It also adds the authentication token to allow communication with the API as the user data is protected from unauthorized access.

⁴<https://apexcharts.com>

This chapter presents the research questions of this master thesis. Furthermore, the study design and the results of the study are shown. The chapter closes with a conclusion and an outlook on future work.

5.1 Research questions

This thesis aims to increase the web app users' stress awareness and provide them with appropriate stress coping strategies. Two research questions were set up to verify whether the objective was achieved, and the study described below aims to answer these questions:

Research question 1:

Do the participants feel that their stress awareness has increased after the usage of the app?

Research question 2:

Do the participants feel that their stress level has decreased by receiving recommended stress coping strategies in the app?

5.2 Study design

A user study was conducted to answer the above research questions and evaluate the web app programmed in the scope of this thesis. In order to properly evaluate all functionalities of the web app, especially the display of different stress coping strategies and the comparison of stress levels over a period of time, the study duration had to be long enough. Therefore, a study duration of 14 days was chosen.

During the course of the study, the participants had to wear a fitbit tracker or smartwatch to record their heart rate data, which is then used by the Stila classifier to compute the participants' stress level. Participants were also required to use the web app at least once a day to view their stress levels and use the recommendation board. The usage of the web app was tracked with Matomo¹.

¹<https://matomo.org>

The participants were asked questions about their stress awareness in a pre-survey before the start of the study in order to check whether they perceived an increase in their stress awareness after using the app. The same questions were part of the post-survey, which participants had to complete after the study period.

5.3 Results

The following chapter lists all data collected during the study. This includes demographics of participants, user survey data, and event data tracked with Matomo.

5.3.1 Participants

A total of ten subjects participated in the study. The gender distribution of the participants was even. There were 50% female and 50% male participants. The average age of the participants ($n=10$) was 25.5 ($s=5.2$). Two of the participants used the web app mainly on computers and therefore large screens, while the majority of the participants ($n=8$) used the web app mainly on their smartphone. All participants completed both the pre-survey before the study and the post-survey after the 14 days of using the web app.

5.3.2 User survey data

The following section lists the results of the pre- and post-survey. The pre-survey was conducted before the start of the study, while the participants answered the post-survey after using the web app for 14 days. The participants were asked to rate multiple statements using a 5-point Likert scale (1: *strongly disagree* - 5: *strongly agree*).

Pre- and post-survey comparison statements

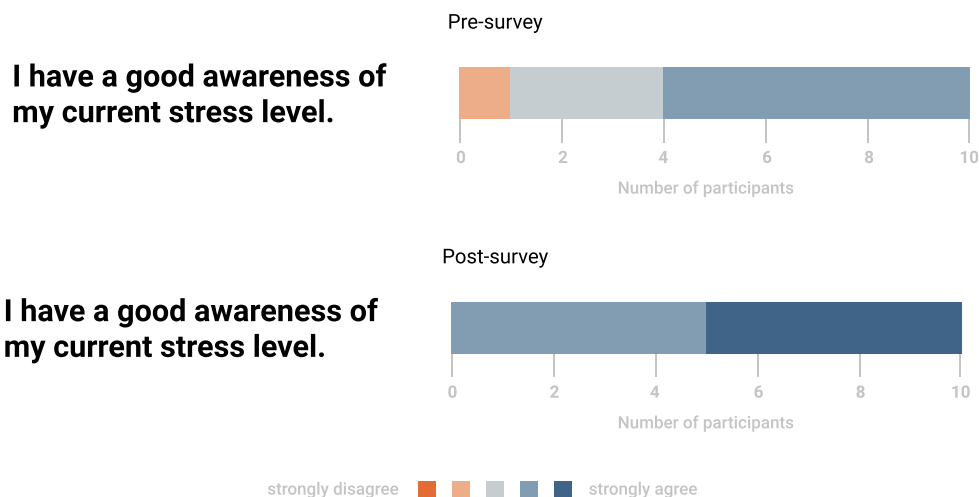


Abbildung 5.1: Ratings of the statement “I have a good awareness of my current stress level.” in the pre- and post-survey.

Three statements, which were formulated identically in the pre- and post-survey, were evaluated by the participants. The aim was to determine whether there was a significant increase in the stress awareness of the participants. In the pre-survey, participants rated the statement “I have a good awareness of my current stress level.” with an average score of 3.5 on the Likert scale (see Figure 5.1). This average score increased to 4.5 in the post-survey with a statistical significance of $p = 0.0042$. The average score of the second statement, “I have a good awareness of the development of my stress level over time.”, also increased significantly from 3.0 in the pre-survey to 4.2 in the post-survey with a statistical significance of $p = 0.0043$ (see Figure 5.2). However, the third statement, “I have a good understanding of what causes me stress.”, had a low statistical significance (see Figure 5.3). Its average score only increased from 3.8 to 4.3 ($p = 0.0886$). The participants rated the corresponding statement “The web app has improved my stress awareness” from the post-survey with an average score of 3.9 (see Figure 5.4).

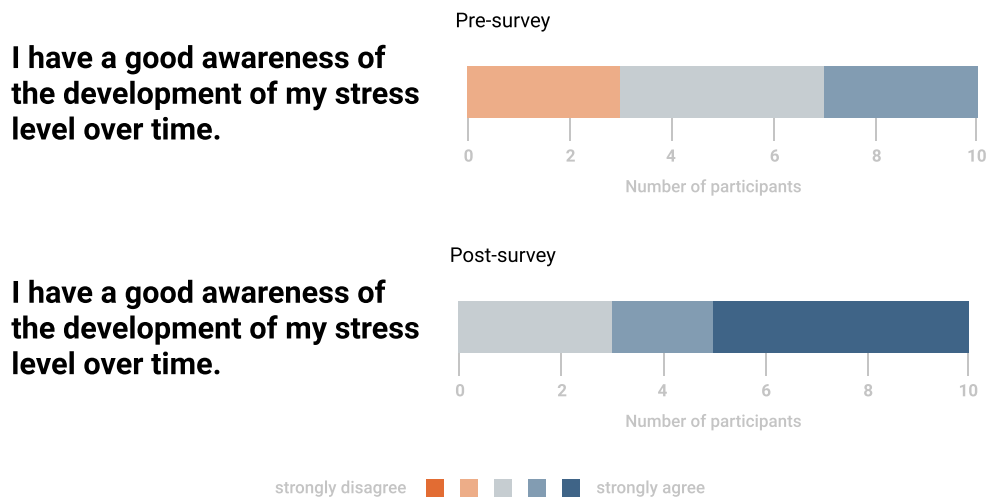


Abbildung 5.2: Ratings of the statement “I have a good awareness of the development of my stress level over time.” in the pre- and post-survey.

Statements regarding data charts

While using the web app, participants could view many different charts. The three charts most likely to be used to improve the users’ stress awareness were examined to find out which is best suited for this purpose. Therefore, participants had to rate the statement “This chart helped me to increase my stress awareness (*Type of chart*)” (see Figure 5.5). The lowest average score was assigned to the heart rate chart (2.7). The chart showing the user’s stress level was placed in the midfield (3.4). The chart that offered the possibility to compare stress levels of several days or self-selected periods was rated best (3.6). Another statement regarding the charts was “Viewing my stress levels daily has reduced my stress level.”. Participants rated this statement with an average score of 3.1 (see Figure 5.6).

Usage and effectiveness of stress coping strategies

Besides stress awareness, stress coping strategies were the second main focus of this thesis. Therefore, during the study, participants were recommended 12 different stress coping

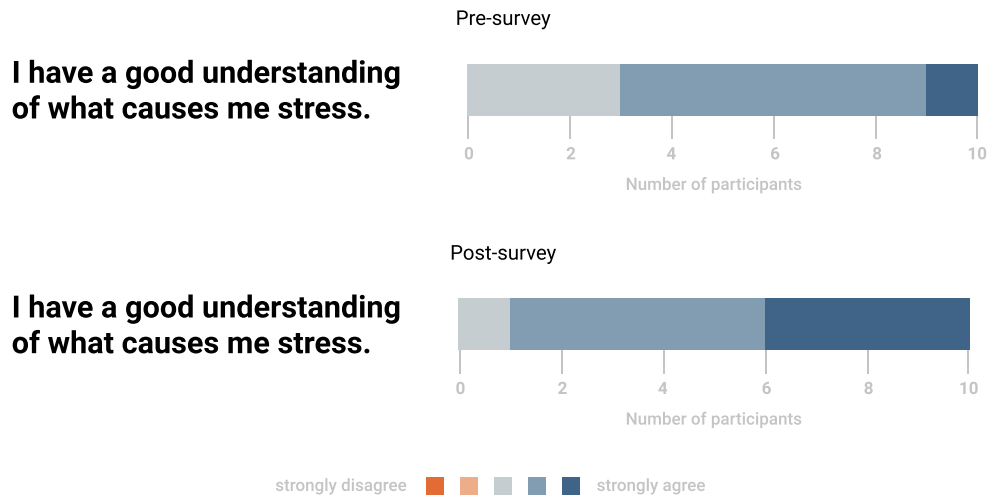


Abbildung 5.3: Ratings of the statement “I have a good awareness of the development of my stress level over time.” in the pre- and post-survey.

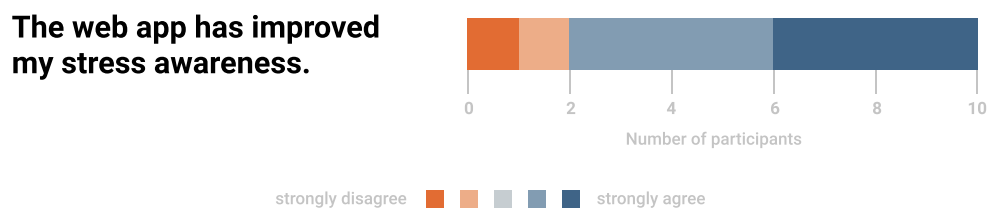


Abbildung 5.4: Ratings of the statement “The web app has improved my stress awareness.”

strategies. Beforehand, these recommendations were divided into categories: physical, social, health and mindful. First, participants were asked which recommendations they had tried. This revealed that a total of 23 physical, 20 social, nine health, and six mindful recommendations were tried. Next, the participants were asked to state which recommendations helped them to reduce their stress levels. The distribution of categories was similar here, only the placement of mindful and health switched. Participants found 18 physical, 14 social, four mindful, and two health recommendations useful in reducing their stress levels.

Statements regarding stress coping strategies

The participants were also asked to rate various statements regarding the stress coping strategies (see Figure 5.7) provided in the web app on a Likert scale (1: *strongly disagree* - 5: *strongly agree*). The first statement, “Overall, the recommendations have helped me to lower my stress level.” got an average value of 4.2 on the Likert scale. Furthermore, the following two statements related to the timing of the recommendations and how often they were displayed to the user. The statement “The recommendations were shown to me at a convenient time.” reached an average value of 3.1, while the statement “The recommendations were shown to me in an appropriate frequency.” got 3.6.

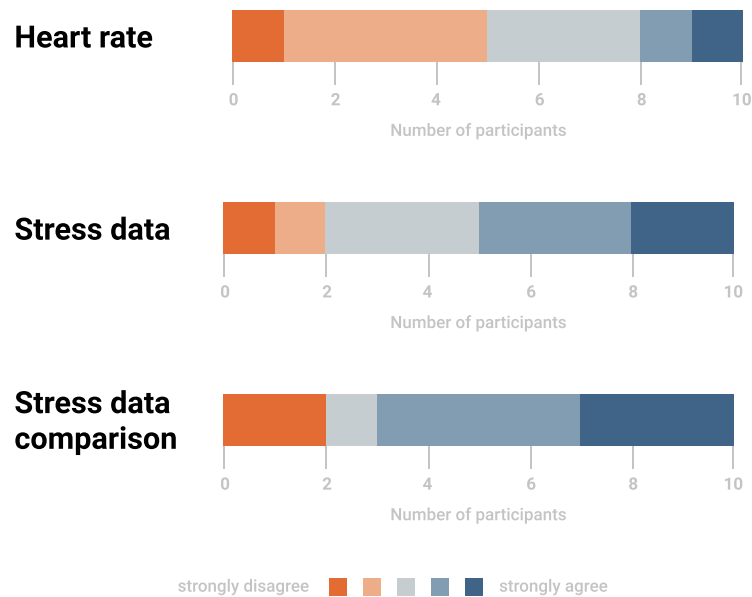


Abbildung 5.5: Ratings of the statement “This chart helped me to increase my stress awareness (*Type of chart*)”.

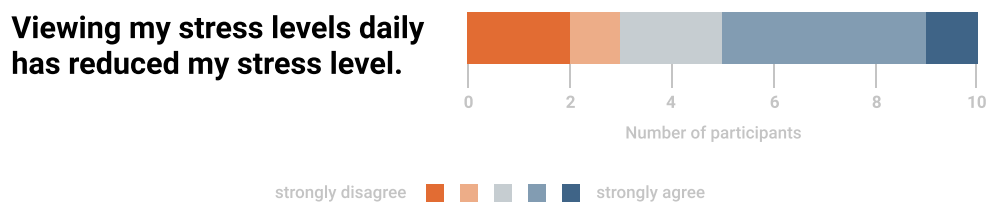


Abbildung 5.6: Ratings of the statement “Viewing my stress levels daily has reduced my stress level.”.

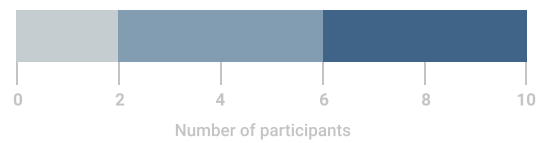
Statements regarding user interface design

While designing and prototyping the web app, user interface guidelines were considered. Therefore, in the study, three statements were used to evaluate the user interface design of the web app (see Figure 5.8). The first statement, “The web app was easy to use.” was rated with an average score of **4.3** on the Likert scale. An even higher score with **4.5** got the statement “The web app was easy to learn.”. Finally, the last statement, “The important app features were quickly accessible.” was rated with **4.1**.

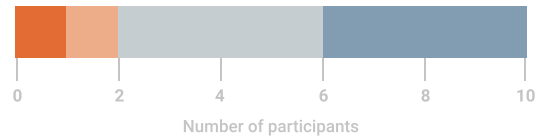
Statements regarding persuasive system design

Not only user interface design guidelines were used while developing the web app, but also the guidelines for persuasive system design by Kukkonen [25]. Hence, the persuasive design of the web app was also evaluated in the study with two statements (see Figure 5.9). First, the statement “I understood every information in the web app.” received a **4.3**

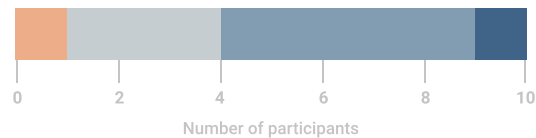
Overall, the recommendations have helped me to lower my stress level.



The recommendations were shown to me at a convenient time.



The recommendations were shown to me in an appropriate frequency.



strongly disagree ■ ■ ■ ■ strongly agree

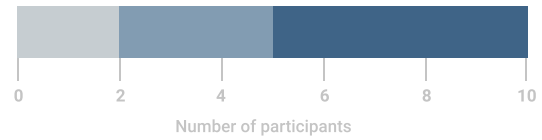
Abbildung 5.7: Ratings of the statements regarding stress coping strategies.

on average on the Likert scale. And second, the statement “I perceive the web app to be trustworthy.” got a **4.6**.

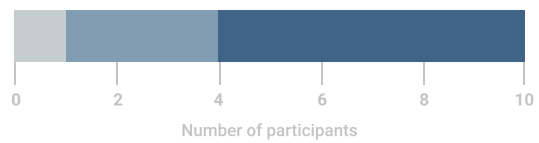
Statement regarding gamification

Finally, participants were asked to rate a statement regarding the gamification element. The gamification element was a login badge that built a streak if the user logged in daily. The statement “The log in badge motivated me to log in every day.” was rated with an average value of **3.5** on the Likert scale (see Figure 5.10).

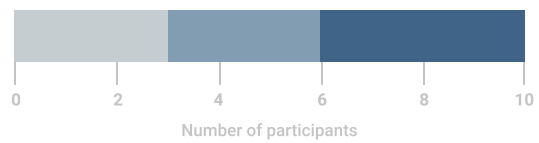
The web app was easy to use.



The web app was easy to learn.



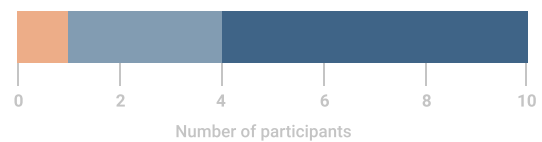
The important app features were quickly accessible.



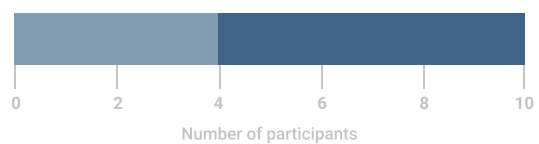
strongly disagree strongly agree

Abbildung 5.8: Ratings of the statements regarding the user interface design.

I understood every information in the web app.



I perceive the web app to be trustworthy.



strongly disagree strongly agree

Abbildung 5.9: Ratings of the statements regarding persuasive system design.

**The log in badge motivated
me to log in everyday.**

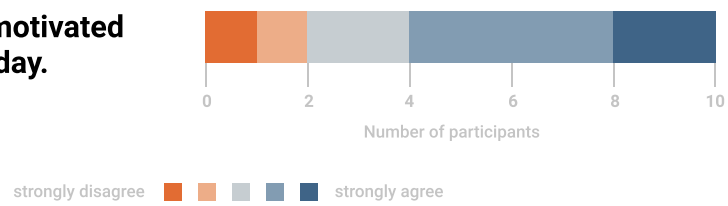


Abbildung 5.10: Rating of the statement regarding gamification.

5.3.3 Tracking data

In addition to collecting data from the questionnaires, user events in the web app were tracked with Matomo during the study period. During this period, a total of 114 visits by the participants were recorded. Each visit had an average duration of 2 minutes and 56 seconds ($s=3m\ 25s$). Per visit, the users performed on average 9.8 actions ($s=7.8$). The table below shows the frequency of tracked events during the study period.

Event	Total number of executions
Revert action	1
Drag recommendation	8
Link activity and recommendation	16
Hide recommendation	16
Info button clicked	74
Move recommendation by click on button	91
Fetch stress comparison data	98
Change priority of recommendation	144
Fetch biomarker data	158

5.4 User survey evaluation

The following section evaluates the above user survey results regarding stress awareness, stress coping strategies, design guidelines, and gamification.

Perception of increased stress awareness

The significant increase of the average score of the statements “I have a good awareness of my current stress level.” and “I have a good awareness of the development of my stress level over time.” on the Likert scale from the pre- to the post-survey, shows that the web app was successful in providing a perception of increased stress awareness. Participants generally felt better stress awareness and had a better idea of how their stress level changes over time. However, the web app was unsuccessful in improving understanding of what triggered participants’ stress, since the average score of the statement “I have a good understanding of what causes me stress.” did not increase significantly.

Since the increased stress awareness could have had other reasons than the use of the web app, the participants should also evaluate the statement “The web app has improved my stress awareness.”. The evaluation shows that the participants largely attribute their increased awareness to the app.

Data chart evaluation

The evaluation of the different data charts concerning the increase of stress awareness has shown expected results. According to the participants, the chart showing only the user’s heart rate data was the least effective in increasing stress awareness. This is probably because heart rate does not allow a direct conclusion to be drawn about the stress level. The display of the computed stress level, on the other hand, was more helpful. Participants found the chart that compared days or custom time ranges to be the most useful for increasing stress awareness since it can improve the understanding of the development of the stress level over time.

Another question was if the daily viewing of the stress level could already help in reducing the users' stress level. The assessments of the statement "Viewing my stress levels daily has reduced my stress level." suggest that an increased stress awareness was only effective in reducing the stress level for half of the participants.

Usage and effectiveness of stress coping strategies

The recommendation board provided the participants with several stress coping strategies. The results show that users preferred trying either physical (e.g. "Do some sports, like jogging or fitness exercises.") or social (e.g. "Get together with a friend or family member.") strategies in contrast to health or mindful strategies (e.g. "If something bothers you, concentrate on dealing with your problem." or "Try to eat more healthily. Add more fruits and vegetables to your meal plan.").

The preference of the categories physical and social is in line with another study, in which recommendations against stress were categorized and evaluated [31]. However, the average age of the participants in this and the previously mentioned study was about 25. It could be that the preference of these categories is due to age, and the mindful and health categories could become more important as age increases. Another starting point for explaining the preference could be the faster feasibility of physical and social recommendations since it is, for example, simpler to go jogging than to change one's diet plan.

Since the users tried on average six recommendations and 12 different ones were shown to them, provided they have logged in every day, participants tried around half of the recommendations. Subsequently, participants found an average of four, or one-third of the recommendations, helpful in lowering their stress level.

Evaluation of the stress coping strategies and the recommendation board

Overall, the recommended stress coping strategies were successful in creating the perception of a lowered stress level (see Figure 5.7). This is in line with the participants' statements above that four recommendations effectively lowered their stress level on average. It also coincides with the literature review that was conducted to select the stress coping strategies (see Chapter 4).

However, one problem with the web app was the timing of displaying new recommendations. Since no push notifications could be used, the timing was limited to the active usage time of the participants. For this reason, a new recommendation was displayed every time a participant logged in on a new day. As a result, the timing of new recommendations was not evaluated positively by the majority of participants. Nevertheless, the frequency of displaying new recommendations was rated somewhat more positively. This is presumably because one recommendation per day is adequate to focus on and have enough time to execute.

Evaluation of user interface design

Shneiderman's Eight Golden rules [35], and Nielsen's Usability Heuristics for User Interface Design [23] were followed and implemented in the design and development of the web app. As a result, the statements in the user survey regarding the usability of the user interface were consistently rated as positive. The participants found the web app easy to use and were able to learn how to operate it quickly. In addition, most participants found that the most important features of the app were quickly accessible. This suggests that com-

pliance with the guidelines and the use of Google's Material Design positively influences the user interface experience.

Evaluation of persuasive system design

In addition to the user interface design guidelines, Kukkonen's persuasive system design guidelines have also been followed and implemented [25]. Two critical points in terms of persuasiveness in health apps are trustworthiness and clarity of information. Both of these points were almost universally rated positively by the participants. Thus, it can be assumed that the inclusion of Kukkonen's guidelines increased the persuasiveness of the web app.

Evaluation of gamification element

Since current studies find controversial results about using gamification in health apps [14], the use here was also researched. Unfortunately, due to the limited development capacity in this thesis, the only possible implementation was a login badge that built up a login streak if the user logged in every day. This badge was intended to motivate the user to log in daily, which helps increase stress awareness. The concept of streaks is common in current apps, especially for learning or fitness apps. In the post-survey, participants were asked to rate the statement "The log in badge motivated me to log in everyday". More than half of the participants rated the statement positively. It can therefore be assumed that the motivation of some users can be increased with the help of gamification elements.

5.5 Tracking evaluation

During the duration of the study, the use of the web app was tracked with Matomo². The tracking results show that the web app was presumably used almost every day by all participants. However, even though the average time spent in the web app was relatively high, the standard deviation suggests that some participants did not spend much time using the web app. The standard deviation in the average number of actions performed in the web app allows the same conclusion.

In addition to the default values, specific events were also tracked using Matomo. The analysis of this data shows that the main functions of the app (display of stress data and the recommendation board) were used very frequently by the participants. The data suggests that the position of recommendations was moved quite regularly in rows and columns on the recommendation board. However, functionality that was not often used on the recommendation board was hiding recommendations and linking activities to recommendations. In addition, the drag and drop functionality of the recommendation board was not often used, as most of the web app usage was on mobile phones, and the option was not usable there. Regarding the display of stress data, the stress data for individual days or custom time ranges were accessed slightly more often than the comparison of stress data.

5.6 Limitations

The study used to evaluate the web app has some limitations. First, the small number of participants (n=10) limits the validity and statistical significance of the results collected. The small number of participants was related to the high pre-conditions: Participants had to own a Fitbit or Wear OS smartwatch themselves. In addition, the study required that

²<https://matomo.org>

the web app was used daily for 14 days at a stretch. Furthermore, all participants in the study were approximately the same age. The average age was 25.5 years with a standard deviation of 5.2 years. This average age could account for some of the responses. Finally, all results evaluated were based on the participants' self-assessment. Measurements of real world data did not back up the answers.

5.7 Conclusion

This thesis explored two research questions. The first research question, "Do the participants feel that their stress awareness has increased after the usage of the app?" is regarding stress awareness and the second research question "Do the participants feel that their stress level has decreased by receiving recommended stress coping strategies in the app?" deals with stress coping strategies. Therefore, a web app was developed within the scope of the master thesis, which visualizes the stress data of the users in numerous charts. Furthermore, the web app offers a recommendation board that is used to recommend stress coping strategies. The recommended stress coping strategies were selected based on a literature review (see chapter bla). In the design and development of the web app, guidelines for user interface design and persuasive system design were followed to improve the user experience and promote the increase of stress awareness. In addition, wireframes were created, which were evaluated in a pre-study and later served as the basis for programming the web app.

5.7.1 Increase of stress awareness

The results of the user survey, taking into account the limitations, allow the conclusion that the web app was able to increase the stress awareness of the participants significantly. Eight out of ten participants rated the statement "The web app has improved my stress awareness" with *agree* or *strongly agree*. In addition, the statements "I have a good awareness of my current stress level." and "I have a good awareness of the development of my stress level over time." showed a significant increase in the average score on the Likert scale compared to before and after using the web app. These results show that the feature to compare stress levels for days or custom time ranges in one chart was conducive to increasing stress awareness. It enabled participants better to understand the evolution of their stress levels over time. However, the recognition of stressors was not increased significantly by using the web app.

5.7.2 Decrease of stress levels

Considering that this is only the participants' self-assessment and the actual stress level data was not examined, the study results also suggest that the use of the web app was able to reduce the participants' perception of their stress level. Again, eight out of ten participants rated the statement "Overall, the recommendations have helped me to lower my stress level." with *agree* or *strongly agree*. So the recommendations were already effective, although the timing of showing new recommendations was not individualized. The results also suggest that the web app motivated users to engage with meaningful stress coping strategies. In the pre-survey, the majority of participants indicated that they had never engaged with them before.

5.8 Future work

Due to the limited time and development capacity in the course of this master thesis, many adaptations, functionalities, and verifications have been left for the future. The following section covers different suggestions, which directions the research in the field of applications for stress management should consider. This primarily concerns the deeper analysis of survey results as well as the expansion of the functional scope of stress management apps.

Verification of results with real data

Even though this master's thesis study showed that the participants felt a decrease in their stress level after receiving the stress coping strategies and increasing their stress awareness, this is only a self-assessment. A subsequent and important step would be to actually compare the computed stress data of the users before and after using the web app in order to prove the actual benefit.

Improvement and enrichment of visualization

The study revealed that many participants did not see any improvement in identifying their stressors even after using the web app. This is probably because although participants see the appropriate stress level for each point in the day, they then have to specifically remember the appropriate situations, which can certainly fail often. One solution to this problem would be to develop the web app further. One concrete suggestion is to display the activities entered by the user directly on the stress graph. This way, the user would not have to remember and could directly establish a connection between an increased stress level and a specific activity.

Input of activity data

The previously mentioned point benefits from a complete record of the user's activities. This could be fostered by further development of the web app. Provided that the web app automatically retrieves the fitness tracker or smartwatch data at a certain frequency, it could proactively alert users currently experiencing an increased stress level. Users could then be offered the opportunity to directly enter the activity they just performed that has triggered stress. Of course, it must be ensured that these notifications are freely adjustable for the users, as they could potentially lead to even more stress.

Timing of new recommendations

Further development of the web app using machine learning could also be helpful. An exemplary application for this would be an individualized timing for the recommendation of new stress coping strategies. Artificial intelligence could learn when a user usually carries out activities that stress him or her and make certain recommendations at this time or shortly before or after.

Personalized recommendations

Building on the previous point, it would be a great addition if the recommendations were tailored to the user [22]. For example, the user's age or circumstances should be taken into account. In addition, artificial intelligence could learn in which situations what kind of recommendations are helpful. A recommendation loop could be used for this purpose, which asks the user whether a recommendation just given was helpful.

Gamification

Since the use of gamification in health apps is still a controversial issue, further exploration of it in stress management apps would be appropriate. There are a variety of different ways to use gamification that should still be explored in this context.

Questionnaires

The questionnaires for the pre-study and for the study were created with Google Forms. The pre-study questionnaire was filled out by participants while using the interactive wireframe prototype. The pre- and post-survey questionnaires were sent to the participants by email. The pre-survey was filled out before starting the 14-day study, the post-survey was filled out afterwards.

General questions

After viewing the app's dashboard, please answer the following questions

* Required

1. Your gender: *

☐ Female

☐ Male

2. Your age: *

3. What is the main function of this app? *

4. Which color scheme do you prefer? *

☐ 1

☐ 2

Operation of the app - stress comparison

Follow the instructions and evaluate the complexity

5. Compare your weekly stress levels from the current and last week. *

	1	2	3	4	5	
easy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	complicated

6. Compare your stress levels from the last two days. *

	1	2	3	4	5	
easy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	complicated

7. Compare your stress levels from the current and last month. *

	1	2	3	4	5	
easy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	complicated

8. Get extra information about the graph of your computed stress levels. *

	1	2	3	4	5	
easy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	complicated

Operation of the app - recommendation loops

9. View your recommendations. *

	1	2	3	4	5	
easy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	complicated

10. Let's say you did the first recommendation and found it helpful. Add it to your strategy. *

	1	2	3	4	5	
easy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	complicated

11. Let's say you don't want to do the other recommendation. Delete it. *

	1	2	3	4	5	
easy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	complicated

12. Let's say you want to have the deleted recommendation back. Restore it. *

	1	2	3	4	5	
easy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	complicated

Concluding questions

13. Do you think this app could help you to improve your stress awareness? *

	1	2	3	4	5	
not at all	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	absolutely

14. Do you think this app could help you to reduce your stress levels? *

	1	2	3	4	5	
not at all	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	absolutely

15. Do you have any additional comments or suggestions?

Stress awareness and coping

This short survey is part of the Stila study on stress awareness and coping. It will only take around 5 minutes. If you encounter any issues, please don't hesitate to contact us: stila.study@pms.ifi.lmu.de

* Required

Please rate the following statements regarding your stress awareness on a scale of 1 to 5.

Stress awareness: Recognizing what's causing you stress and how much stress you experience at any given time.

1. I have a good awareness of my current stress level. *

	1	2	3	4	5	
strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	strongly agree

2. I have a good understanding of what causes me stress. *

	1	2	3	4	5	
strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	strongly agree

3. I have a good awareness of the development of my stress level over time. *

	1	2	3	4	5	
strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	strongly agree

Please rate the following statements regarding your stress coping on a scale of 1 to 5.

Stress coping: A method of limiting stress and its effects by learning ways of behaving and thinking that reduce it.

4. I know some constructive stress coping strategies. *

	1	2	3	4	5	
strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	strongly agree

5. I use constructive stress coping strategies to reduce my stress level. *

	1	2	3	4	5	
strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	strongly agree

6. I am open to trying new stress coping strategies. *

	1	2	3	4	5	
strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	strongly agree

General
information

Please give us some general information about yourself. Remember: all information is anonymize and evaluated for research purposes only.

7. Age: *

8. Gender: *

☐ Female☐ Male☐ Diverse

9. Matriculation number

Please only fill out your matriculation number, if you want to collect 6 MMI points after finishing the study.

Questionnaire – Stress awareness and coping

* Required

Thank you for participating in our study. Your two-week participation is now over. Please fill out the final survey (duration approx. 5 - 10 minutes).

Stress awareness

1. I have a good awareness of my current stress level. *

	1	2	3	4	5	
strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	strongly agree

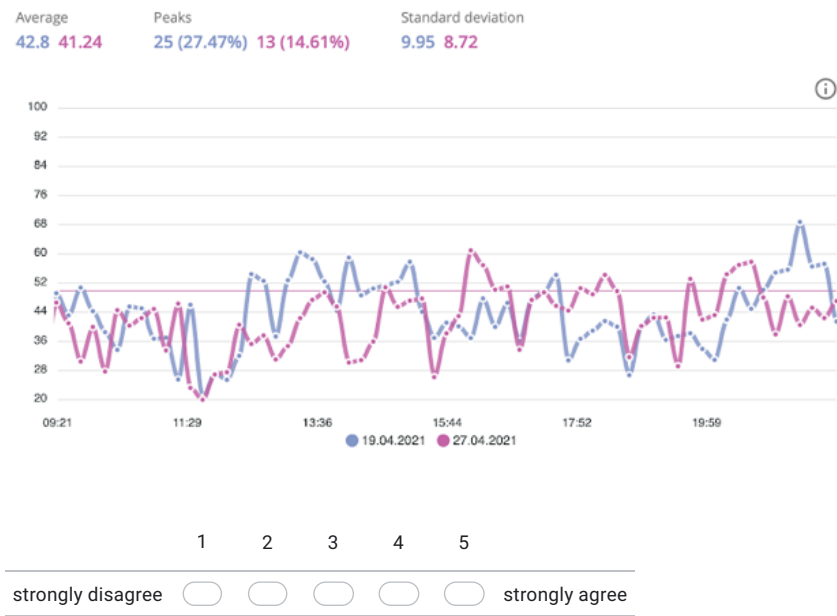
2. I have a good understanding of what causes me stress. *

	1	2	3	4	5	
strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	strongly agree

3. I have a good awareness of the development of my stress level over time. *

	1	2	3	4	5	
strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	strongly agree

4. This chart increased my stress awareness (Comparison of computed stress data).*



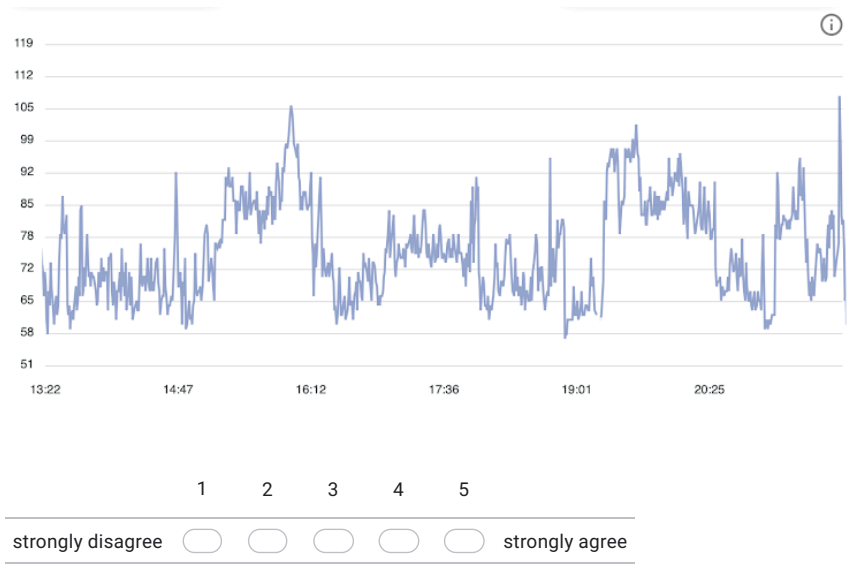
5. This chart increased my stress awareness. (Data of computed stress) *



1 2 3 4 5

strongly disagree ☐ ☐ ☐ ☐ ☐ strongly agree

6. This chart increased my stress awareness. (Data of heart rate) *



7. The web app has improved my stress awareness. *

1

2

3

4

5

strongly disagree

strongly agree

8. Viewing my stress levels daily has reduced my stress level. *

1

2

3

4

5

strongly disagree

strongly agree

Recommendations

This section covers questions about the web app's recommendations

9. Which of these recommendations did you try? *

- ☐ Do some sports, like jogging or fitness exercises.
- ☐ Get together with a friend or family member.
- ☐ Go outside and take a walk.
- ☐ Do some physical exercises like stretching while working or studying.
- ☐ Meet a friend outside and grab a coffee or tea.
- ☐ If something bothers you, concentrate on dealing with your problem.
- ☐ If something bothers you, talk to someone about it.
- ☐ Try guided meditation.
- ☐ Do some yoga.
- ☐ Try to avoid alcohol, if you feel stressed. It is not an effective coping strategy.
- ☐ Try to eat more healthy. Add more fruits and vegetables to your meal plan.
- ☐ Take a break. If news events are causing your stress, don't listen to or watch the news for a while.
- ☐ I didn't try any recommendation.

10. Which of these recommendations helped you to lower your stress level? *

- ☐ Do some sports, like jogging or fitness exercises.
- ☐ Get together with a friend or family member.
- ☐ Go outside and take a walk.
- ☐ Do some physical exercises like stretching while working or studying.
- ☐ Meet a friend outside and grab a coffee or tea.
- ☐ If something bothers you, concentrate on dealing with your problem.
- ☐ If something bothers you, talk to someone about it.
- ☐ Try guided meditation.
- ☐ Do some yoga.
- ☐ Try to avoid alcohol, if you feel stressed. It is not an effective coping strategy.
- ☐ Try to eat more healthy. Add more fruits and vegetables to your meal plan.
- ☐ Take a break. If news events are causing your stress, don't listen to or watch the news for a while.
- ☐ No recommendation helped me.

11. Overall, the recommendations have helped me to lower my stress level. *

	1	2	3	4	5	
strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	strongly agree

12. The recommendations were shown to me at a convenient time. *

	1	2	3	4	5	
strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	strongly agree

13. The recommendations were shown to me in an appropriate frequency. *

	1	2	3	4	5	
strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	strongly agree

User Experience

14. Did you use the web app mainly on mobile or on desktop? *

☐ Mainly mobile

☐ Mainly desktop

15. The web app was easy to use. *

	1	2	3	4	5	
strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	strongly agree

16. The web app was easy to learn. *

	1	2	3	4	5	
strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	strongly agree

17. The important app features were quickly accessible. *

	1	2	3	4	5	
strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	strongly agree

18. I understood every information in the web app (at the latest after I have read the additional information). *

1 2 3 4 5

strongly disagree ☐ ☐ ☐ ☐ ☐ strongly agree

19. The log in badge motivated me to log in everyday. *

	1	2	3	4	5	
strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	strongly agree

20. I perceive the web app to be trustworthy. *

	1	2	3	4	5	
strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	strongly agree

General information

21. Age: *

22. Gender: *

☐ Female

☐ Male

☐ Diverse

23. Matriculation number:

Please only fill out your matriculation number, if you want to collect 6 MMI points after finishing the study.

24. Additional comment

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