

Dynamic Balance

Designing an interface for a personalized e-health solution aimed at individuals with ASD

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Abstract

The Dynamic Balance project focuses on development of an emotion management application for people with autism as well as research on design techniques and sensory preferences in context of ASD. First, both the scope and the problem of this project are defined and explained. Then, relevant literature research is first conducted, followed by a review of existing technologies in the field of emotion management. Results of the literature search suggest that simplicity in design, clarity of feedback as well as consideration of user's individual preferences are the key pillars of designing software in this context. In the method section, the choice of iterative design approach is discussed and requirements are set up. The first iteration of the app is a mockup that highlights the functionality of the application. The second prototype contains screen designs of the application, and the third prototype is the implementation of those screen designs in an actual mobile application form. From first iteration to the final design, the changes are made based on user as well as expert and use-test survey evaluation results: blue has been made a primary color, styles of "stress-symbols" has been changed, and a possibility of audio recording has been made. The final iteration of Dynamic Balance is a system of two applications: mobile and wearable, with ability to save stressful moments, evaluate those moments and reflect on them. The system has various customization options such as color and style of UI elements. After the final design is made and evaluated, the answer to the main research question of this project is given based on results of evaluation and topic research.

Acknowledgements

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Introduction

Autism is a developmental disorder that is usually discovered in an individual at between two and three years of age. It causes development of social impairments such as lack of social intuition and understanding of social norms and communication (Lord, Risi et al. 2000). As of 2014, there are 25 million people diagnosed with ASD worldwide, with the percentage of ASD diagnosis among young children being 1.5% in 2014 (Centers for Disease Control and Prevention, 2014). Autism is a serious disorder, which presents severe challenges to everyday life. With ASD, any stressful situation can possibly cause a serious meltdown. A meltdown is a response of an autistic person to a complicated, overwhelming situation, possibly causing withdrawal, avoidance, aggression and loss of behavioral control (The National Autistic Society, 2018). Meltdowns can become quite intense, damaging and unpredictable, considering how people with autism struggle with recognizing their emotions.

The supervisor of this project, Jelle van Dijk is a design-researcher at the University of Twente. His research focuses mostly on embodiment theories and healthcare-related solutions for individuals with ASD. Jelle also has a connection with a few healthcare institutions, and have work on the concept of an emotion-management application that is aimed at individuals with ASD and encourages emotional self-reflection for quite some time. In an earlier project a concept was developed of Dynamic Balance has been developed (Mencke, 2017).The idea is to combine wearable technology that is able to track physical properties of a human body with user input and a machine learning algorithm and create service that allows users to reflect on their emotional states and is able to prevent meltdowns through learning about experiences of the user.

Even today there are many systems that combine wearable technology such as smart watches and fitness bracelets capable of measuring body data with mobile applications. Such applications with their IOT approach to emotion management provide their users with guidance and awareness about their emotions. There are even specialized mood management applications on the market for people with bipolar disorders, problematic anger control, etc. Furthermore, there is computer software designed to improve emotion recognition in individuals with ASD (Wainer, Ingersol, 2011) as well as mobile

applications (Leijdekkers, Gay, 2013). However, there is no such specialized, automated mobile software when it comes to ASD with a focus on personalization and reflection, which uses wearable technology combined with mobile software.

Designing for people with developmental disorders requires a special approach. Currently, there is a wide amount of literature and studies available about sensory, psychological, social and cognitive qualities found in individuals with ASD, but even though, there is research conducted with relatively big sample sizes, and some conclusions could be possibly drawn, researchers state that their findings still cannot be generalized. It is impossible to draw generalized conclusions on what individuals with autism like or dislike, on how they perceive the outside world or interact with it. Therefore, the key to designing in this context is an individual approach to the user, with consideration of their needs, preferences, habits and lifestyle.

The aim of this project is to develop a working prototype for the original concept of Dynamic Balance, perform a detailed research on functionalities and interactions that could be implemented in the system and develop a new version of the graphical interface for both smartphone and wearable modules of the system, a personalized helper for people with ASD, which is able to track levels of stress of the user and has a meaningful, clear and effective user interface. As mentioned above, the system has two components, which closely work together: an app for an android watch, and a smartphone app. The watch measures heartbeat and uses a machine learning algorithm to investigate stressful moments and later use that information to prevent them. Another important feature is tapping on the screen of the watch to save user's current state, so it can be saved and later compared to other states from the database. The application on the phone, in addition, "calls" the user when the meltdown gets close, listening to the data incoming from the watch. The user is also free to customize the app however it fits him/her, add captions and images to saved states, manage those states and record audio or video messages, which will be played when the meltdown is close and the app generates a "call" (Mencke, 2017).

What also sets the whole system apart from similar applications is the built-in machine learning algorithm, which is currently being developed by Ralitsa Spasova, a master student of Artificial Intelligence at the Radboud University Nijmegen. Individuals with ASD are not highly skilled in recognizing their

emotions as well as threats incoming from the outside world. The watch gadget, on the other hand, is only capable of measuring its user's heartrate. However, the idea is that, in the beginning of usage, there is a calibration period, where both the user and the system try to figure out what makes a situation stressful, considering things like heartrate, temperature, time, etc. So, in a way, this application rewards consistent feedback from the user, by becoming "smarter" and more personalized. The promise of this project is that such a system could really become essential in one's life if used properly and consistently.

Therefore, the research question is:

"How should UI of an emotion management application for individuals with ASD be designed to provide a useful, meaningful and positive user experience that encourages reflection and allows options for personalization?"

And sub-questions are:

- 1. What are the requirements for designing UI for people with ASD?
- 2. How to effectively design for personalization without making the product and the process complex?
- 3. How should the UI and functionality of a mobile application be designed to provide a positive user experience for and support the user?

Method

Design approach

To successfully answer the research question and design a system that provides the user with meaningful, personalized experience and respects the user's freedom. Looking at the project from this perspective, it becomes apparent that such design approach could become successful if there is strong connection between a designer and the target user. Testing prototypes together with the user and receiving critical feedback could propel the progress of development and the margin of change between older and newer design iterations to big heights, and therefore, in this project the feedback from the user as well as the

target audience is essential to the whole design process. Furthermore, by connecting and working together with the target group, the designer is able to understand user's struggles and overall qualities better, as well as become more empathetic towards them.

Firstly, to better understand the context of the problem as well as needs and preferences of the target audience, a literature and state-of-the-art reviews have been conducted. Literature reviews were focused on sensory perception as well as design techniques and requirements for individuals with ASD, and the state-of-the-art review was focused on relevant technology existing within the context of this project.

Such a system with emphasis on individuality and personalization will have some important requirements that in the end will have to be met. An effective way to create a well-rounded and polished product is use the iterative design technique. Because there are three major powers at play: the client, the user and the designer, the communication has to be continuous, and the designer has to get a lot of feedback from both the user and the client, combining it to improve the system.

The system, therefore, will be designed through a number of iterations. Once a prototype is shown to and tested with the user and once the client reviews the design of the prototype and progress of its development, feedback that is gathered by the designer will be used to correct, improve and develop the current prototype into the next iteration, and then the cycle of testing-reflecting will repeat again.

There are three main aspects, in which the evaluation of a prototype is done: usability, customizability and functionality. State of usability will be evaluated by assessing the system using these guidelines (Nielsen& Bellcore, 1993):

Usability	The system is easy to use, allowing the user to effectively use the system after a short period of time with it.
Efficiency	The system is efficient, letting the user achieve a high level of productivity.

Remembrance	The system is easy to remember, so the user can easily come back to the system after not using it for some time.
Error-handling	The system is relatively error-free or error-forgiving, so that the user simply cannot make many mistakes by design, or the mistakes the user is allowed to make are minor and have little effect on how the system works.

Moreover, because of the aim of this project, personalization options and customizability are also key aspects of the system. As mentioned before, it is quite hard to make generalized conclusions about how to design for individuals with ASD, and how important individuality is in this context. The personalization aspect will be evaluated during user testing by letting the user reflect on the customization properties of the system. Even though customizability is so essential, the first priority is still usability, since it is not efficient to make an overall problematic product customizable (Schade, 2016). To evaluate customizability, the user will answer questions about his/her satisfaction with the amount and quality of options for personalization that are already available and give suggestions on what they personally would like to see in the next iteration or a final product. Functionality is also very important. The system has to fit all the functional and technical requirements set by the client. Furthermore, the designer would also have to get feedback from the user on the subject of possible improvements and additions in context of system's functionality.

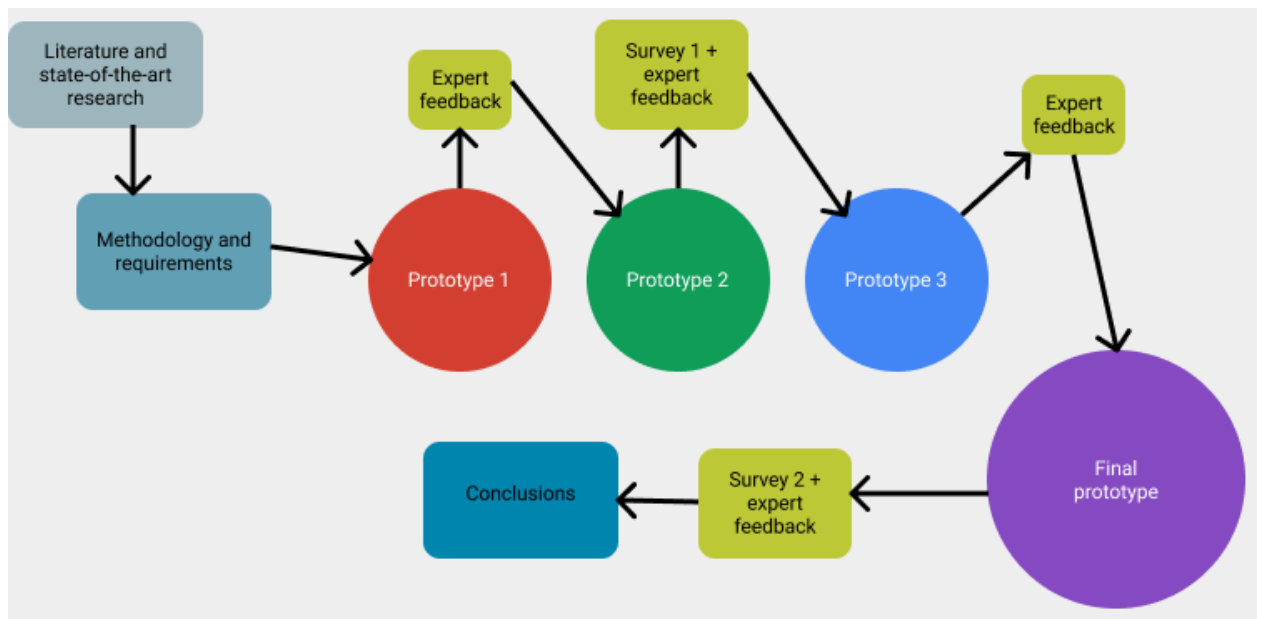


Figure 1: Infographic of the design process

Requirements

Functional requirements for the system discussed in this work are:

Requirement	Description	Source
1.Real-time feedback (functional)	Both wear and mobile application's home screens shows a clear real-time evaluation of the user's heart rate.	Dr. van Dijk, survey participants
2.Savable moments (functional)	It is possible to tap on either the circle on a wearable or on a phone to right away save a moment with time, intensity and name as properties on a local database.	Dr. van Dijk
3.Moment manipulation (functional)	It is possible to tap on either the circle on a wearable or on a phone to right away save a moment with time, intensity and name as properties on a local database.	Dr. van Dijk, survey participants
4.Personalization (interface)	The application allows the user to personalize it by changing the color of the UI and picking a set of symbols which are going to represent intensity of a moment.	Dr. van Dijk, survey participants, Fletcher-Watson (2016)
5.Audio messages (functional)	The user can record an audio message for him/herself in the application.	Dr. van Dijk
6."Call" function (functional)	The user will receive a "call" notification from an app with his/her pre-recorded message upon accepting the call.	Dr. van Dijk
7.Simple design (interface, user experience)	The application's design should be simple, intuitive, non-distracting and should allow the user to feel calm while using it.	Bartoli, Garzotto et al. (2014), survey participants

Background research

ASD and technology

Some studies have provided us with strict design guidelines for applications and software aimed at individuals with ASD. Bartolli suggests, that three main guidelines for designing a system that has to stimulate psychological and physical development in children with autism are: availability of evolving tasks, unique goals and availability of instructions, rewarding experience, dynamic stimuli, simple graphics, clear audio and understandable transitions (Bartoli, Garzotto et al. 2014). The tasks provided by such application have to be ever evolving to stimulate development progress effectively, each goal has to be concrete, explicit and unique, suited to achieve a given objective and the child has to understand the goal before using the system. Bartolli also adds that avateering can increase the productivity of the app, since the child could associate him or herself with someone in the digital space. In addition, Grynzspan (2008) suggests that individuals with autism are more effective in learning from an application when the design is simple and understandable, and not complex and entangled. Moreover, Fletcher-Watson (2016) makes suggestions regarding the principles for developing mobile software targeted at people with ASD. According to Fletcher-Watson, personalization and formative evaluation are major principles in this context, it is important that the design team doesn't make any assumptions regarding the preferences of the user while designing the application and also designs the product through multiple iterations and demos evaluated by the target group to ensure that the interface is appropriate and understandable. (Fletcher-Watson, 2016).

Sensory abnormalities

Overall sensory perception in individuals with autism is abnormal. Leekam et al. (2007) notes that out of 200 tested individuals with ASD, over 90% had sensory abnormalities. Even though it's not exclusive to autism, research shows that ASD patients are more likely to have sensory disorders, and these findings persist across a variety of age and IQ. In addition, Klintwall et al. (2011) points out that 76% of tested preschoolers with autism shown signs of sensory abnormalities. Furthermore, subjects that have not reached the threshold for being diagnosed with autism spectrum disorder having autistic features

exhibited much lower levels of sensory abnormalities. These findings could be linked to the fact that autistic individuals tend to develop atypical neural circuitry, which could cause them to be either hypo or hypersensitive to various stimuli. Tomchek et al. (2007) adds that the reason for systematically abnormal visual perception could be the atypical operation of superior temporal sulcus (STS) within dorsal visual stream.

Color perception

Even though not critically, color perception in children with ASD is different from color perception in healthy individuals. However it cannot be considered completely atypical, according to Franklin et al. (2008), children with ASD are less accurate with their color memory, color-based search and chromatic detection. Furthermore, even considering said differences in color perception accuracy, categorical color perception appears to still be intact in children with autism. Simmons et al. (2009) adds, that the tests have also shown that children with ASD are weaker at memorizing color compared to a group of normally developed children. In addition, according to Ludlow et al. (2014), adolescents with ASD identify chromatic stimuli less efficiently, and chromatic discrimination in children with autism is reduced, when compared to the results of a group of typically developing children. There are still no clear reasons for such differences in color perception, however, potentially these could be caused by atypical anatomical and functional organization of the brain as well as color obsessions being common in autism. Also, it is worth noting that tested group cannot represent the whole population precisely, since there is a lot of room for individual qualities in every tested subject.

Color preferences

Juvenile patients diagnosed with autism spectrum disorders show color obsessions and color preferences that slightly differ from preferences of the target group. As noted by Masataka et al. (2016), while most preferred colors among healthy adolescents were, by popularity, red, blue and yellow, and most avoided were brown and pink, the ASD group has shown slightly different results, with yellow being the most disliked option and green as well as brown being preferred more compared to the target group. However, Masataka also notes that the score for red, blue, yellow and pink was almost identical in both groups, the

number of subjects tested was not high enough to accurately represent the population and presented chromatic categories were restricted. But despite this, the results have also shown that subjects with ASD were certainly likely to avoid yellow and favor brown. Explaining this phenomenon, the author suggests that this could occur due to the fact that yellow had the highest luminance value, considering that individuals with autism tend to have hypersensitivity when it comes to visual stimuli. Furthermore, it is suggested that yellow is the most fatiguing color out of the given palette.

Shape perception

When it comes to perceiving shapes the results are also quite unique in patients with ASD. Salmanian et al. (2012) states that the group of youth with ASD that was tested with various shape recognition tasks was less accurate and fluent compared to the target. According to the findings on this study, individuals with ASD are weaker at learning new patterns, matching different patterns to the sample and recognizing meaningless shapes. The author explains it with the difference in cognitive ability between the subjects of the two tested groups. Additionally, according to Potrzeba et al. (2015), youths with ASD when tested with various generally-shaped objects did not show any significant shape bias, while healthy children, on the contrary showed it quite significantly. Even though results were still quite individual in this case, 19 of 32 children did not show any shape bias during more than half of presented tasks. When it comes to shapes in motion, Mottron et al. (2003) adds that subjects with autism were overall less efficient in visual processing. In all of articles mentioned above the sample sizes were not big enough to exclude individuality and represent the population better, so that might be the reason for such difference. In addition, the difference in cognitive abilities is mentioned, which could be another explanations for such abnormalities when it comes to shape recognition.

Summing up, it is apparent that analyzing which shapes or colors might be more or less effective in this context can be hard and inaccurate. The color preference of adolescents with ASD was proven to be almost normal, with strong avoidance of yellow. However, it is important to consider that every case of ASD is unique, and people with autism often tend to develop individual color obsessions. Moreover, autistic children are proven to be less efficient in color search, memory and recognition tasks, and less

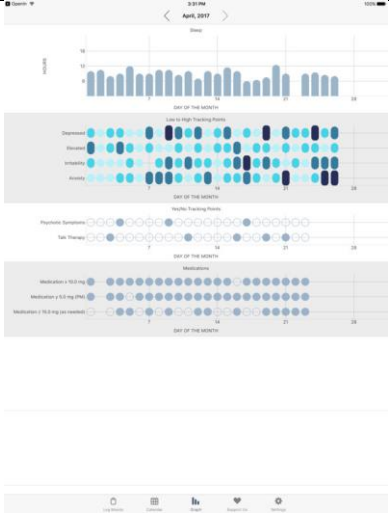
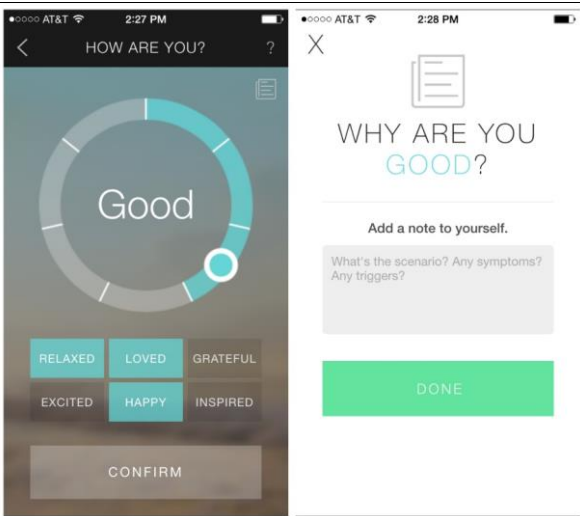
prone to chromatic discrimination. In addition, autistic individuals are less accurate in recognizing and matching shapes, and infants with ASD do not show any significant shape bias systematically. This all could be because of the fact that most individuals with autism spectrum disorders tend to have atypical sensory perception. To sum up, even though there are some systematic qualities to the ways autistic people perceive the world, it is impossible to draw a generalized conclusion, but it is clear that these individuals require a different approach when it comes to any kind of sensory stimulation. Furthermore, in context of software applications, individuals with ASD are more likely to be successful and satisfied if the user interface as well as become more skilled in using the app while the overall presentation is simple, understandable and not complex and entangled.

After analyzing relevant literature, more understanding about design with special needs has been gained, as well as a clear conclusion about the importance of individual approach and personalization in context of development for people with ASD has been drawn. It is stated in all of analyzed works, that even though there are some general tendencies and perception and behavior shared among people with autism, the role of individuality is too great to draw any conclusions based on that.

Existing technologies and related work

In order to get some understanding of the current state of existing technologies in this project’s scope as well as to get some inspiration for the ideation phase, a review of current tech and software related to the topic has been conducted. The question that had to be answered after conducting this search was: “What is the current state of software technologies in context of emotion management and how this project differentiates from it?” The following table sums up the findings.

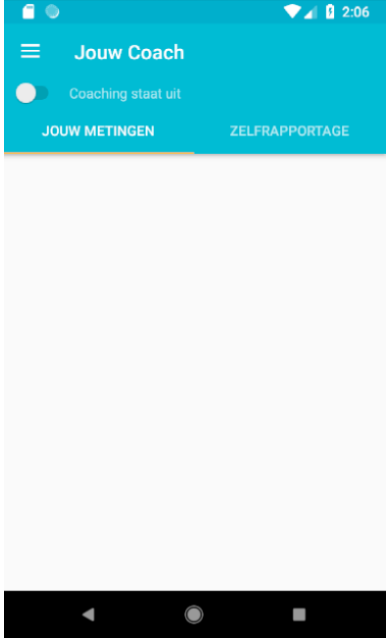
Tech	Description	
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<i>eMoods Bipolar Mood Tracker</i>	eMoods is a mood tracking app designed for people struggling with not only bipolar disorder, but depression and anxiety. It allows the user to record and reflect on their mood state throughout the day. The app also takes things like hours slept, therapy frequency which have been filled out by the user to asses one's emotional state and progress into account. eMoods is able to generate monthly "reports" in case the user wants to share their progress with a therapist. Website: emoodtracker.com	
<i>Moodtrack Social Diary</i>	Moodtrack Social Diary is a flexible journal app designed for logging mood states. Mood states can be logged as often as the user wants throughout the day and are shared publically with other users of the app. Only a paid version of the app allows for a private experience. Website: app.moodtrack.com	
<i>Pacifica for Stress & Anxiety</i>	This mobile application is designed to support people in dealing with stress and anxiety, as well as getting into meditation. Pacifica has a broad spectrum of functions such as mood tracking, though recording, goal tracking, meditation tracking and even location of nearby therapists. As a meditation app, it has built-in audio lessons and guidelines for various kinds of meditation and self-regulation. The mood tracking is done by the user rating their day manually. Pacifica also has a social function which allows the user to share their feelings and get feedback from other users of the app. Website: www.thinkpacific.com	

<i>The Feel wristband</i>	This piece of wearable technology has skin conductivity, temperature and heartrate sensors for tracking emotional well-being of the user. Data measured by the wearable is then used to calculate emotional state of the wearer, which is then displayed on a phone with a <i>Feel</i> application installed. The <i>Feel</i> application, apart from providing the user with real time feedback also gives them personalized recommendation and coaching. Website: www.myfeel.co	
<i>Beyond Verbal</i>	Beyond verbal is an API designed to recognize voice patterns and access emotional state of the speaker based on those patterns. The API is integrable into many domains of technology and is used for developing software for smartphones, wearables, robotics, and even automobiles. Website: www.beyondverbal.com	
<i>PIP</i>	PIP is a small device that measures skin conductivity. The team behind PIP currently has three apps the PIP itself is compatible with: "Relax & Race", "The Loom" and "Stress Tracker". Stress tracker logs emotional states after the user places their thumb on the PIP device and saves them. The states can then be displayed as a calendar, where each day where the PIP has been used is displayed by a pie chart of different emotions. Website: thepip.com	

<i>“Stone” by Spire</i>	Spire’s “Stone” is a wearable device that clips to clothing and measures breathing patterns. This device also has an app which uses recognized patterns measured by the clip and converts that information into a “stress level”. Website: spire.io/pages/stone	
<i>Casio pro trek</i>	This smart watch is capable of measuring temperature, movement, heartbeat and has a sim card inside. This wearable watch can be connected and used with a number of mobile apps and provides great functionality for sports, monitoring health-related issues and monitoring planned activities. Website: wsd.casio.com	
<i>Breathing stone</i>	Designed by Joost van Hoevelaak, Breathing stone is a stress monitor designed for individuals with ASD. The system consists of a wearable and smartphone application that tracks peaks of stress and help the user relax by guiding him/her through a number of breathing exercises. Stress is measured through use of a wearable that is able to measure heart-rate (van Hoevelaak, 2010).	

<i>Emotional t-shirt</i>	This t-shirt has a built-in component that measures skin conductance. Based on that, LED lights on the front of the shirt display wearer's mood in form of an emoji (van Hoevelaak, 2010).	
<i>Emwave biofeedback stress reliever</i>	This device is capable of measuring blood density and calculating pulse based on that. Also, if heart rate gets too high, the device would suggest a breathing pattern for the user to calm down and bring the heart-rate back to normal. (van Hoevelaak, 2010). Website: www.techchee.com/2007/04/29/emwave-biofeedback-stress-reliever	
<i>Driver fatigue bracelet</i>	This wearable has a built-in infrared sensor that is used to detect if the user is asleep or awake and is designed for drivers. If the driver falls asleep while wearing this bracelet, the wearable will create a mild vibration to wake him/her up. (van Hoevelaak, 2010). Website: gizmodo.com/173902/driver-fatigue-bracelet	
<i>OOC cushion</i>	The OOC cushion has a device that replicates heartrate inside of it. The heart rate generated by the device can be changed by manipulating the knob mounted on the pillow. The user can focus on the heart rate recreated by the pillow to steer away from stress or anxiety. Website: www.powertoolkit.nl/alles-over-interventies/ooc-kussen	

<i>Sense-IT</i>	Sense-IT is an emotion support application currently in development that is aimed at supporting individuals with a lack of emotional awareness. The application works on a smartwatch and a smartphone and ties the two together. Heartbeat and blood volume data measured by the smartwatch is combined to calculate arousal levels and display them on both the screen of the watch and the phone screen to make the user more aware of their emotional state. “Moments” of stress recorded by the system are saved and can later be displayed through the smartphone app, showing time, date and intensity.	
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After analyzing state-of-the art products in context of my project, it became clear that even though there are products with qualities similar to ones my project has, there are still no such no specialized experiences for people with ASD. While popular emotion/anxiety management applications are proven to be effective, according to reviews, most of them still lack automation, machine learning and connection to wearables, personalization and customization options. In addition, mostly all wearables have specific software to come with them, but none of that software offers wide functionality and deep, personalized user experience.

Design process

First iteration

Prior to this project, there was a project completed by Valerie Mencke at the University of Twente as a master thesis (Mencke, 2017). Valerie has been working under Jelle van Dijk’s supervision on early designs of the Dynamic Balance system and has went through many UI design options for both mobile and wearable parts of the system, as well as multiple realizations of the application’s functionality and customization options. This provided a first stepping stone in further designing and developing these applications, since Valerie made first visualizations of the reference circle idea, capturing its look and feel.

The project was continuously, through multiple iterations tested together with a user on the autism spectrum by showing him a video mockup prototype of the app. So, final designs and conclusions that Valerie made during her project work on Dynamic Balance has been used as a starting ground for designs and apps discussed in this work.

It was very important to get the purpose of the system as well as its requirements right.

MainActivity wear -Tap : Button -ReferenceCircle : ImageView -Time : TextView	MainActivity mobile -Burger : Button -List : Button -Settings : Button -Tap : Button -ReferenceCircle : ImageView	List -Burger : Button -List : Button -Settings : Button -Container : ScrollView -momentGrade : ImageView -name : TextView -time : TextView -Edit : Button -Remove : Button	Settings -Burger : Button -List : Button -Record : Button -Color : Spinner -Style : Spinner -Home : Button -Submit : Button
View -Burger : Button -List : Button -Settings : Button -name : TextView -time : TextView -annotation : TextView -Back : Button -gradeView : ImageView	Edit -Burger : Button -List : Button -Settings : Button -name : EditText -annotation : EditText -Submit : Button -gradeButton : ImageView -Cancel : Button -Record : Button	Record -Burger : Button -List : Button -Settings : Button -startRecording : ImageView -saveRecording : Button -playRecording : Button	Call -acceptCall : ImageView -declineCall : ImageView -pictureView : ImageView

Figure 2: A diagram representing UI elements in every activity screen of the application.

So, as can be seen in activity diagrams above, the user should be able to save stressful moments to the system with a possibility to later review, edit them and adjust the UI to his/her liking through changing the style and color of the application through the settings. Furthermore, to gain more directional ideas and inspiration, a search for existing technology has been done, which included analyzing general UI design tendencies in applications for Android Wear and designs of emotion/stress management and guidance applications for Android mobile. Moreover, since Android is a powerful and very popular platform for both commercial and independent developers, and thousands of applications get made and pushed out on Play Market every day, Google has created a foundation for Android UI design called Google Material Design (Google Inc., 2018). It contains large amounts of information on efficient use of color palettes, shapes, layouts, typography and icons in travel, business, lifestyle and even e-health

applications. Because the system has to be developed using the Android platform, Google Material Design is used as a source of guidelines throughout early stages of this project.

After primary research has been done, to put the functionality of the app on paper, an activity diagram as well as a use case diagram has been drawn (appendix). Based on that as well as on the UI from other applications for similar purposes, a number of mockup screens has been made using Balsamiq (Balsamiq Studios, 2018).

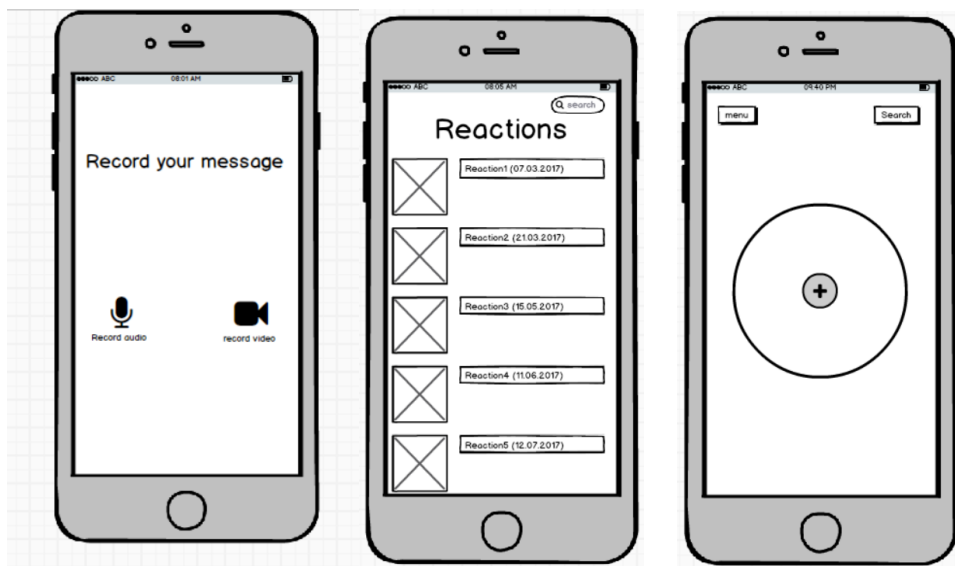


Figure 3: Mockup screens created in Balsamiq.

These mockups were used to generalize early ideas about the UI and how the app is going to look like as well as some usage properties. There were six screens created – one for every key function of the app: home menu for saving states inspired by the circle in designs of Valerie, a reaction list screen with every saved moment and a picture assigned to it, record screen where audio and video messages are recorded, an alert screen representing the pop-up when the measured stress-level is high, an edit/upload screen for a saved moment with ability to attach a photo or video and add a reflection and a settings screen with various setting options.

Evaluation

These mockups were then reviewed by a supervisor of this project, Jelle van Dijk, and his suggestions were very useful in making a transition to the next iteration of the app. The first suggestion was to make the

notification screen look like a regular call. That would make the notification less provoking as well as mask it for people around the user. The call would also contain an “answer call” and “decline call” buttons that look similar to the ones a user sees when receiving a regular phone call. The call screen would also be decorated with a background picture that a user can choose deliberately. Also, one of the suggestions was to make some editing/removal options available on the list screen to improve usage flow and cut unnecessary steps to perform moment editing.

Results of the first evaluation have helped to better understand the app’s future development direction as well as get more ideas about functional relations within the app. The next iteration was mostly built off the first prototype, with call and list screens still requiring some re-design. The mockups, even though very basic, also provided some layout guidelines for further iterations, with an emphasis on functionality.

Problem	Possible solution
The call from the app should look like a regular phone call	Re-designing the call screen and getting rid of notification-like design.
List screen doesn’t allow for moment manipulation	Adding edit, view and remove options/buttons to every element in the moment list
List screen doesn’t show intensity of moments	Adding symbols to represent intensity and displaying them on every element of the list of moments
No personalization options	Adding more personalization options available from the settings screen

Second iteration

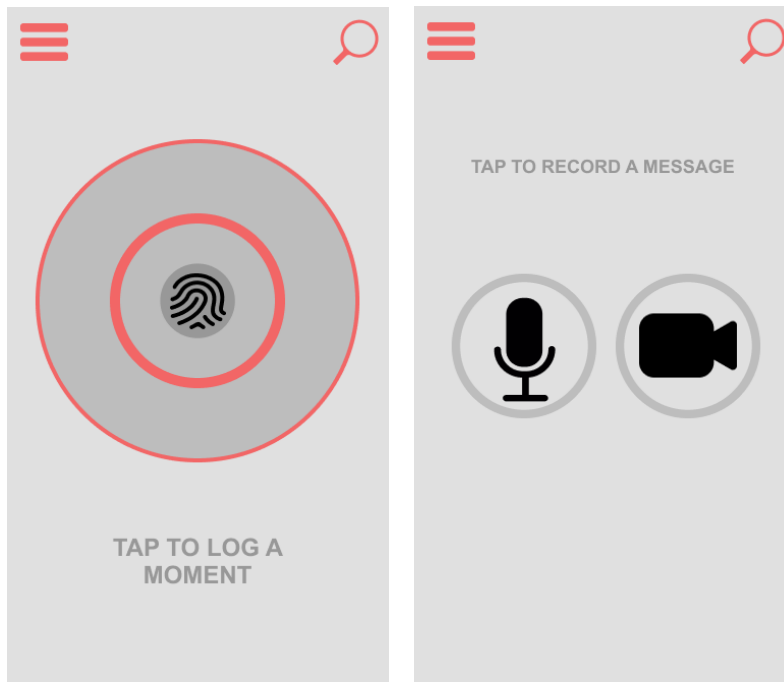
After evaluating the first prototype made in Balsamiq (Balsamiq Studios, 2018), realization of an actual Android application has begun. Android is a well-known and powerful platform, with over 2 billion devices running on it as of May 2017, and holding 86% of mobile OS market share as of Q1 of 2018 (Costello, 2018). It is easy to get into, responsive, flexible, and is an operative system that can run on smartphones, wearables, personal computers, tablets and so on. Moreover, thousands of application developers constantly share their knowledge on domains such as StackOverflow and GitHub with everyone who is interested for free, which makes realizing almost every app idea doable. There are also countless courses and lectures on the topic of Android development as well as Java development.

The project is built in Android studio IDE, the code of most of the project components is written Java, and the layout of active components such as buttons, image views, sliders and controllers is written in Extensible Markup Language (XML). Java is a class-based computer-programming class-based language used for development of PC and mobile applications, games, operative systems for machines and robots and so on. Android studio IDE does a great job of organizing both Java classes as well as XML documents into a “project tree” with an ability to link and call different classes and documents from other components of the program, as well as imported media and other files.

However, before the second prototype has been realized in Android studio into a working application with basic functionality, all of designs for icons, buttons and text views has been created in Figma, a desktop design tool application. While visually designing the application and considering the context, two things were important to keep in mind – the design of the app would have to allow various customization options (requirement 4), while at the same time the app would be designed in a non-distracting or triggering fashion (requirement 7). Since one of the requirements for the system is to assist and guide its user to a higher level of emotional awareness, it was important to also maintain a calming and comforting atmosphere. This iteration of the app had a total of 6 screens: the home screen with a circle that references user’s current stress state and a fingerprint-styled button in the middle of a circle that serves the purpose of saving user’s current emotional state, an “edit moment” screen, where a user would add annotations, names and change pictures of any moment, a screen with a list of moments, symbols representing intensity of each moment, a call screen that appears any time the measured stress level gets to a critical point, with two buttons to decline and accept the call, a settings screen where the user can personalize the app by changing the color of the UI as well as other other properties and a “record message” screen, where the user would be able to record audio or video messages that are used to make the “call”. Primary colors for the UI were chosen to be red and grey, since, as discussed in the relevant literature review section, some research has shown that reaction to shades of red in individuals with ASD was mostly positive. Besides, every screen has now been updated with two buttons: a search button and a menu button. The menu button is located on the top left of every screen and allows to open a small pop-up navigation menu that would allow the user to get to any screen in just one click. The search button

located on the top right of the screen would serve a purpose of finding any moment by name or id, and instantly opening the overview of it. The UI was deliberately designed to be simple and understandable, with up to only 4 interactive components per screen. By minimizing the amount of visual stimuli, it is also possible to improve effectiveness of visual feedback: the reference circle from the home menu, for example, stand out a lot more, while other UI elements are few and simple, leaving the focus on the center of the screen.

With screen designs being finished, in order to start fulfilling the requirements with this prototype, it was important to find out how to create and store moments as well as information such as annotations, dates and time on the phone, and using arrays and lists of various types of data would make the application even more complicated as well as slow it down drastically. Fortunately, Dr. Klaassen, a researcher at the University of Twente and also creator of the Sense-IT emotion management application has agreed to share some insights about development of mobile and wearable applications. The best way to store data textual data for an Android app is to use SQL databases (Claassen, personal communication). It turned out that Android has a built-in library called SQLite that allows the developer to create SQL databases with any amount of columns or rows for data storage. Also, Dr. Klaassen has shared some tips on how to manage an app with different activities and pass data between those activities without using databases. He also mentioned, that it is very important to manually allow use of body sensors and let the wearable application communicate with the mobile application.



Figures 4 & 5: Home and record screens in the second iteration

Finished Figma designs were then exported as screen images and a survey has been created to evaluate usability qualities of the application.

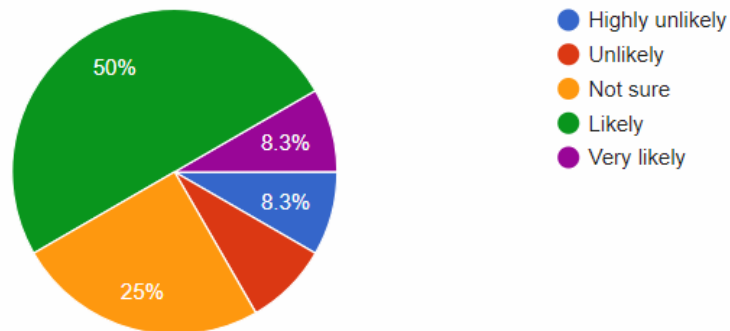
Survey and evaluation

The survey consisted of 13 questions: 10 with fixed answer options, and 3 open questions meant for getting qualitative feedback from the participants (see Appendix B2). The survey was based off of a Perceived Usefulness and Ease of Use questionnaire (Davis, 1989). The first section of the survey introduced the participants to various screen designs with short explanations of functionality attached. Even though the prototype only had red UI at the time, the participants were provided with multicolored options. The second section contained questions and fields for open feedback. The questions were set up to evaluate how supporting both the concept and the overall design were, how the requirements were met and what preferences in style options did the participants of the survey have. The survey was then posted on an ASD-related subreddit for its visitors to participate.

Response

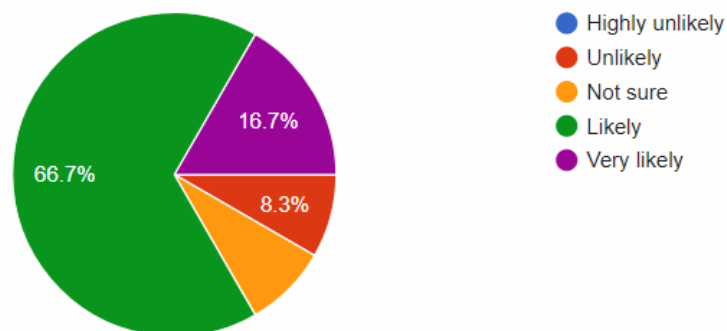
Using the system would improve my everyday life

12 responses



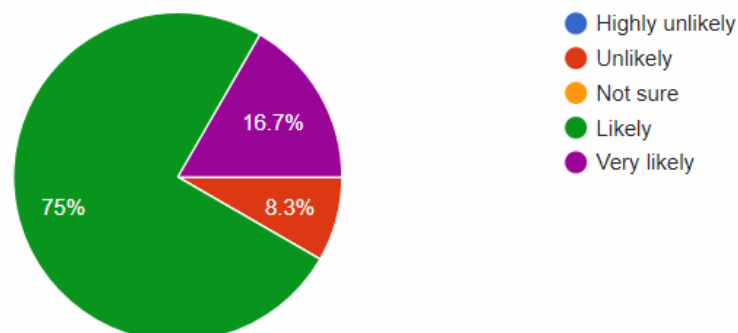
Using the system in my everyday life would make me understand and recognize my emotions and emotional states

12 responses



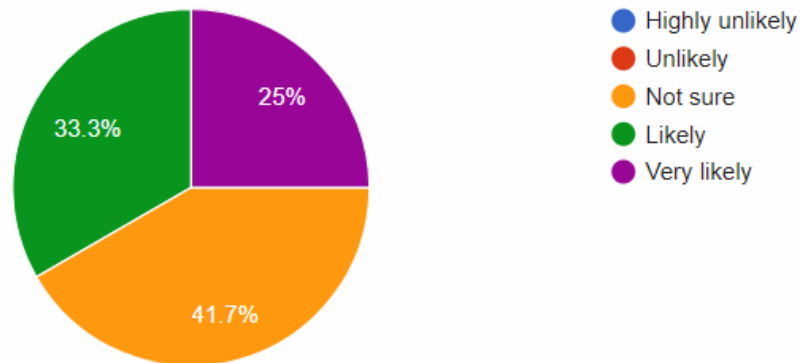
Learning to operate the system would be easy for me

12 responses



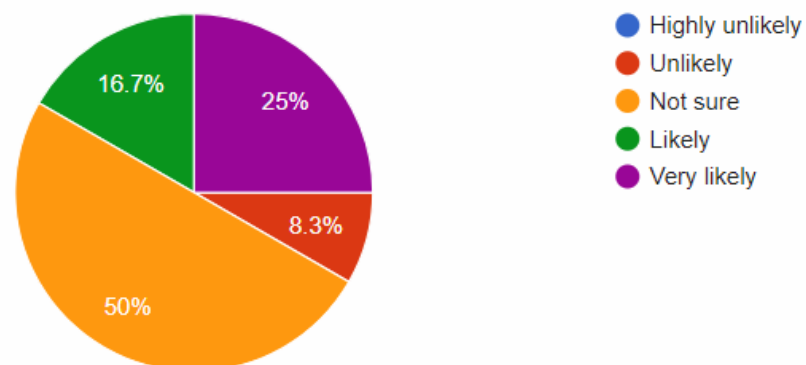
I would find it easy to get the system to do what I want it to do

12 responses



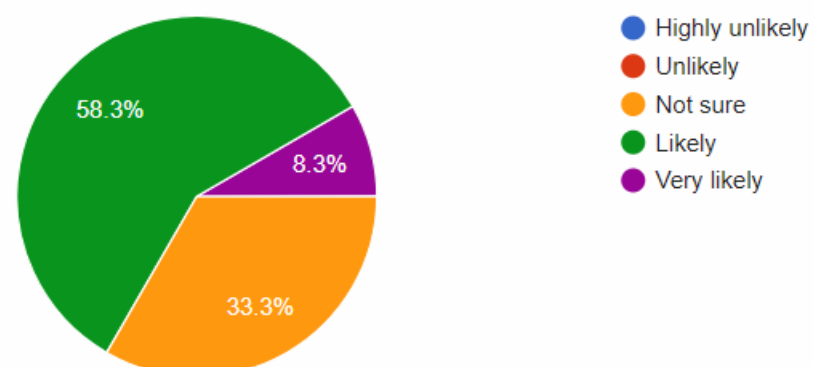
I would find the system to be flexible to interact with

12 responses



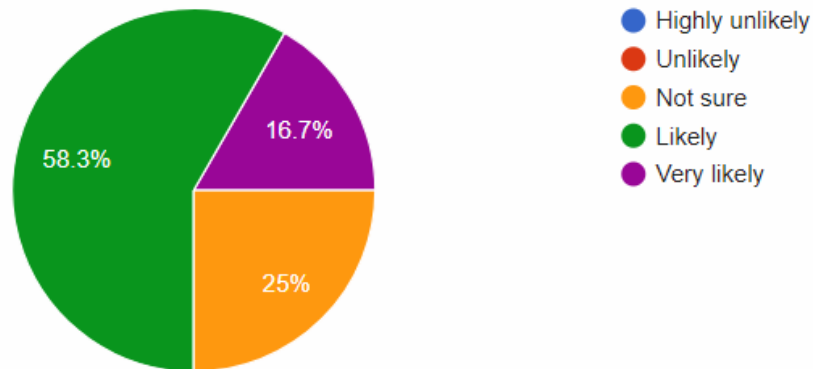
It would be easy for me to become skillful at using the system

12 responses



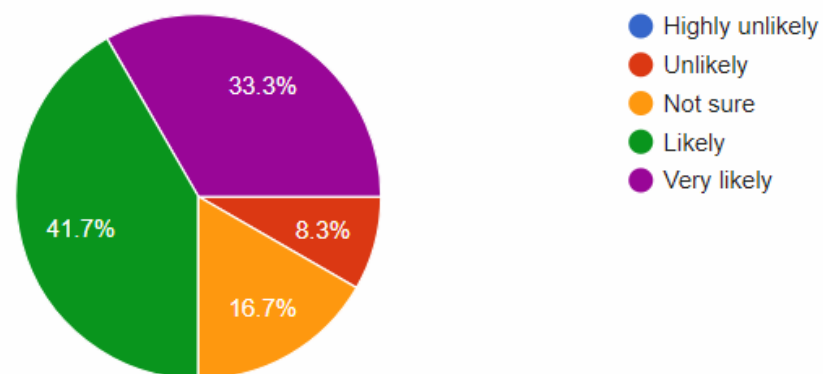
I would find the system easy to use overall

12 responses



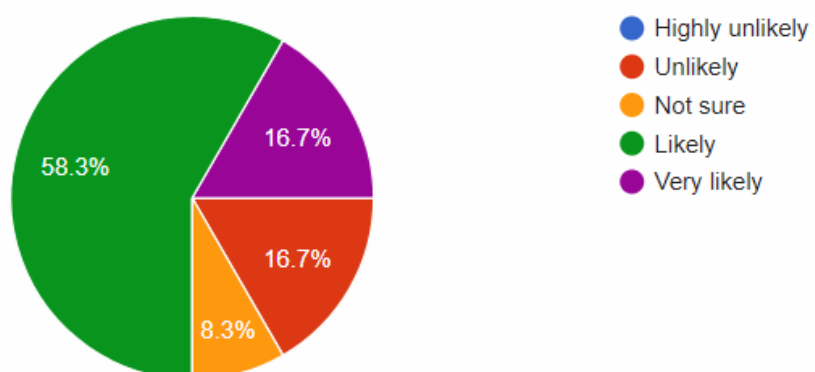
I would be satisfied with the customization options of the system

12 responses



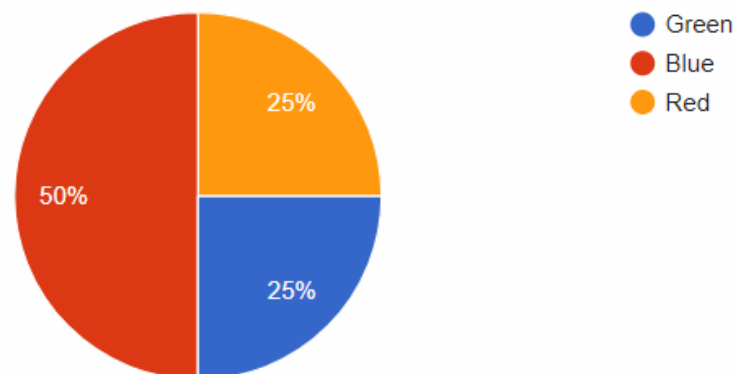
I would find the core interface (circle and symbols) clear and understandable

12 responses



I liked the ... color palette more than the other two

12 responses



The results of the survey have shown that a high percentage of participants were interested in the application and found it to be useful in context. Furthermore, the majority of participants found the user interface to be simple yet effective and intuitive, and also thought the system would be easy to use and understand, not requiring a lot of learning to operate. One of the questions was about preference in color options, and 50% chose blue, while 25% chose the green palette and 25% chose the red one. The most criticized aspect of the design was the choice of symbols representing stress levels of saved moments. While some participants found them clear and memorable, quite some found them distracting and hard to understand. Two of the participants were unsatisfied with the symbols because

They found them distracting, sharp and unclear. Furthermore, some qualitative feedback has been received in subreddit's comment section as well as in the survey itself. The participant have shared really clever suggestions like use of color gradients to represent stress and making two sets of stress representational symbols into an option in the settings menu. Furthermore, some participants suggested a color picker option, which would allow the user to pick any specific color of any color palette and apply it to the UI of the application.

Third iteration

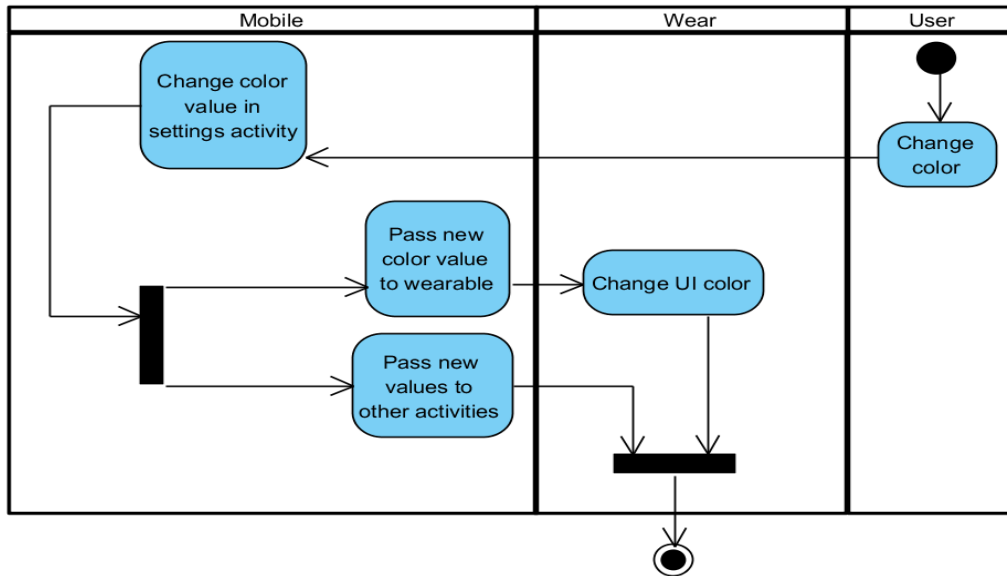


Figure 6: Activity diagram representing the color changing mechanism.

After the results of the survey has been taken into account, lots of design and technical changes were made to the prototype to turn it into a working app. First, the options for changing color were realized in the app. It is done by passing an integer with a specific value linked to color of the UI between activities. Upon starting and receiving the integer from a previous activity, current activity uses the value of the integer to “paint” its UI into one of three available colors. In this case, 1 would stand for red, 2 for green, and 3 for blue. Since most of participants of the survey have chosen blue as a preferred color option, it has been made into a primary color option.

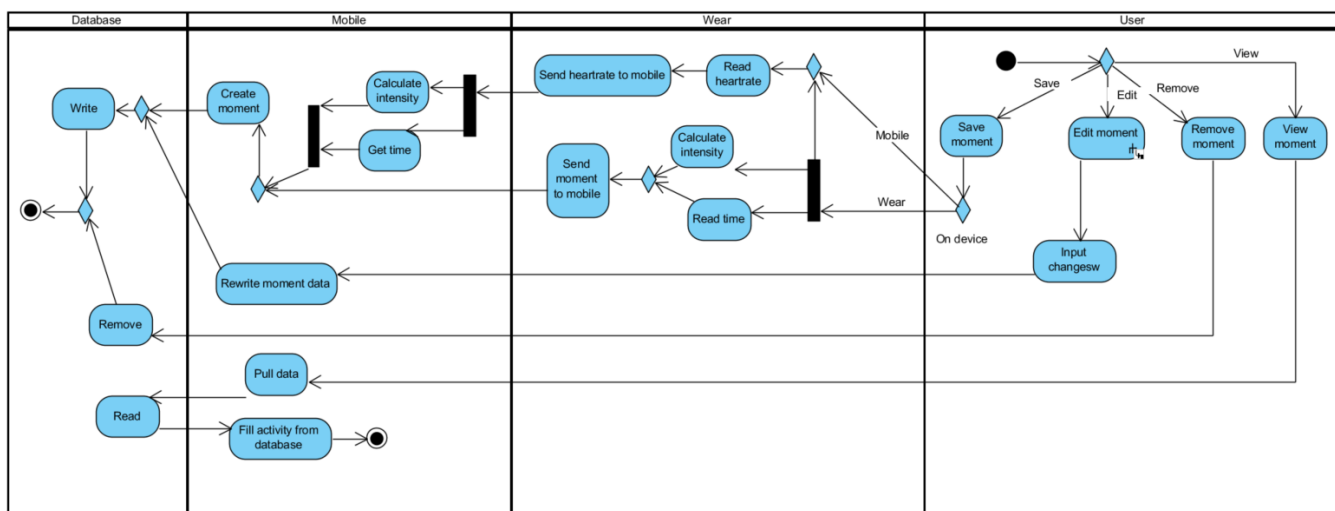


Figure 7: Activity diagram representing data creation and editing cycle in the system

The next development step was the creation of the database. Using the SQLite library, the application is now able to create upon startup an SQL database stored locally on the memory of the smartphone. The SQL database has a total of 8 columns, each for storing various properties of a moment. As seen in the diagram above, the user is able to tap on the home screen of either mobile or wearable apps to save the moment, and the application automatically stores values like intensity, time and date in the database, which is then used to also create moments on the moments list screen. By tapping on any moment in the list it is also possible to overwrite data in the database therefore adding new annotations and renaming moments.

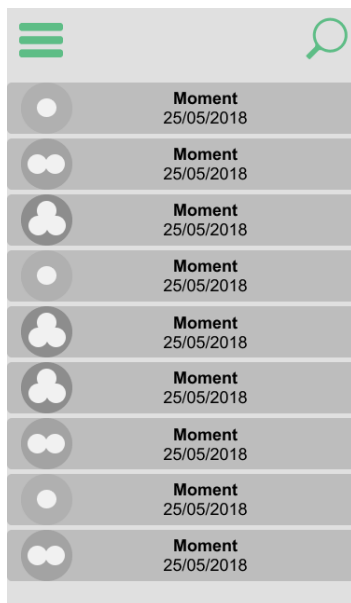


Figure 8: New design of the moments list screen after the results of the survey have been processed.

Since a change in design of symbols representing stress levels has been highly requested, a new design of these symbols was created. One of the critical points made by participants was that the symbols were too sharp and complicated, not channeling calmness and hard to memorize and understand. Therefore, new symbols were put together with circular shapes of neutral white and grey colors, and the number of intensity levels has been cut to a number of three. One circle would represent lower stress levels, two circles would represent moderate and three circles merged together would represent a high stress level.

Moreover, taking suggestions about using color gradients into account, every symbol now has a background ellipse, which shades of gray also represent levels of stress.

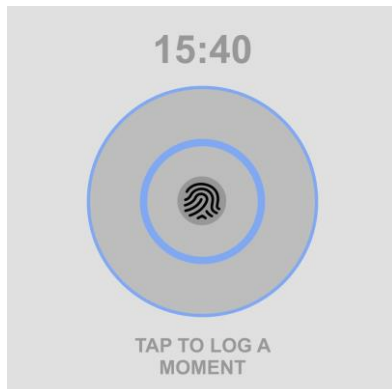


Figure 9: UI of the wearable application.

It was also important at this point to already start setting up the communication between the wearable and the mobile app. The design of the wearable screen is very similar in design to a home screen of the mobile app, since its design was taken as reference. However, the reference circle has been made smaller to fit the screen of the wearable device, and an additional TextView to show current time as can be seen in the figure above. The color of the UI would also be changed by applying settings in the phone app, since the communication between the two applications is continuous, but the primary color of the wearable app is also blue. The radius of the reference circle around the tap button is linked to the data collected by the heartrate sensor and is being updated in real-time. Then, the heartrate data is also sent to the mobile app through a Bluetooth connection, making it possible for the phone app to also have real-time updates on the emotional state of the user.

To evaluate the app, again, various use cases have been live-tested. Unfortunately, at this point in the project could not be tested together with a real user, so the evaluation has been done to only assess usability. Moreover, the phone app was the only working component out of the two, since there were some difficulties in installing the wearable application at this point. Nevertheless, the functionality of the smart watch application has been tested on an emulator, but still, the sensing part was not present since it is impossible to emulate heart rate sensors built into the watch (see Appendix C1).

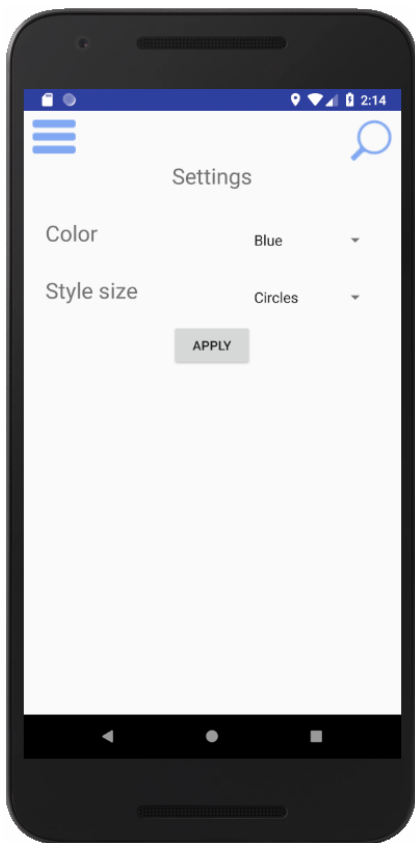


Figure 10: Emulated settings activity screen.

Evaluation

After testing and evaluating the prototype and comparing the results of the evaluation to desired requirements and goals, the following conclusions were drawn. At this state, the mobile application was able to provide the user with a color customization option present, fulfilling requirement number 4. In this iteration, there were 3 color options and 1 style option present, with the second one not yet being implemented. Moreover, at this stage, it was already possible to save moments to the database by tapping on the center of the reference circle and edit or remove them to the user's liking in the list view (requirement 2). However, since the wearable app module has not been tested together with a mobile app, the app still failed to grade moments based on heartrate. Also, the edit screen did not provide any options for changing the rank of the moment or addition of audio recordings. But even though the second requirement has not yet been met with this prototype, a timer has been implemented in the mobile app to mimic the change in heartrate without actually measuring it and in that way add to simulation moment saving. Regarding the call function (requirements 5 & 6), the implementation was not yet present at this

stage. The call activity has been developed and implemented, but since the recording mechanism was still not present in this prototype, it was not accessible to the user and served no technical purpose.

Overall, even though some requirements were not realized, this prototype has provided a good foundation for the final version of the application. With the moment saving mechanism fully working and various color and style options as requested by survey participants available, the app was able to already provide at least a somewhat complete experience.

Final design

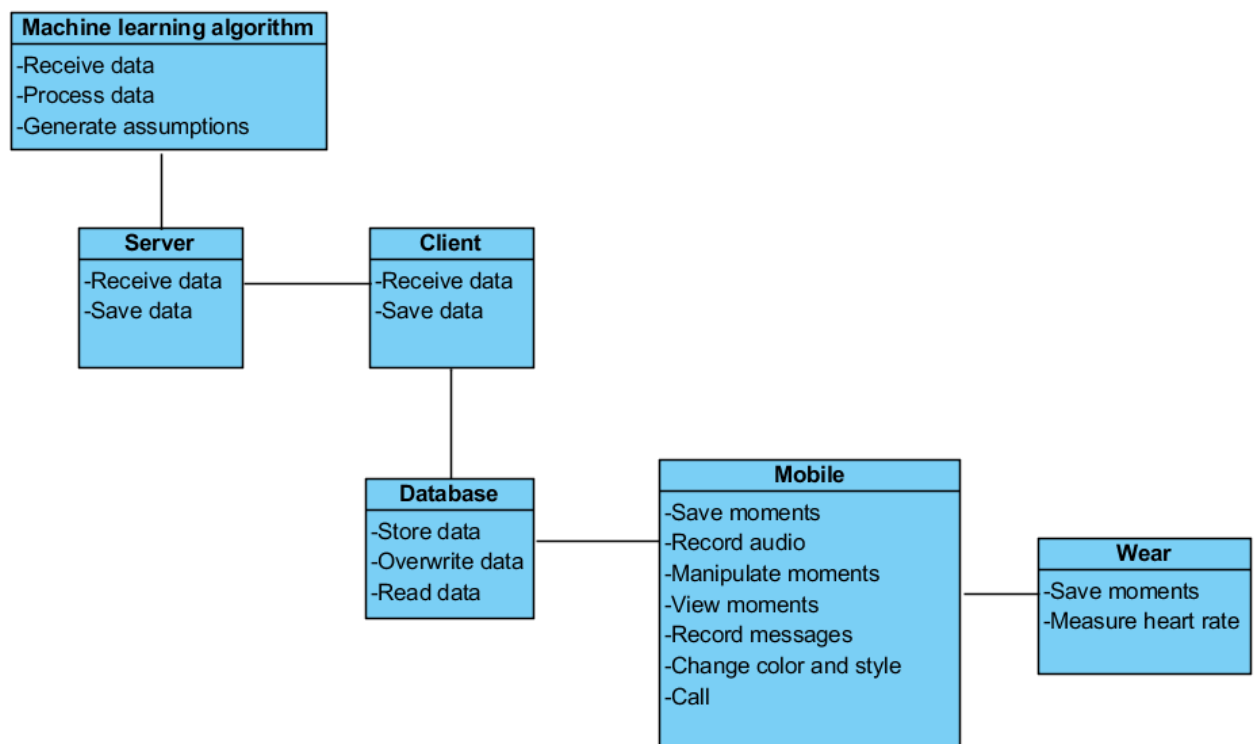
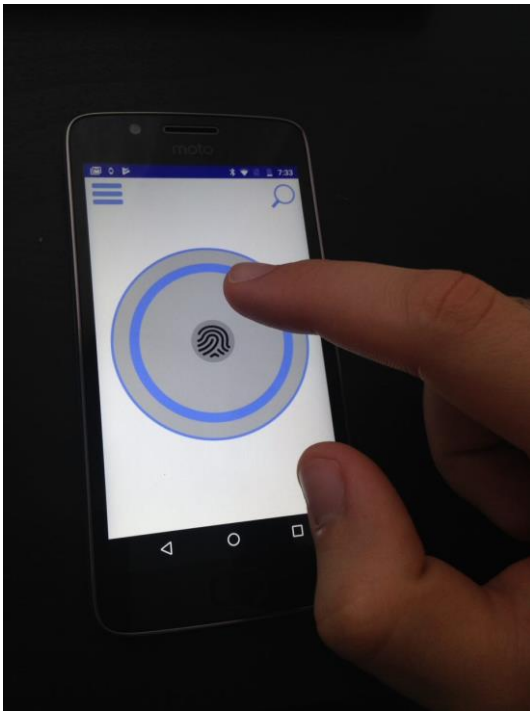
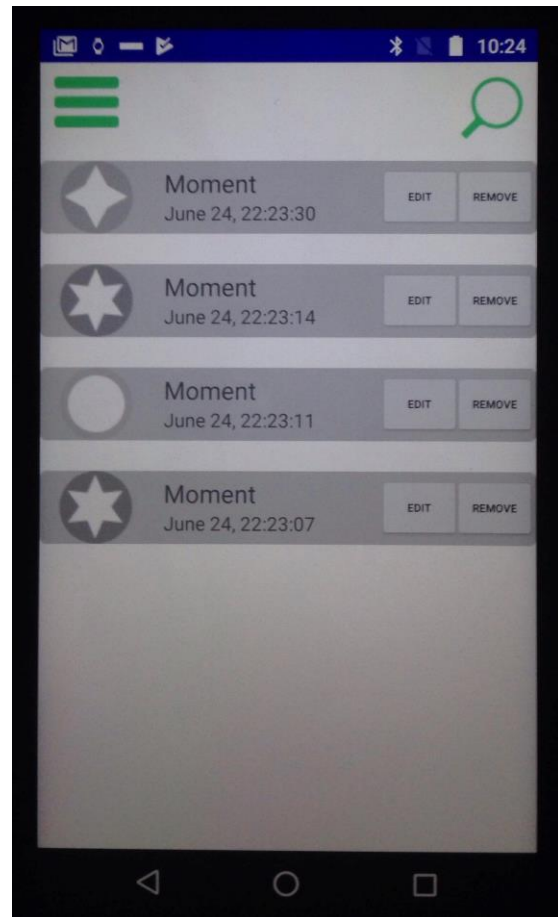
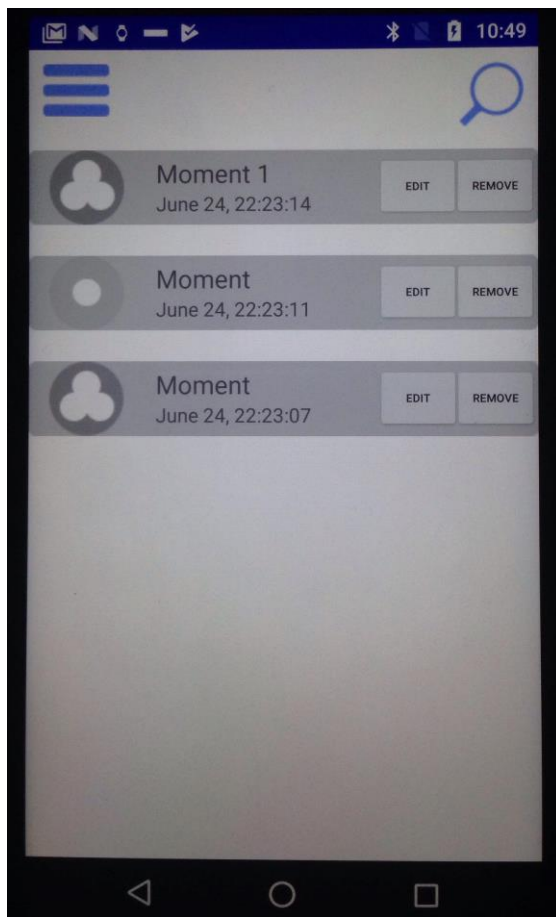


Figure 11: Diagram representing all modules of the system. Machine learning and server modules are yet to be implemented.



Figures 12 & 13: Applications running on Moto G5 and Huawei Watch 2

At this point, the core of the application has already been built, and a foundation to build upon was present. In order to fulfill all of the remaining requirements, a few functions still had to be implemented: more customization options, the “call” function, connection between wearable and mobile modules of the application, ability to change grades of saved moments and record function for audio messages.



Figures 14 & 15: Two style options as seen on the list screen

The first new function that has been implemented in this iteration was the option for changing the style of symbols in the settings screen. As discussed before, the opinions of individuals who participated in the survey have been split, and almost half of the participants were not satisfied with symbols representing stress levels and found them to be unclear and distracting. On the other hand, a considerable number of participants have also expressed their appreciation of the symbols and found them to be clear and memorable, so a choice has been made for the app to feature both sets of symbols and let the user freely switch between these two options. Furthermore, the user would now be able to set the intensity of the moment in the edit screen, also letting the system know the user's evaluation of the moment by storing it in the database (see Appendix C2). System evaluation value however always remains highlighted on the edit screen.

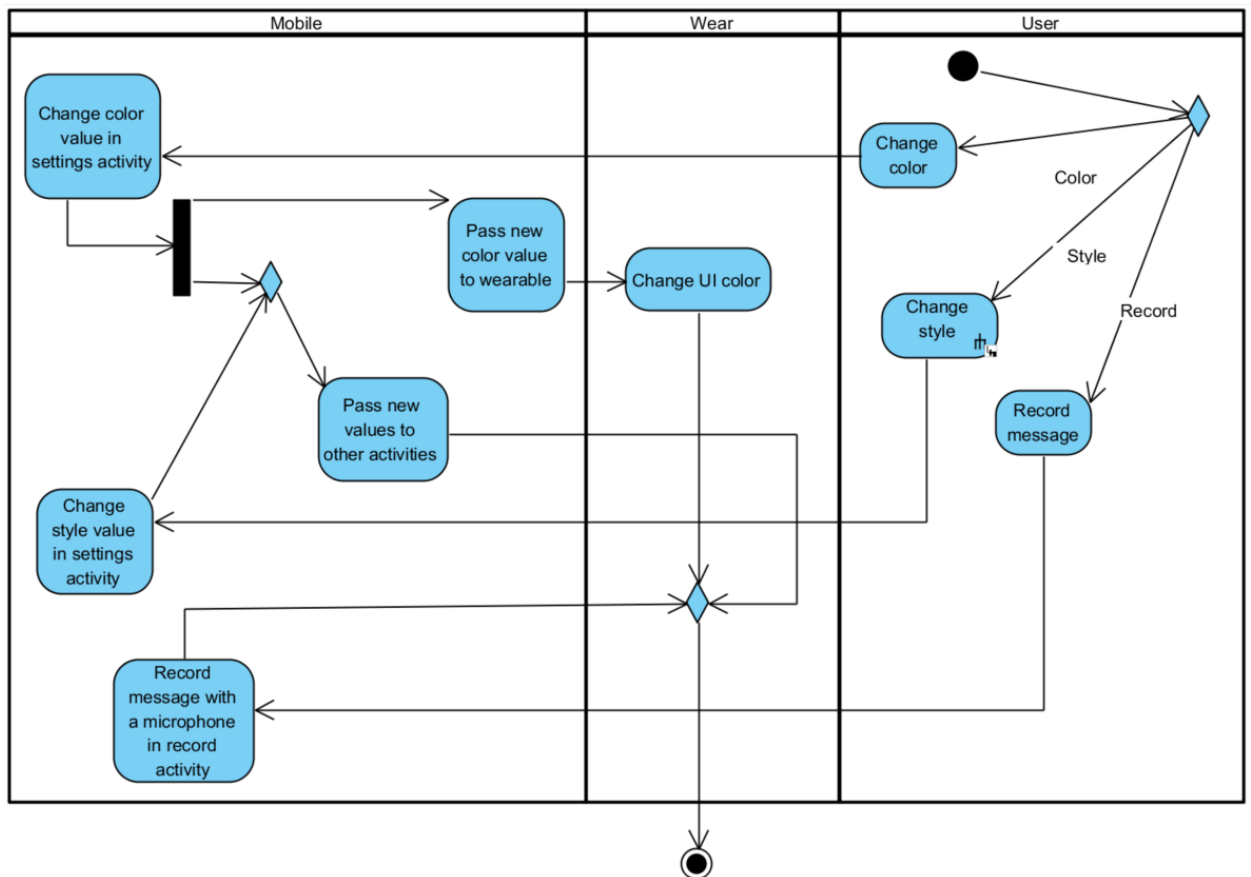


Figure 16: Updated activity diagram representing personalization options of the application.

As can be seen in the diagram above, both style and color options are not written and saved into the SQL database used for storing moments, but are instead passed as integers between activities. Because the wearable app will only consist of the home screen, the only value passed to it will be the color value. Since there are no styled UI elements shown on the wearable's screen, style parameters are not required.

The next function that has been implemented was the record function.

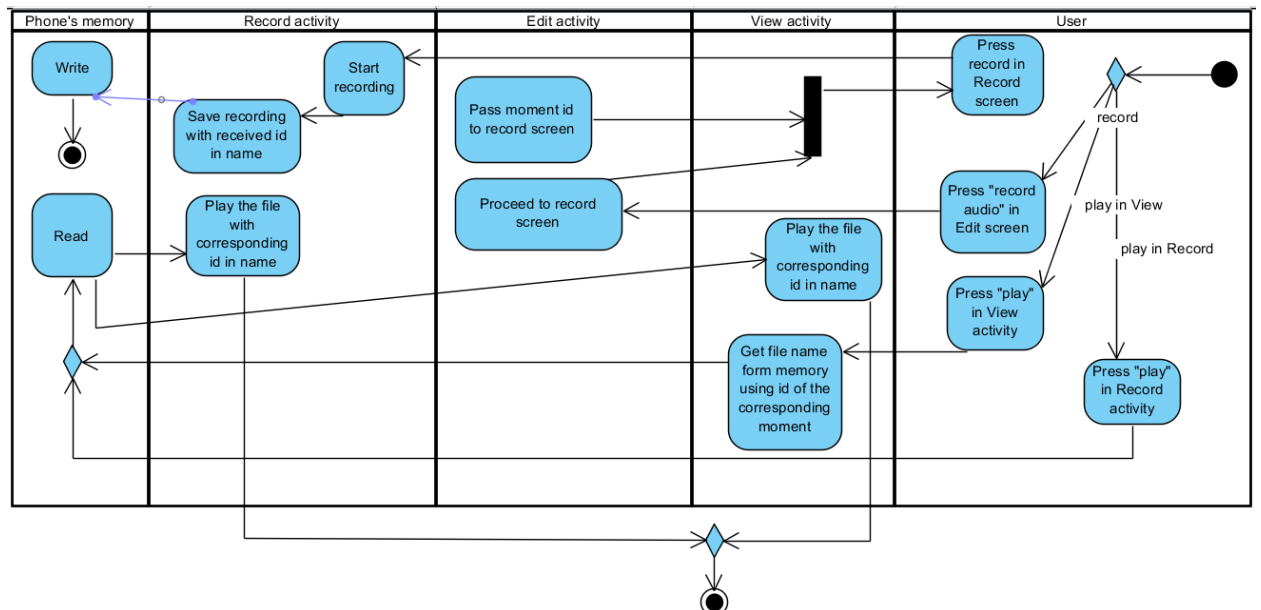


Figure 17: Activity diagram representing recording and playing of audio messages.

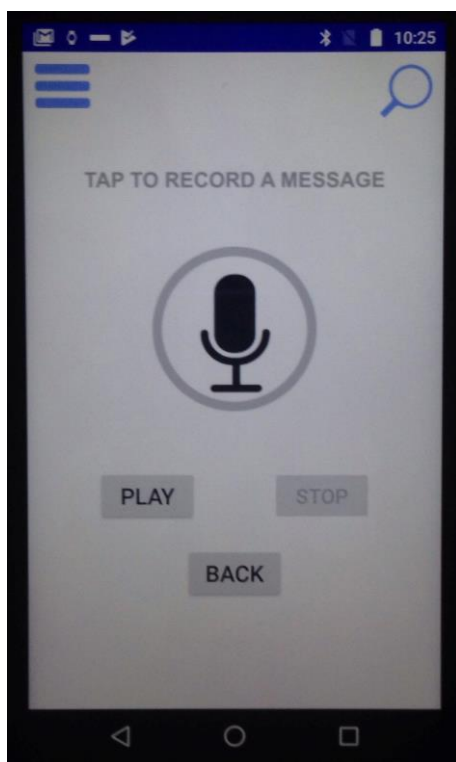


Figure 18: Record screen as seen on a screen of a smartphone.

As displayed in the diagram above, all recording related activities are carried out by the user among three activities: record activity, view activity and edit activity. The record option for a moment-related message is only available from the edit moment screen. When the record button on the edit screen is pressed, the user is redirected to a record screen, which stores the id value of the corresponding moment. The user is

then able to record a message that is automatically saved to the phone's local memory. To play the recorded message, the user is presented with two different options. It is possible to play the recorded message right after it has been recorded to check quality and contents of the message before submitting it. In case the user is not satisfied with the message, it is possible to re-record it right away. Another play option is available on the view screen. By tapping on the desired moment to view it, the user is now able to see moment details as well as play the corresponding audio message by tapping on the moment's intensity symbol (see Appendix C1). Moreover, if a user deletes a moment from the moment list screen, the corresponding audio message is automatically deleted from the phone's memory using the id of the moment that's being deleted. The message recording for the call function, however, functions somewhat differently. The record screen for the call message is accessible at the settings screen, where the user has to go through the same procedure of recording as explained and showed before. But, in this case, the passed id argument is 0, which does not correspond to any of the moments, making it unique and letting the system know that the message recorded with that id should be used when the call screen is initiated.

The final component that had to be tested was the wearable module of the application. Due to some technical difficulties, the connection between the modules has been hard to establish. With Android Wear 2.0 being a fresh OS (Official Android webpage, 2017), there is very little information regarding development of wear 2.0 apps that is openly available to non-commercial developers on the internet. Because of this, the setup of the wearable module took a while and required the trial-and-error approach.

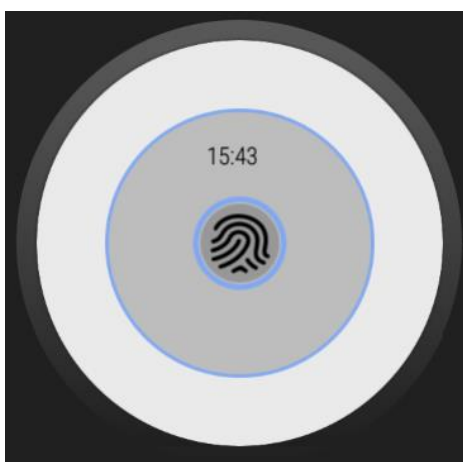


Figure 19: Wearable module running on the emulator.

The communication mechanism has been developed at this point, but it could not been tested together with the mobile app, since the emulator did not have heart rate measuring hardware, and the release version of the application did not seem to install on the actual watch. The application, however, have been re-built and installed on the wearable after the second survey has been set up, making the system complete.

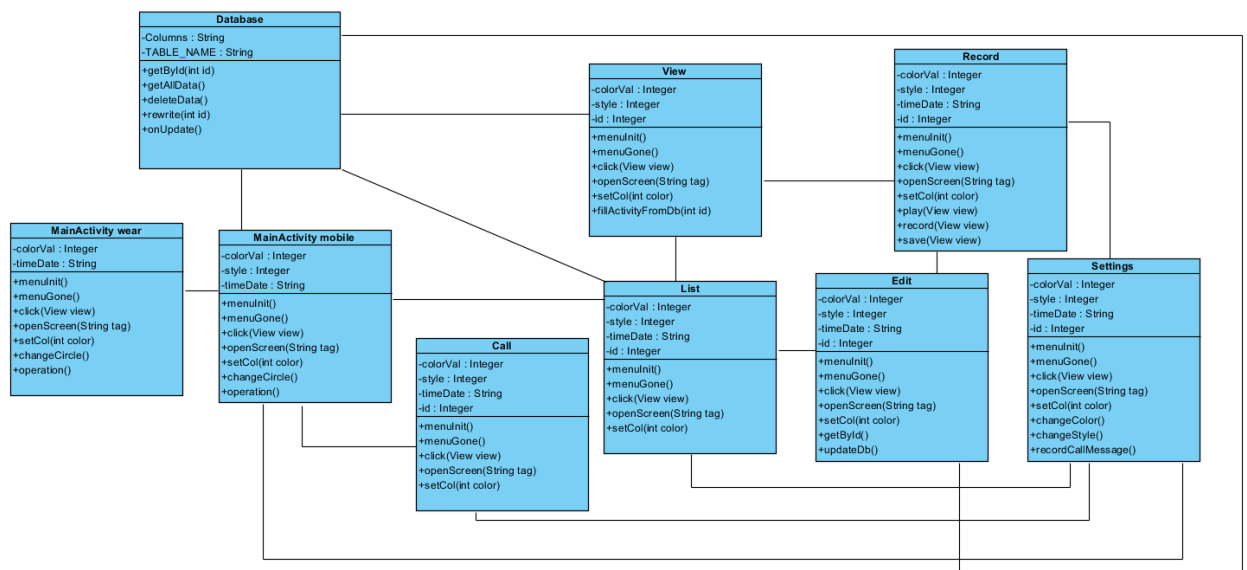


Figure 20: A class diagram of the application highlighting relationships between classes as well as methods and values used by every class of the system.

Figure 20 shows how the system works and highlights relations between its components. As shown in the diagram, some variables related to audio recording, color and style change are passed between the system's classes continuously, instead of being stored in a database. Values that are stored in the database are used only for moment creation and management. As can be also seen on the diagram above, some classes share same methods among them, and this is due to various screen using common UI elements that should respond in the same way. For example: both menuInit() and menuGone() methods are present throughout almost all activity classes, since these methods are responsible for initializing the mini-menu after the user taps on the burger button. Furthermore, almost any main screen is accessible from any

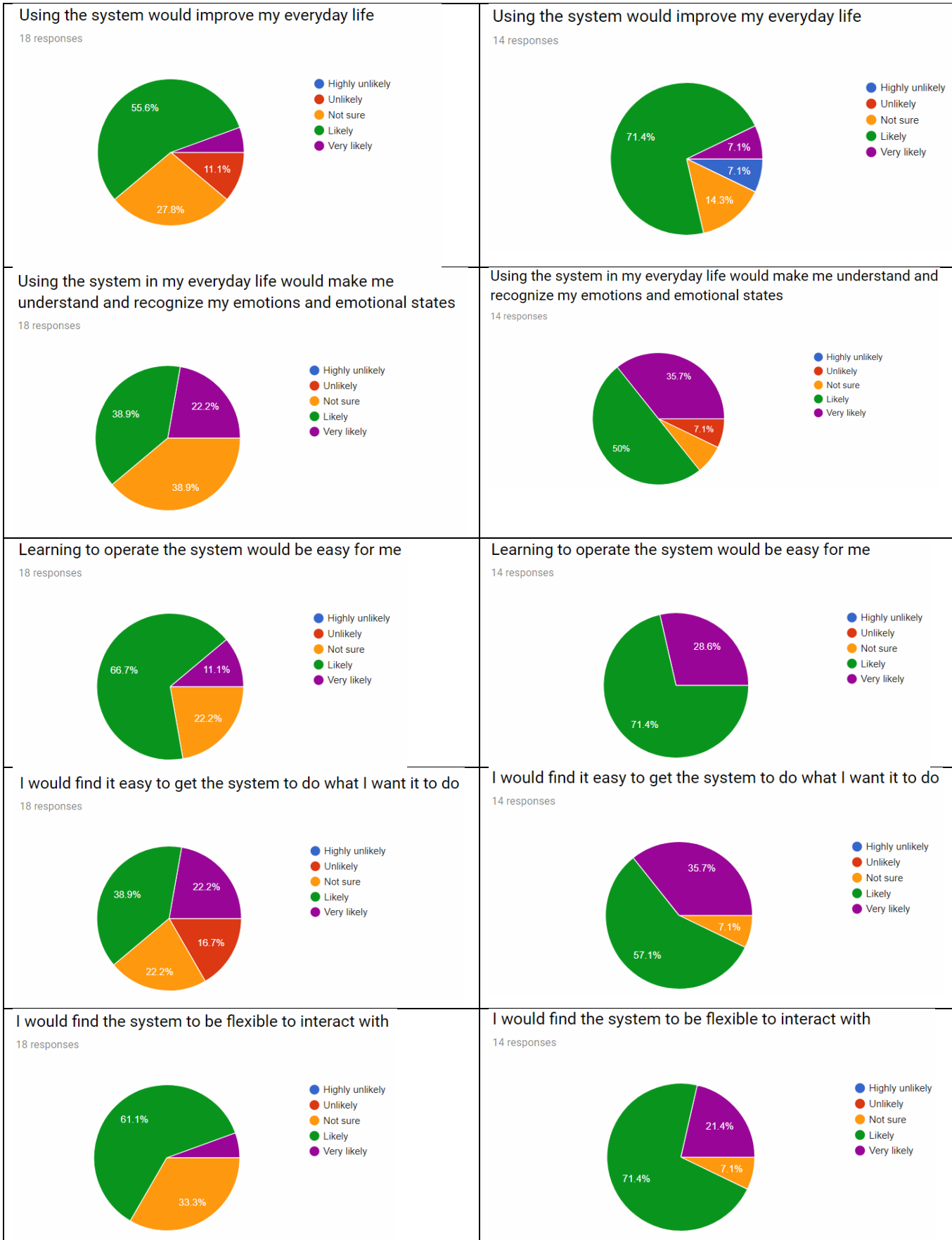
other screen of the mobile module, so the re-directive methods are very similar in almost all of the app’s activities, with most of them sharing same names.

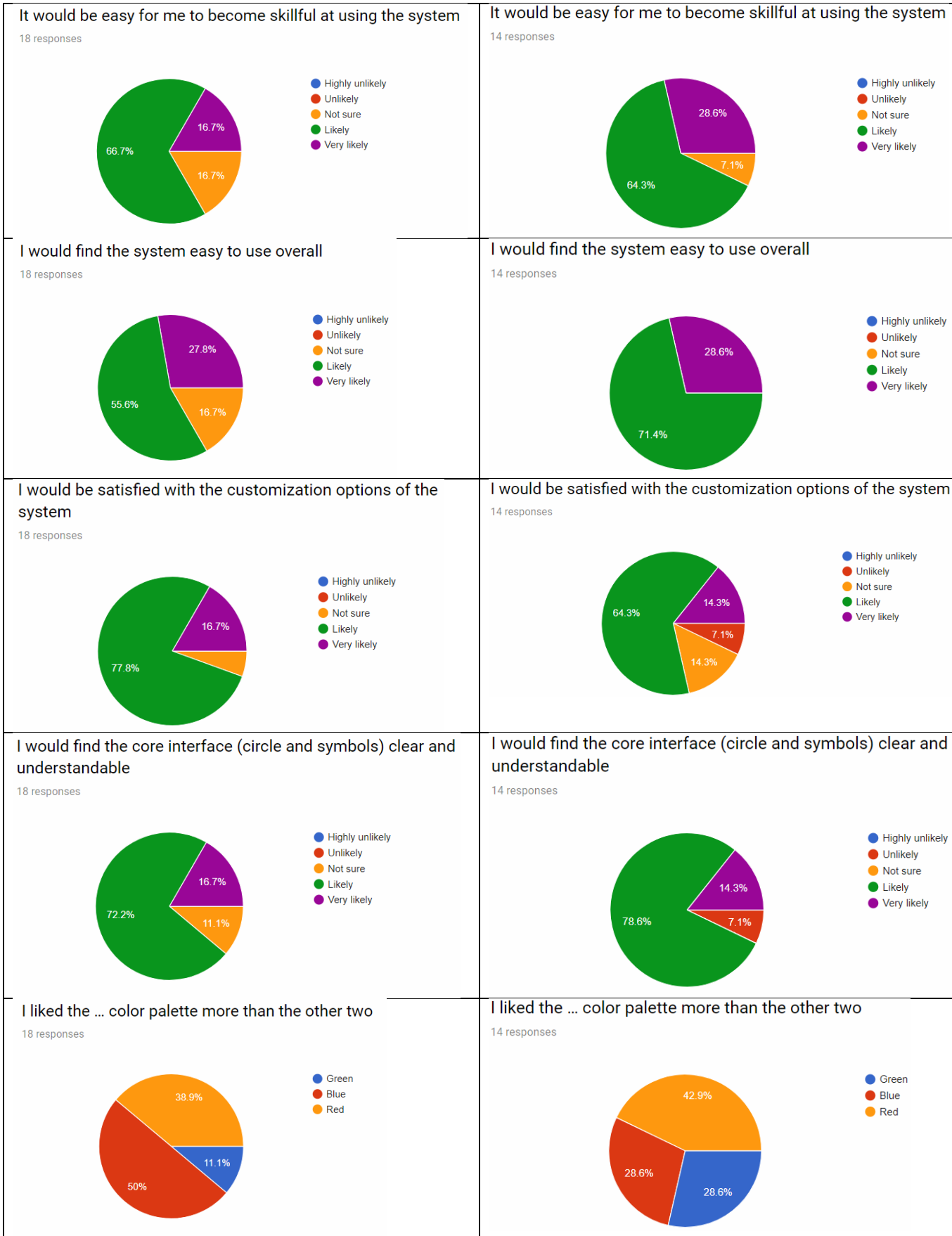
Dr. Klaassen has provided some testing hardware for this project: a Motorola G5 smartphone and a Huawei watch 2 wearable (see Appendix D1). Because the app was built for and tested on these devices, the layout of every screen has been adjusted accordingly. The G5 smartphone has a 5.0 inch screen with a resolution of 1920 by 1080 pixels, so these exact parameters were used as reference for layout files, and tested previously on an emulator with identical screen properties to ensure that all of the components are scaled appropriately to fit a 5.0 inch display. Same roles have been applied to the wear application, using the 1.2 inch 390x390 display of Huawei watch 2 as reference for it.

Second survey

To evaluate the last iteration of this project, a second survey has been set up and sent out on multiple subreddits. This time, a second survey for people without ASD has been created, in order to get more qualitative and quantitative feedback without mixing it with feedback from participants with ASD.

ASD subreddit response	Polls subreddit response
Have you used the app on your phone? 18 responses Yes No 44.4% 55.6%	Have you used the app on your phone? 14 responses Yes No 78.6% 21.4%





Evaluation

Overall, the evaluation has been done through both testing usage of the app, expert evaluation as well as analyzing the responses gathered in the survey.

A usage test has been carried out in order to assess the system from a standpoint of requirements and goals. At this point, the user was able to save, view and edit moments to the system, adjust color and style of UI elements, attach recorded audio messages to moments and receive “calls” from the app when certain conditions are fulfilled, with the message of the call also being pre-recorded by the user. However, the one requirement that hasn’t been fulfilled is the communication between wearable and mobile modules, making moment creation function inaccessible from the wearable. This, as mentioned before, was due to installation issues with on test hardware as well as the emulator not having access to heart rate measuring hardware.

In addition, Dr. Klaassen has also performed an expert evaluation on the final design (see Appendix D2). During the evaluation, some bugs have been found out as well as some design flaws. The color setting of the app went to primary color (blue) after the phone was in sleep mode for some time. This could be fixed by making a second database with setting values instead of having those values floating around between classes of the application. Another important remark has been made about the “play audio message” function accessible from the view screen. There was no play button for playing the audio message, since the message was played after a user presses at the stress grade symbol of the chosen moment. That led to confusion, so this issue would be solved by also adding a “play recording” button to the view screen.

Design problem	Bug	Evaluator	Possible solution
No addition of pictures		Survey participants	Implementing a gallery picker in the app, accessible from both settings and edit moment screens
Unclear play button on View screen		Dr. Klaassen, survey participants	Implementing a special play button for the View screen
	Color reset	Dr. Klaassen	Adding a static database for storing colors and styles

Discussion

In this chapter, all of the work and research done throughout the course of this project will be briefly summarized and reviewed, and the research question will be answered. For sake of convenience, the research question as well as the three sub-questions will be stated again:

“How should UI of an emotion management application for individuals with ASD be designed to provide a useful, meaningful and positive user experience that encourages reflection and allows options for personalization?”

And sub-questions are:

- 1. What are the requirements for designing UI for people with ASD?
- 2. How to effectively design for personalization without making the product and the process complex?
- 3. How should the UI of a mobile application be designed to provide a positive user experience for and support the user?

To answer the research question above, the sub-questions will be answer first.

The answer to the first sub question can be given by summing up the findings of the literature research as well as feedback from survey participants. As discussed in the literature review section, there are some general guidelines for designing media for individuals with ASD. Among them are: availability of instructions, dynamic stimuli, rewarding experience, simple graphics and uncomplicated looks, clear audio as well as availability of clear and understandable transitions (Bartoli, Garzotto et al. 2014). Furthermore, all of studies on perception in people with ASD that were reviewed in the literature section of this report have concluded that preferences on color, shape and other forms of visual stimuli vary widely among individuals with ASD, even though some tendencies in sensory-related preferences can be spotted. In addition, survey participants have expressed their appreciation for simple, non-distracting designs with neutral colors. As discussed in the evaluation section of the second iteration, a major portion of participants did not like the icons representing stress levels. Participants have expressed their concerns about icon designs: the icons were star-shaped, with sharp edges and peaks. According to feedback from

the users, the nature of the symbols was distracting and overwhelming, failing to reinforce the aim and message of the application. In addition, the positive feedback mostly indicated that the participants found the system to be easy to understand and operate. Also, the importance of consideration of user's personal preferences can be yet again seen in the results of the evaluation: while the majority of participants liked some design choices regarding color and symbols, others disagreed. Because of this, the system has to be flexible and avoid ignoring desires of any kind of user. Therefore, as an answer to the first sub-question, the requirements for designing UI for individuals with ASD are: clear, simple, understandable and non-distracting UI of elements, availability of customization options as well as clear and mild visual feedback, ease of use and learning.

Adoption of personalization options and techniques is getting more common in recently developed digital products. Development of such products has to base itself around three pillars: stability of the core infrastructure, tangibility of fixed components and soft characteristics of the system (Teng, Jiao et al. 2010). Furthermore, according to Teng, personalization requires looking at a user as an individual and taking his/her innate preferences, implicit needs and background into strong consideration. During early phases of the project, specifically in first iteration, the only personalization option that has been available was related to color. The expansion of personalization options happened after the results of the first survey came in. As mentioned before, some participants have requested a change in symbol design, while also providing their suggestions for desired changes. Moreover, some suggestions regarding coloring options have been given, among which were the implementation of a custom color picker. However, since the implementation of things like color picker wasn't really desired by many participants, these ideas weren't implemented for the sake of keeping the system as simple and responsive as possible. Summing these findings up, it is now possible to answer the second sub-question. So, in order to effectively design for personalization without making the product and the process complex the designer should analyze the system with tangibility in mind, deciding which components could be personalized without changing the core of the system in order to enhance personal experience of the user. Furthermore, user's individual qualities and demands have to be taken into account and reviewed, and based solely on that concrete

personalization options should be designed. In this way, it would be possible to avoid over complications in system's design as well as unnecessary functionality.

The answer to the third question can be given by looking at the results of testing and survey evaluation of later iterations. To generate powerful yet simple visual feedback, circular shapes and their resizing has been used (Mencke, 2017). Furthermore, most of UI elements with standard Android buttons being the only exception were created with circular shapes in mind. Almost all corners of rectangular UI elements are rounded, and pointy or sharp symbols are paired together with rectangular shapes (see Figure 11). These design choices were based on feedback from potential users, as discussed before, as well as Google Material Design guidelines. Moreover, many survey participants have expressed their satisfaction with icon and element designs, labelling them as clear and understandable. The color choice have also been praised by some participants: the participants found toned-down, dimmed shades of green, red and blue to be neutral, calming and non-distracting. So, in order to provide positive experience and support the user, the UI elements have to be simple, pleasant to look at, clear and colorful, without being saturated.

So, having answers to the three sub-questions, the main research question can be answered: The user interface of an emotion management application for individuals with ASD should be designed with close cooperation and strong consideration of the target user's personal needs and preferences, using simple, rounded non-distracting shapes and dimmed colors, while also providing choice options for customizing said shapes and colors. The design should also allow for fast learning and provide the user with clear yet simple visual feedback using, again, regular colorful shapes and icons.

Throughout the course of this project, a lot of insight about how systems for users with special needs are built and designed. In addition, survey studies made it easier to better understand the needs of the target user, as well as his concerns and preferences. Even though the final version of the application has been made according to the planning, fulfilling the requirements that were set for the system in the beginning, there is a lot of room for improvement. For instance, the communication between the mobile and

wearable modules of the system has not been set up in a satisfactory manner, since there were little technical information available on the subject of wearable programming, and there were some clear connection problems with the hardware available for this project. Luckily, the wearable app was installed in the end, but the system at that point did not have a calibration algorithm, which makes the reading of heart-rate fixed, not allowing personalized grading. Upon reviewing the final design of the application, Jelle van Dijk has made suggestions about expanding functionality. For example, the application may have an image-picker for every moment, or a “set background image” option for a call screen. In that way, the number of personalization options would be expanded, creating overall a more personal experience. During expert evaluation of the final design, Dr. Klaassen provided some suggestions for further development of Dynamic Balance. Among these suggestions were a sorting function for the list screen and putting color and style values into a separate database to avoid concurrency issues. In addition, as mentioned in the introduction section of this report, Ralitsa Spasova, a master student at the Radboud University Nijmegen is currently working on a machine learning module for Dynamic Balance. To integrate this project with Ralitsa’s work, the Database should be expanded with fields for properties such as activity type, weather type, location and acceleration. The app should then also be integrated and use a Google API for wearables, which would make the moment creation and learning more automated and precise (Spasova, personal communication).

The evaluations carried out during this project have shown that test participants found the system to be useful and helpful for their everyday lives, with broad yet useful functionality. Furthermore, responses gathered in the second survey were generally more positive than feedback gathered with the first survey. Use-case evaluations as well as functionality evaluations have also shown that the system’s framework is stable and provides a good foundation for future work, while also being a complete system at its current state.

While comparing the latest iteration of Dynamic Balance with similar applications, two important things stand out: availability of customization options and the internet-of-things nature of the system. Of all the tech covered in the state-of the-art review, Dynamic Balance only shares similarities with Sense-IT.

However, taking into account future plans regarding potential updates of Dynamic Balance and the integration of a machine learning algorithm that is able to process data used to create and saved moments to then be able to predict these moments, it becomes clear that there are no similar applications available on the market today.

Looking back on the process of project management and cooperation with various stakeholders, it is important to draw some conclusions. These conclusions could be really useful in context of future work that should be done with this project. As mentioned earlier, the core design of the system has been inspired and influenced by the work of Valerie Mencke. The most influential stakeholder has been dr. Jelle van Dijk, since designing for embodied empowerment is his primary focus, and he has supervised and ideated both this and Valerie's projects. During early stages of this project, the first prototypes and designs were based on reference circle designs from Valerie's master thesis (Mencke, 2017) as well as feedback from Jelle. However, in later stages of this project, I have discovered the Sense-IT app for emotion management built by Dr. Randy Klaassen. Since Sense-IT has a lot of similarities with Dynamic Balance in terms of functionality and concept, Dr. Klaassen became a major helping force in this this project. Furthermore, as mentioned before, Ralitsa Spasova is currently developing a machine learning module for this project, so it was important to keep in touch with her while building the application. Even though there were many individuals involved in the making of this project, the communication management could have been more efficient. With both Dr. van Dijk and Dr. Klaassen playing major roles in this project's development, they have been providing feedback separately, and there hasn't been a feedback or review session set up with both of them present. In my opinion, bringing Dr. van Dijk and Dr. Klaassen together for such a session would make the evaluation of prototypes broader and deeper. Furthermore, if Sense-IT has been discovered and Dr. Klassen has been contacted earlier, it would be possible for him to give feedback on earlier prototypes. In addition, the work on the machine learning module has already started before this project has been started, but the first contact with Ralitsa has been made after some parts of the application has been already built, which made it hard to merge this project with her work at that point. If the contact have been made sooner, it may have been possible to make the final prototype of

this application use the machine learning algorithm. To sum up, contacting all of stakeholders in the very start of this project and going through all design stages in cooperation with all of them would considerably reinforce the whole process.

To sum up, at its current state, Dynamic Balance is a complete standalone system with lots of room for future upgrades and improvements. Even though the realization at this point may not be perfect or very deep, the feedback from various prototype tests and evaluations shows that the target audience found the application to be purposeful and helpful.

Ethical reflection

Dynamic Balance is a personalized helper for people with ASD, which is able to track levels of stress of the user. This system has two components, which closely work together: an app for an android watch, and a smartphone app.

The idea of an app that tracks emotional well-being of the customer could change the way people with personality disorders carry themselves in public. Having to live with such a system at hand is really like having your own personal coach that listens to you and keeps you safe at all times. Arguably, one of the big reasons autistic people are not eager to socialize is their hypersensitivity to the happenings of the outside world. Imagine living a life, always blinded by the sun and deafened by the sounds of the world, often not knowing when or where to go, or where you're at. As said before, since people with autism spectrum disorders are not great in identifying triggers and keeping track of their emotional state, meltdowns could easily happen and worsen the state of a person permanently. Therefore, help is almost always needed. Unfortunately, not many people understand what autism is and how to approach human beings who suffer from it. And, furthermore, it is impossible to have access to a specialist on every given day at all times, especially considering the flow of life nowadays. But can a machine fix this problem? In my opinion, yes. Even though the user would have to be wearing the watch and checking the app on his/her phone with consistency, as soon as it becomes second nature, the app could fill the need of having a helper. A helper that is completely unbiased, always listens to its master, never gets tired and who's

only priority is you. With this kind of support a new understanding of oneself can come, and insecurities as well as anxiety can be defeated. In addition, use of this system could eliminate the caution and struggles of opening up and sharing your fears with another person, which could certainly make the whole process of self-improvement faster.

A big challenge in creating such an application and making it work for the user is making it not able to worsen a possibly stressful moment or create additional triggers. It is logical, that in a hard situation, having to deal with a user interface that further links at one's current emotional struggle can easily become overwhelming, harmful and worsen the episode. Furthermore, according to Bartoli, a design of an interactive system aimed at people with ASD is effective, when it consists of simple graphics and audio feedback without any complications (Bartoli, Garzotto et al. 2014). Actually, during the survey I have conducted to evaluate one of iterations of the app's user interface, a lot of people with ASD were concerned with this aspect of application, and confirmed that for them it would definitely make the episode more intense and complicated. Many people were also commenting on some design decisions they thought were too confusing or unnecessary. For example, results of this survey had shown that the participants prefer blue color of the UI interface over green and red. Furthermore, a big percentage of participants were not quite satisfied with symbols that were used to represent stress levels different moments. It was mainly because of the core design of the symbols, which used sharp edges and star-like shapes, and a screen populated with such small, sharp symbols would be uneasy and unpleasant to look at for the user.

After the feedback has been gathered and processed, however, the design in the next iteration of the app was drastically changed. Sharp symbols were replaced by more soft shapes brought together by a number of simple white ellipses, and a big ellipse in the background, which also represents stress levels with color saturation. However, since one of the main goals is to make the app customizable, and since some participants have responded positively to sharp-shaped symbols, it has been decided to leave them as an alternative option. Furthermore, since, as mentioned before blue was the most favored color option for the user interface, so a choice has been made to make it a primary UI color, with red and green being

secondary options available in the settings screen. Another point made by the respondents was connected to how the machine learning algorithm works and data privacy. Some participants were curious as to how the systems is going to “learn” from the user’s input and at what point in the usage cycle this data will be generated.

In the very beginning of the design process for this application, my supervisor, Jelle van Dijk has explained to me that it is very important not to overwhelm the user with functionality. Therefore, the data required for the process of “learning” is not being inserted by the user during a stressful moment, but instead inserted in the “edit” screen of any particular moment chosen from the list. That means that the user is free to go to the screen with all the saved moments at any time and change the intensity grading on any of them by choice. The next question which has to do with privacy has been solved by making all the moments and messages saved on a local SQL database on the phone’s memory card. The database is also changeable via the app, allowing the user to delete specific moments, change properties of saved moments and even clearing the whole database completely. The online cloud alternative would solve storage problems and open new opportunities of easily transferring and sharing saved data, but it also opens possibilities for phishing and overall makes the data less safe. There are multiple known occurrences of various companies and governments using data collected in various social media to advertise and spy on individuals (Barnes, 2006). In addition, a relatively safe cloud service costs money and is quite hard to obtain, which puts it outside of the scope of this project. However, in other similar applications, there is actually an option to really integrate the use of an application into therapy with the use of cloud services and sharing options. For example, in an application called *eMoods Bipolar Mood Tracker*, there is an option to export all of the saved data as a report on emotional well-being of the user in a readable and clear format and share it with the user’s therapist. This actually makes an application more efficient in the context of emotional health and therapy, and applications without such options are less about real healthcare. In case of this project, once the machine learning algorithm is working properly and the application has proven to be efficient and useful rather than distracting through user testing, it

would be a good idea to add such functionality and make the service more serious. But then, for sake of privacy, the data should be encrypted and safely stored on a secure, rented domain.

Some respondents were also curious as to how accurate the stress-measuring component will be. It would not be ethical to push out a product that has a goal of helping its user better understand their emotions and predicting them, but does the measuring inaccurately. In the current iteration, which still lacks the learning algorithm, the only data that the system can measure is heartrate, which is not sufficient for a final product. Even with the learning algorithm, one property is not enough for the system to evaluate a situation that may have been caused by lots of different emotional, physical and psychological triggers. A possible solution to this problem can be addition of other aspects/properties of user's life that the system also measures. For example, by learning about the user's emotional moments time-wise and date-wise, the system could be able to make assumptions and predict possible stressful moments based on the user's schedule. This would improve the assumption accuracy drastically, and the learning algorithm will allow the system to adjust to the ever changing lifestyle of its. Also, there other data like body temperature, skin conduction (which is widely used in wearables like PIP to measure blood pressure) or current weather can be used in the algorithm to draw even more accurate assumptions.

Even though the survey has made it possible to better understand the needs and preferences of the user a real user testing has to be conducted. For a designer, whose work has to be evaluated and tested by a user, it is very important to make sure that the testing process goes according to the rules. It is important to be very sensitive to the user's needs and concerns, to make sure that the user is in agreement with all of terms of the testing, and is familiar with the research topic. Also, according to the Interactive Design Foundation, there are seven pillars of ethical user testing: honesty, sensitiveness, accurate representation, availability of consent, intensions without harm, security of user's data, and value of participant's time (Mortensen, 2017). All the surveys set up to evaluate this project's prototypes were anonymous, with extensive explanations of the project's concept and goals, to ensure that participants are sufficiently informed. Furthermore, it has been stated that the collected data, although anonymous,

will be used to design further iterations of the project. Without these, it won't be fair for the user to participate in a test case or survey without taking personal risks.

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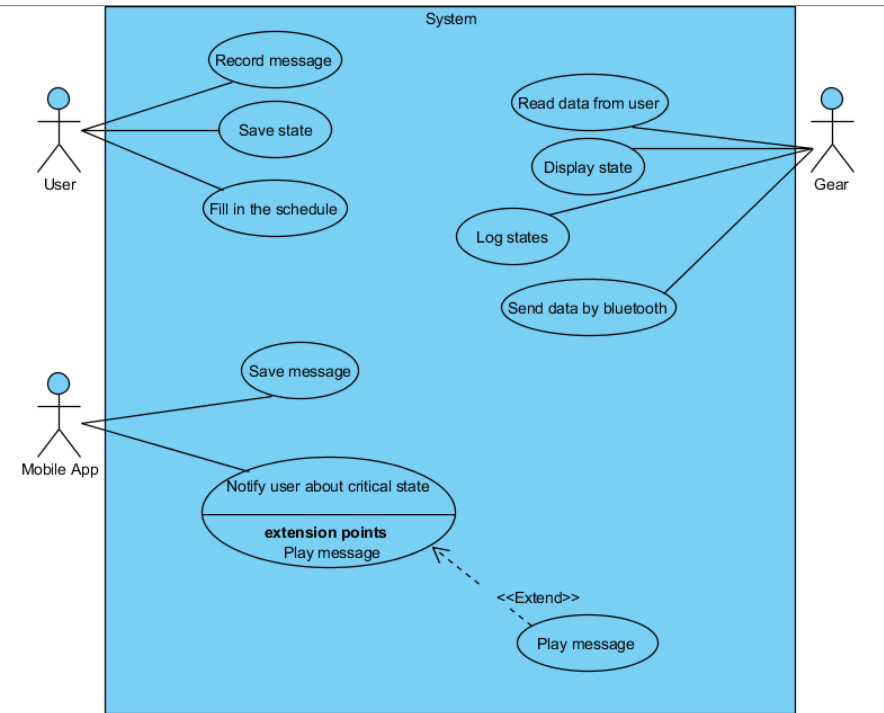
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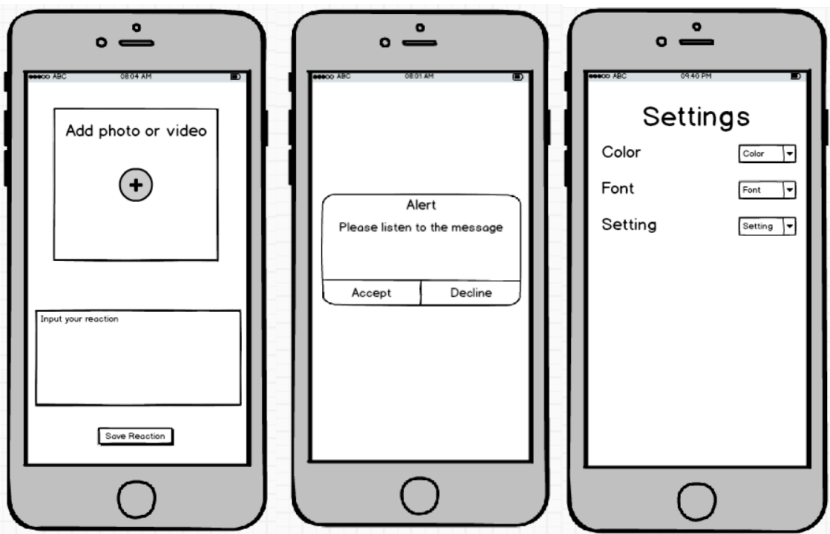
Appendix

Appendix A

1. Early use case diagram of the system



2. Mockups made in balsamiq

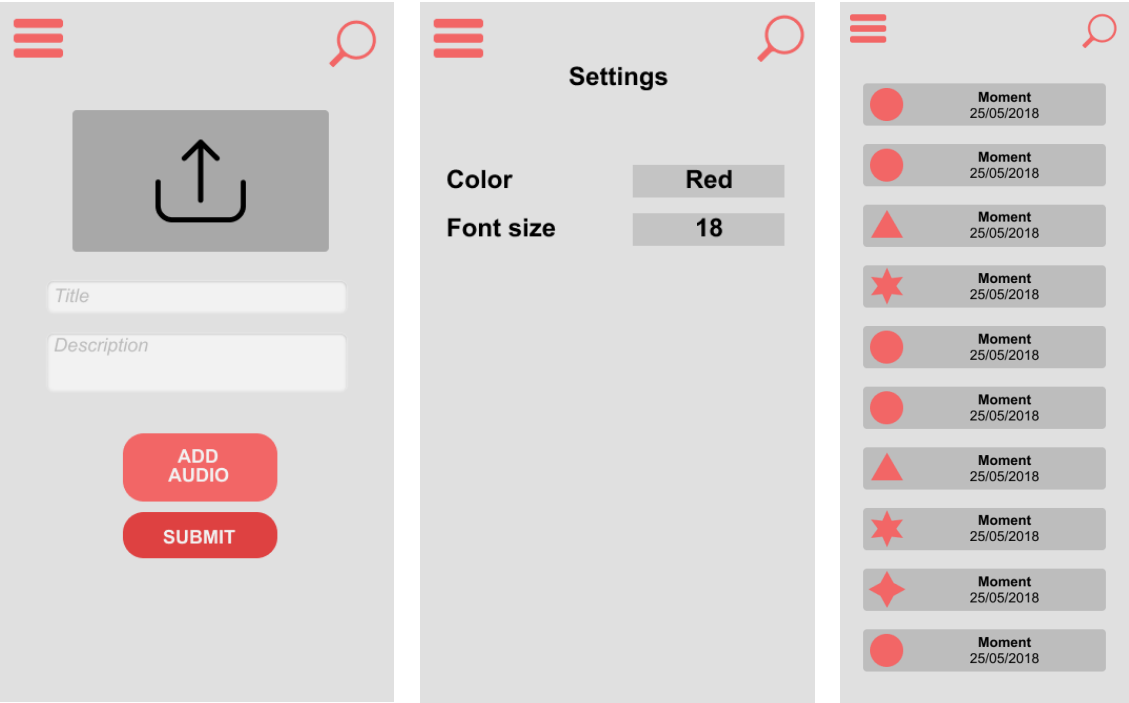


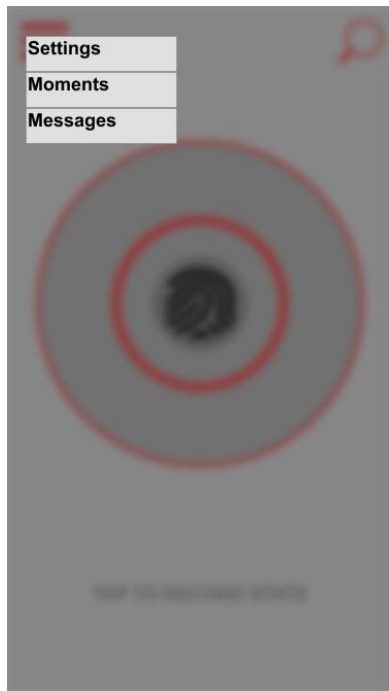
3. Figma workplace



Appendix B

1. Figma designs of the second iteration





2. Survey

1. Using the system would improve my everyday life (1 to 5)
2. Using the system in my everyday life would make me understand and recognize my emotions and emotional states (1 to 5)
3. Learning to operate the system would be easy for me (1 to 5)
4. I would find it easy to get the system to do what I want it to do (1 to 5)
5. I would find the system to be flexible to interact with (1 to 5)
6. It would be easy for me to become skillful at using the system (1 to 5)
7. I would find the system easy to use overall (1 to 5)
8. I would be satisfied with the customization options of the system (1 to 5)
9. I would find the core interface (circle and symbols) clear and understandable (1 to 5)
10. I liked the ... color palette more than the other two (3 options: red, green, blue)
11. What are, in your opinion, the weakest parts(part) of the design? (Open)

12. What are, in your opinion, the strongest parts(part) of the design? (Open)

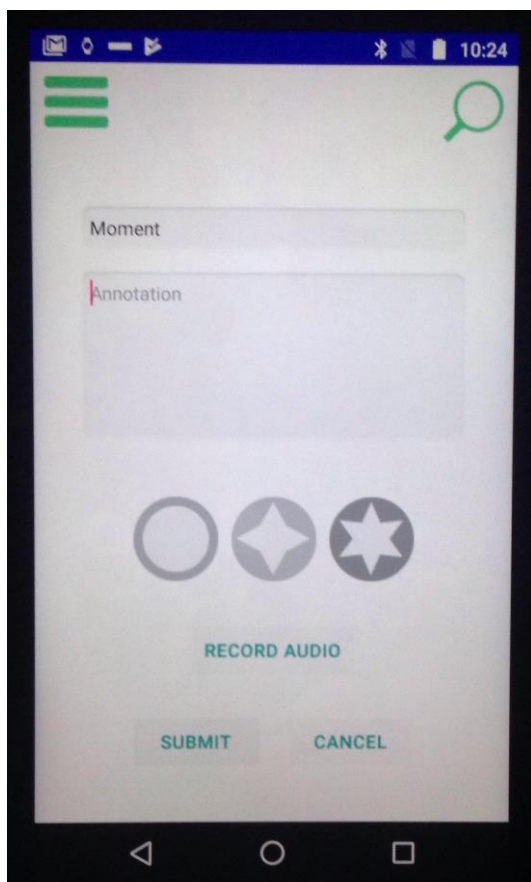
13. Open feedback (Open)

Appendix C

1. UI for the wearable app designed in Figma.

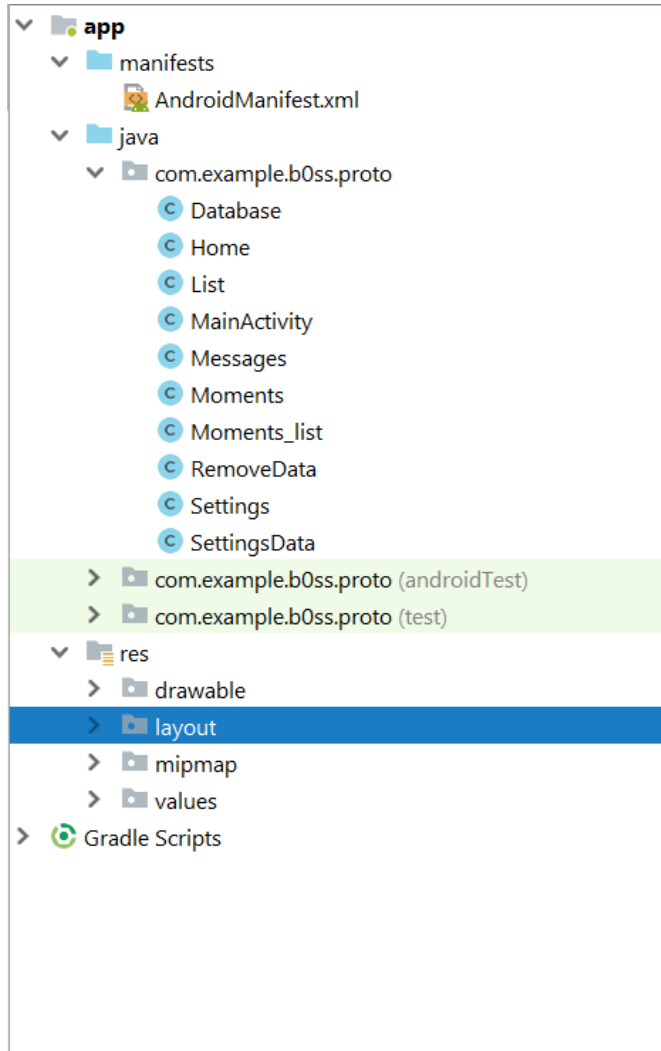


2. Edit moment screen in the final version of the application



Here, the user is able to change the name and annotation as well as intensity of the chosen moment, and also attach an audio message to that moment.

3. Android studio project tree



Appendix D

1. Moto G5 and Huawei Watch 2



2. Notes from dr. Randy Klaassen's evaluation of the system

Not too clear that small radius is small intensity, tap to record text is confusing, the annotation after the "submit audio" case disappears, "play" option on view screen is unclear, search icon has to be changed, fields on the view screen are confusing suggests input possibilities.

Audio recording is nice, pages, sorted list of moments. Some functions are hidden under icons. It is not clear for example that the audio message is hidden under the "stress level icon". The application provides an easy way to enter self-report by the user and a way to overrule the technology.

3. Notes from meeting with Ralitsa about integration

Add weather to database

Add activity type to database

Add acceleration to database

Add steps per minute to database

Add stress level measurement like sense-it app } all from google service (automatically every five minutes)