FAKULTÄT FÜR !NFORMATIK
Faculty of Informatics

On the Use of Wearables and Biofeedback Interventions for People with Anxiety Disorders

DIPLOMARBEIT

zur Erlangung des akademischen Grades

Diplom-Ingenieurin

im Rahmen des Studiums

Biomedical Engineering

eingereicht von

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Wien, 27. Mai 2019

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MASTER'S THESIS

submitted in partial fulfillment of the requirements for the degree of

Diplom-Ingenieurin

in

Biomedical Engineering

by

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to the Faculty of Informatics

at the TU Wien

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Vienna, 27th May, 2019

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Erklärung zur Verfassung der Arbeit

Anna Lea Kutsch, B.Sc.

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Wien, 27. Mai 2019

Anna Lea Kutsch

Acknowledgements

I would like to thank everybody who supported me during the work on my master thesis project and writing the thesis. First of all, I would like to thank my advisor Assoc. Prof. Dr. Dipl.-Ing. Hilda Tellioğlu, who guided me and steered me in the right direction. Her office was always open when her support was needed.

Furthermore, I would like to thank Mag. Karl Kreiner, who supported me as valuable discussion partner to find a solution when I faced challenges. Moreover, I would like to thank him for reading this master thesis and sharing his very helpful thoughts with me.

My thanks goes also to DI Kurt Edegger who tested the prototype applications together with Mag. Karl Kreiner during the developing process. Both contributed to this project with wonderful ideas and suggestions.

My thanks goes also to the Austrian Institute of Technology which gave me the great opportunity to work on this very interesting project.

Furthermore, I would like to thank all participants of the user study. Without their participation the evaluation of two developed stress reducing applications would not be possible.

In addition, I would like to thank Dr. Silke Middendorf for proofreading my master thesis and her valuable comments on the thesis. She always supported and encouraged me during my whole study.

Finally, I would like to thank my parents, who always believed in me and supported all my decisions and steps in my life. They continuously encouraged me during my study and during writing this master thesis. Without their continuous support this master thesis would not have been possible.

Kurzfassung

Die Europäische Kommission hat das Ziel, die Barrierefreiheit für Menschen mit Mobilitätseinschränkungen zu verbessern, wobei psychische Probleme oder Ängste eine Ursache für eine eingeschränkte Mobilität sein können [1]. Eine Möglichkeit, Menschen mit psychischen Problemen oder Ängsten zu unterstützen, sind Gesundheits-Apps. Die Beliebtheit von Wearables ist in den letzten Jahren gestiegen [2]. Es gibt allerdings nur wenige, bzw. keine Untersuchungen über ihre Wirkung bezüglich Angst. Da Angst eine Form von Stress ist [3], wurde in dieser Diplomarbeit untersucht, wie Smartwatch Apps zur Stressreduktion eingesetzt werden können.
Aus diesem Grund wurde eine Literaturrecherche durchgeführt, um die Wirkung bereits existierender Interventionen auf psychische Probleme herauszufinden. Basierend auf diesen Ergebnissen wurden verschiedene Konzepte für stressreduzierende Smartwatch Apps entwickelt, um so Möglichkeiten und Einschränkungen von Interventionen herauszuarbeiten. Auf Grund dieser Konzepte wurden 5 Prototypen („Flying Boxes “, „Seasons“, „Vibes“, „Visual Cue“ und „Walk with Me“) nach dem ISO 13407 Standard entwickelt und implementiert, um weitere Möglichkeiten und Einschränkungen zu identifizieren und verschiedene Umsetzungsmöglichkeiten von stressreduzierenden Smartwatch Apps aufzuzeigen. Die Konzepte dieser Prototypen basieren auf Biofeedback in Kombination mit Gamification („Flying Boxes“, „Seasons“), Ablenkung durch haptische Signale („Vibes“), stimmungsaufhellende Wirkung durch die Erinnerung an positive Erlebnisse („Visual Cue“) und der Unterstützung verschiedene Situationen im Alltag zu reflektieren („Walk with Me“). Um weitere Einblicke in die Wirkungsweise auf Stress von Biofeedback Smartwatch Anwendungen zu erhalten, wurde eine parallele, einarmige Studie zu den Biofeedback Anwendungen „Flying Boxes“ und „Seasons“ durchgeführt.
Die Ergebnisse dieser Studie weisen darauf hin, dass diese Biofeedback Anwendungen wahrgenommenen Stress reduzieren können. Außerdem konnte in der Studie eine signifikante Reduktion der Herz Rate, nachdem „Flying Boxes“ für 60 s genutzt wurde, nachgewiesen werden. Welche der beiden Anwendungen eine größere stressreduzierende Wirkung hat, scheint von den Nutzern und der Situation, in welcher sie eingesetzt wird, abzuhängen.

Abstract

The European Commission established the aim to improve the accessibility of public transportation for people with limits regarding mobility. One reason for limitations using public transportation can be mental disorders and anxiety [1]. Mental health applications are one approach to support patients in their mental disorders.
Wearables have become popular in the last years [2], but no research is available on how they can have an impact on anxiety. Thus, the aim of this master thesis was to investigate how smartwatch interventions can have an effect on stress, as anxiety being a form of stress [3].
First, it was examined how already existing mental health interventions can affect mental health disorders by performing a literature review. Based on that, different concepts of smartwatch applications aiming to reduce stress were developed to identify limits and possibilities for stress reducing smartwatch interventions. 5 prototypes ("Flying Boxes", "Seasons", "Vibes", "Visual Cue" and "Walk with Me") were further developed and implemented according to the ISO 13407 human-centered design process to gain further insights in possibilities and limitations and to demonstrate different ways how these possibilities can be realized on smartwatches. The concepts of these prototypes are biofeedback in combination with gamification ("Flying Boxes", "Seasons"), distraction by using haptic senses ("Vibes"), enhancing the mood by retrieving nice memories ("Visual Cue"), and assisting in reviewing stressful situations ("Walk with Me"). To gain more information about the stress reducing effects of biofeedback smartwatch interventions and their usability a parallel one-armed user study was conducted on the two developed biofeedback interventions "Flying Boxes" and "Seasons".
The results of this user study suggest that the biofeedback applications "Flying Boxes" and "Seasons" are able to reduce stress, and after applying "Flying Boxes" for 60 s, the heart rate, a biomarker for stress, was reduced significantly. If "Flying Boxes" or "Seasons" is more effective in reducing stress, seems to depend on the person and on the circumstances under which the intervention is used.

Contents

CHAPTER 1

Introduction

The European Commission established the aim to improve the accessibility of public transportation for people with limits regarding mobility. Many factors can lead to a limitation and reduction in mobility. One reason belongs to the field of mental disabilities [1]. The WHO estimated that 100,000,000 people suffer from anxiety or depression in Europe at any time [4], and in Austria 10% of the population suffers from at least one mental health issue. The number of people affected by a mental disability is increasing [1]: It is estimated that depressive disorders become the main reason for disability in high - incoming countries by 2030 [5]. Therefore, it is of major importance to treat and reduce mental disabilities.

Typically, mental disorders are treated with psychotherapy and psychopharmacotherapy, which has shown effectiveness [6]. However, treating the anxiety disorder is not possible for everyone: a lack of services, stigma or delayed access of therapy causes a gap of treatment [7]. Even if a treatment plan exists, the patient has to reach the psychotherapist or self-regulating community which can be challenging [8].

There is no typical anxiety of mobility, but it is possible that people affected by an anxiety or depression project their anxiety into actions occurring in the context of mobility. Thus, for those a barrier of mobility exists. On the one hand it can influence the treatment, and on the other hand it is essential to participate in transportation to maintain social contacts and support the recovery process [1]. Within the project "PHOBILITY active" research is conducted, focusing exactly on this topic, with the aim to support people with phobias, anxiety or obsessive compulsive disorders, or anxiety caused by depression of taking public transportation [9].

One approach to support patients in their disorders are mental health applications. Since 2007 when mindfulness applications began to become popular, the number of

people applying the training with their smartphone has increased over millions [10]. Furthermore, studies carried out on applications treating anxiety and depression have shown promising results in reducing anxiety and depressive symptoms [11].

In case of anxiety in connection with transportation, interventions that can be used in acute anxiety causing situations need to be portable, applicable during transportation, and accepted. As anxiety is a form of stress [3], the requirements for those interventions could be met by mobile mental health application for stress reduction running on wearables.

In the last years wearables have become popular and available for the general public. By measuring physiological data they attempt to improve the quality of life of the users [2]. To my knowledge there are neither mindfulness applications for wearables available nor is it known how they can have an impact to reduce anxiety and therefore stress. Thus, in this master thesis the first research sub-question how already existing interventions can affect mental disorders like anxiety is examined within a literature review. Based on the state of the art, concepts for smartwatch applications aiming to reduce stress were developed to identify limits and possibilities for stress reducing smartwatch applications. By implementing 5 prototypes based on different concepts as biofeedback in combination with gamification ("Flying Boxes", "Seasons"), distraction by using haptic senses ("Vibes"), enhancing the mood by retrieving nice memories ("Visual Cue"), and assisting in reviewing stressful situations ("Walk with Me") more detailed information about further possibilities and limits are gained. Moreover, the implementation of these prototypes according to the ISO 13407 demonstrates different ways into the research question how stress reducing interventions on smartwatches can be realized and how the needs of potential users can be fulfilled. Finally, a user study of the 2 developed interventions based on biofeedback ("Flying Boxes" and "Seasons") was conducted to gain more information about the stress reducing effects of these interventions and the usability in everyday life.

To summarize, the aim of this master thesis was to investigate the research question:

How can wearable interventions have an impact to reduce stress?

This question was specified into:

- How can already existing interventions affect mental disorders?
- Which limitations and possibilities exist for wearable stress reducing interventions?
- How can possible interventions for wearables be designed to reduce stress?
- How can the needs of potential users be fulfilled?
- Which effects can these interventions have and how can they be used?

This master thesis is organized into 7 chapters. The 1st one gives an introduction into this master thesis. In the 2nd chapter background information is given on stress, anxiety, treatment approaches for mental disorders, and how these approaches can be realized on mobile mental health interventions. The 3rd chapter describes the methodology of this master thesis project. In the 4th chapter the results of this master thesis research are presented. The results of different concepts of stress reducing smartwatch applications, and the results of the development and implementation process of 5 prototype applications are given. Moreover, the findings of the conducted user study of the 2 biofeedback applications "Flying Boxes" and "Seasons" are presented. In chapter 5 the results are discussed before chapter 6 concludes the research of this master thesis project. Finally, chapter 7 gives an outlook how the findings gained during this project can be used in the future.

CHAPTER 2

Background

2.1 Stress

The term stress was known as an engineering term before it entered the field of live science. 1926 stress was introduced in life science the first time by Walter B. Cannon as rather technical term: he described stress as all external forces interrupting homeostasis in living organisms [12]. Fevre et al. pointed out that Selye influenced the word stress as being the physical and psychological result of disadvantageous circumstances. The external condition causing this stress is called stressor. According to the Yerkes Dodson Law there is an individual threshold of stress level. Until this threshold is reached, an increasing level of stress can be advantageous, above this level a loss in performance can occur. These different kinds of stress are called eustress and distress [13].

2.1.1 Eustress

Basically eustress is positive stress which can result in self-development. This can occur when the stressor is seen as challenge. Under this condition the individual does not see himself/herself as stressed. An important feature for the individual to maintain healthiness under stress is to take breaks [14].

2.1.2 Distress

Distress is stress which is seen as negative and can arise when the individual sees the stressor as a too excessive demand. Having troubles taking breaks or to relax can favor distress and can lead to health issues. Often distress comes along with an assumed loss of control, helplessness and a feeling to be at the end of one's tether [14].

2.1.3 Biology of Stress

In the situation of arousal the organism is in disequilibrium and tries to regain homeostasis. The human organism has two different biological stress regulation systems: the physiological and the endocrinological mechanism. The former one is the autonomic nervous system (ANS) and the latter one is the hippothalamus-pituitary-adrenal (HPA) axis system [15].

Stress Regulation in the Autonomic Nervous System

The ANS as a regulatory system is assumed to be linked to physiological stressors. Upon a stressor the activation of the parasymphathetic nervous system is decreased immediately before the sympathic nervous system (SNS) is activated [15]. This leads to an increased release of the catecholamines (CAs) norepinephine and epinephine in the adrenal medulla guiding autonomic mechanisms. The guided autonomic mechanisms resulting in physiological effects like an increased respiration rate, increased heart rate, dilation of skeletal muscle blood vessels, glycogen to glucose transformation and vasoconstriction of digestive and reproductive organ blood vessels [16], [17]. The increasing concentration of CAs is recognized by the brain and supplies the body with energy through receptors in the cerebrum leading to the fight-or-flight response. The ANS responses very fast to a stressor which is due to the half-life of adrenaline which is approximately two minutes [15].

Stress Regulation in the Hippothalamus-Pituitary-Adrenal Axis

The HPA axis is activated when a psychological danger is expected. Thus, it can be activated for long times even without the occurring of a dangerous event. The stress reaction is visualized in figure 2.1.

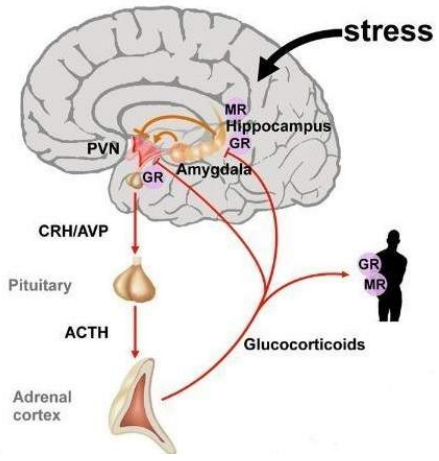


Figure 2.1: The different levels in the body affected by the HPA axis stress response [18].

The prefrontal cortex, hippocampus, and the amygdala are implicated in checking and evaluating the environment. On a stressor they provoke the activation of the hypothalamus. The prefrontal cortex and the hippocampus are activated on baseline. If one of them register a stressor, it activates the HPA axis due to its inhibition. The amygdala is activated on the registration of a stressor and activates the HPA axis due to an excitory event [15]. If the HPA axis is activated, the information is passed to the neurons in the paraventricular nucleus (PVN) of the hypothalamus to guide endocrine actions. Then the neurons release arginine vasopressin (AVP) and the corticotropin-releasing hormone (CRH) into the hypophysical portal blood system. These hormones trigger the release of adrenocorticotrophic hormones (ACTHs) in the anterior pituitary gland and ACTH moves to the triangular adrenal glands above the kidneys. ACTH triggers the release of glucocorticoids (GCs) (cortisol in human). GCs are involved in the stress response by triggering gluconeogenesis, support catabolic mechanisms induced by cathecholamines, increase the glucose movement to the central nervous system (CNS) and to cardiovascular tissue which has an increased need of energy, and control immune and inflammation mediators as well as immunosupressive and anti-inflammatory activities. Furthermore, it is involved in learning to react to specific stressors for the future [16], [17]. The HPA axis is activated approximately 14 minutes slower as the SNS which can be explained by the half-life of GCs of 60 - 80 minutes. The peak of GCs can be detected after 20 - 30 minutes [15].

The HPA axis is a self-regulating feedback system with the GCs as mediator. They enter the brain and can bind there to two different corticoid receptors: the glucocorticoid receptors (GRs) which are spread across the brain and the mineralocorticoid receptors (MRs) which are only present in the hippocampus and in the amygdala. The GRs have a low affinity for GCs and the MRs have a high one. At baseline level, the GCs binds to the MRs due to its high affinity. Thus, the hippocampus and the amygdala are stimulated, but do not activate the HPA axis as the stimulation mechanism works contrary. The hippocampus is deactivated due to a stressor, and GCs are released as described above. With a higher level of GCs it is assumed that they can bind to the low affinity GRs resulting in a further inhibition of the hippocampus. The signal from the hippocampus to the HPA axis is strengthened, and the negative feedback loop has turned into a positive feedback. If the stressor causes the amygdala to become activated, GCs are also increased and can bind to the GRs. This time the binding causes an inactivation of the amygdala, and therefore, the HPA axis is inactivated due to the negative feedback loop [15].

It is assumed that the composition of hormones released through stress vary depending on the stressor, the physical state of the organism, the stimulus of stress, and the application of coping mechanisms [16], [17].

Stress Response due to Chronic Stress

A stressor to which an organism has not been exposed before is called heterotypic stressor, whereas a stressor which occured before is named homotypic stressor [16], [17]. Exposed to stress the brain can change in its construction and molecular outline. Depending on

the experiences of a healthy person, the neural circuits are remodeled to allow sufficient behavior [19]. Facing chronic stress can lead to a maladaptive HPA response [16], [17]. Chronic stress results in a shortening of apical dendrites in the hippocampus neurons and to impaired dentate gyrus neurogenesis. This leads to a disequilibrium in brain structure which can add to mental disorders and not normal physiological responses. The dendrites and spines of the basolateral amygdala grow and the sellate dendrites and spine in the medial amygdala decrease which can lead to an overactivity. An overactivity of the amygdala is connected with mental health disorders. It has been shown that patient with chronic anxiety disorders could profit from mindfulness-based stress training. When anxiety is decreased, amygdala volume is shrinked. In the medial prefrontal cortex chronically stress can result in shortening of dendrites and loss of spines. Dendrites grow at the orbitofrontal cortex. The progress in technology could give evidence that stress experienced in the past can influence future stress responses [20]. It is assumed that the amygdala works as a mediator of the HPA axis during the experience of chronic stress [16], [17].

2.1.4 Biological Measures of Stress

As the response to stress in the body is a complex mechanism theoretically one should include different stress measures [15]. Some stress measures will be described now.

Stress Response Measures of the Sympathetic Nervous System

There is a variety of measures which can be used to identify stress of the SNS like the turnover of heart rate (HR), blood pressure, heart rate variability (HRV), CA release, and galvanic skin response. Facing arousal the temperature input at the eccrine sweat glands changes at the skin resulting in an opening of the sweat pores. The degree of arousal is related to the degree of change of the galvanic skin response as then more pores open. A change of galvanic skin response can be caused by any arousal like anxiety, or fear [15].

Stress measures used most often are the HR, blood pressure, and the computation of HRV. The HRV describes the variability between successive heartbeats [15], also called RR intervals (see figure 2.2) [21]. It is influenced by the parasympathetic and sympathetic part of the ANS. Both parts work as antagonists to regulate the HR intervals. The parasympathetic activity slows down the HR, whereas the sympathetic activity increases the HR [22]. HRV is connected as a biomarker for mental stress and a study could show that the HRV is related to psychological and cognitive stressors. The HRV is reduced under stress compared to baseline [15]. Furthermore, the HRV can be influenced by breathing. The HR is regulated by the ANS, but also influenced by activity, posture, and somatic parameters like respiration and circadian rhythm. Thus, it is not a secure marker of arousal [22].

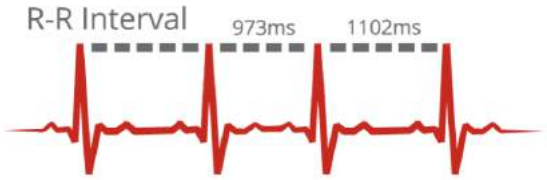


Figure 2.2: The progress of the heart rate shows different times between the heartbeats describing the HRV [21].

Another biomarker of the sympathetic nervous system is the salivary alpha-amylase. The enzyme occurs in the saliva and takes part in the digestion of carbohydrates and starches. It could be shown that the salivary alpha-amylase level increased as a response to physical and psychological stress. The sympathetic as well as the parasympathetic part of the ANS stimulates salivary glands. The level of biomarker can be identified by the non-invasive method of saliva collection [15].

Stress Response Measures of the Hippothalamus-Pituitary Adrenal Axis

As the level of CRH modulated by the hypothalamus is not directly measurable, ACTH and cortisol in venous blood provide an indirect indication of the secretion from the anterior pituitary and the adrenal cortex. In research commonly stress is identified via salivary cortisol. Unbound cortisol diffuses from circulating blood into saliva. The cortisol level in saliva is proportional to the one in blood. The determination of the cortisol level can be conducted via a pure split or the cotton swab method, whereby the probe can be stored at room temperature without a change in the hormone level for some weeks. Critic on saliva cortisol given as a biomarker is that it only presents a part of the HPA axis activation. As the HPA axis responses to stress via the connection of feedback loops, a change in one part of the loop can cause a change in the HPA axis response. That, it takes about 20 to 30 minutes after a stressor occurred until the cortisol peak is reached. Thus, it is recommended to use cortisol together with other biomarkers [15].

2.1.5 Stress and Anxiety

Anxiety is an elementary emotion, whereby Armir et al. describe emotions as states which have a specific function. Thus, anxiety is the state which serves to escape from dangerous situations. The organism has to be aware of a danger to encounter the state of anxiety. The process of becoming aware of a danger can be conscious or unconscious. Therefore, a person who reached the state of anxiety may or may not identify the perception of threat taking part in the state of anxiety. Armir et al. stated that in literature often the term fear is used instead of anxiety, but the terms can be distinguished: fear is distress about a known danger, and anxiety is the distress about an uncertain situation or an unknown danger. Looking at biological theories of anxiety, these theories understand anxiety as a reaction to stress and that environmental stressors influence the well-being [3].

2.2 Anxiety Disorders

People with anxiety disorders are extremely fearful or anxious in situations which should not cause a reaction to this extent. To identify an anxiety disorder the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) and the tenth edition of the International Classification of Diseases (ICD-10) is used. Anxiety disorders have common clinical characteristics but can be divided into more specific anxiety disorders by diagnostic features of the DSM-5 and the ICD-10 [23].

Due to the ICD-10 there is the "Phobic Anxiety Disorder" (F40) which is diagnosed when a well-defined, not dangerous situation provokes anxiety. Usually the situations causing the fear are avoided. "Agoraphobia" (the fear of crowded places), "Social Phobias" (the fear of social situations) and "Specific Phobias" (the fear of very specific situations, e.g. animals) belong to this group of disorder. Another subgroup of anxiety disorder are the "Other Anxiety Disorders" (F41). There the affected person feels anxiety without the relation to a specific situation. An example of a disorder belonging to this group is the "Panic Disorder". With F42 the "Obsessive-Compulsive Disorders" are defined. The main symptom the individual with an "Obsessive-Compulsive Disorder" experiences is the repetition or thinking of obsessive actions over and over again, whereby these actions are not benefiting anything.
The "Reaction to Severe Stress, and Adjustment Disorders" (F43) is a group of disorders which is identified considering the symptoms, the reason and the causative influence which lead to the disorder. A disorder belonging to this group is thought to be connected to an acute severe stress event or to a continued trauma. The "Post-Traumatic Stress Disorder" (PTSD) belongs to the group of "Reaction to Severe Stress, and Adjustment Disorders". PTSD arises delayed after a very dramatic event. Furthermore, another disorder belonging to the group of "Reaction to Severe Stress, and Adjustment Disorders" is the "Adjustment Disorder". In the "Adjustment Disorder" distress and emotional disruptions are experienced as the result of adapting to an important alteration in life. F44 describes the "Dissociative Disorders", which are characterized by the loss of the normal involvement of the memory of the past, the awareness of identity, sensation, and the control of body movements. These disorders are assumed to be psychogenic. They are associated to be connected within time to a traumatic situation or an intolerable conflict disrupted relationships. In Addition, there are the "Somatoform Disorders" (F45). The main characteristic of these disorders are physical troubles and the demand for a medical investigation even when the results of previous investigations were negative. The "Somatization Disorder" (characterized by repeatedly changing physical symptoms which occur at least for two years), "Undifferentiated Somatoform Disorder" (typified due to altering physical symptoms which are not conform with the clinical representation of an somatization disorder), "Hypochondriacal Disorder" (the fear to suffer from a dangerous disease even if the medical results are negative), "Somatoform Autonomic Dysfunction" (a normal body function is assigned to a physical disease), and the "Persistent Somatoform Pain Disorder" (strong pain which appears without the existance

of a physical reason) are subgroups of the "Somatoform Disorders". With F48 "Other Neurotic Disorders", like "Neurasthenia" (tiredness after very easy work or thinking) or the "Depersonalization-Derealization Syndrome" (the environment or the organism changes due to mental activity) are described [24].

2.2.1 Epidemiology of Anxiety disorder

Research in epidemiology analyses the distribution and causal conditions of diseases. Exact data of the number of people suffering from an anxiety disorder is difficult to gain since the number of not reported cases is high as a consequence of a missing diagnose or non treatment. It is assumed that one of ten individuals suffers from an anxiety disorder within one year, whereby the social phobia occurs most often. Furthermore, patients with anxiety disorder have a higher probability to be affected by depression or mental and behavioral disorders due to psychoactive substances. According to Angelini et al. women suffer more often from anxiety disorders than men, whereby the 1 year prevalence to suffer from "Panic Disorders", "Agoraphobia" and "Specific Phobias" is twice as high for women than for men. Also, people living alone, being divorced, or being widowed have a higher risk to be affected by anxiety disorders [1].

Another risk factor to suffer from an anxiety disorder is to be unemployed, having a poor school education, or being in a bad financial situation. Further risk factors are emotional stressful situations in the childhood or adolescence like abuse, humiliation, or overprotectioness by the parents. In addition, experienced violence, sexual assaults, natural disasters, or genetic factors can lead to anxiety disorder, depression, or other mental disorders [1].

2.3 Mental Health Interventions

Mental health applications for smartphones began to become popular in 2007, and since then the number of users has increased over millions [10]. Advantages of mental health smartphone applications over traditional therapies are the affordability with respect to the prize, the anonymity of users, not having to meet geographical or timing commitments, and the well manageable collection in feedback data for developers [11]. Furthermore, there is an acceptance in the population towards these applications, since one fourth of the German population can imagine using online help when affected by a mental disorder or distress [25]. These interventions belong to the field of mobile health (mHealth) which can be defined as medical applications based on mobile devices like mobile phones, monitoring devices, digital assistants, and wireless devices [26]. mHealth is used in health care and public health and has the potential to take advantage of methods often associated with conventional health methods like personalization or interactivity [27].

2.3.1 Guided and Non-Guided Mental Health Interventions

Technology-based interventions can be divided into guided and non-guided interventions [25]. A guided intervention involves a therapist or coach in the treatment, whereas the therapist/coach has a supportive function. The communication between patient and therapist can occur face-to-face, via telephone, by e-mail, or via any other method of communication. These intervention seem to be as effective as face-to-face treatments for depression [28]. In non-guided interventions the user applies the treatment on his/her own [25]. Different findings imply that these interventions may have an impact but are not as effective as guided interventions for depression [28].

"PRIME-D" is an example of a guided intervention. "PRIME-D" is based on evidence based therapy. The coaching is conducted based on text messages by a coach. The frequency of the contact to a coach depends on the user's requirements [29].

It is assumed that guided internet-based interventions have an higher engagement than self-guided treatments, up to 80% [29]. Possemato et al. suggest, based on a study they conduct on veterans with PTSD symptoms, that a guided intervention can increase the engagement on PTSD care [30].

Then there are blended therapies where appointments with a therapist are combined with technical intervention [25]. Using mental mHealth interventions between face-to-face sessions, mental mHealth interventions have the potential to enhance health care delivery by providing care between sessions [31].

Nakao et al. examined the cognitive behavioral therapy (CBT) intervention "Kokoro-no-skill-up-training" blended with face-to-face sessions, whereby participants received less face-to-face sessions as usual. They could show that their blended therapy was able to decrease depression symptoms compared with a wait list control group. Furthermore, there were no drop out rates [32].

2.3.2 Different Approaches for Mental Health Interventions

There are different approaches for mental health training like cognitive behavioral based interventions, mindfulness based interventions, or self-compassion ones as described below [33]. Research conducted in the past proposed that mental mHealth intervention can be a support in managing certain health circumstances [31]. Additionally, there is evidence that the output of the different approaches vary by individuals. A study could show that a brief mindfulness intervention has fewer effects on decreasing distress on individuals who are not comfortable with their emotions [33]. Following, an insight in different therapy approaches and mental mHealth interventions based on these approaches is given. Most of the mHealth interventions address more than one psychological disorder and are non-specific.

The Cognitive Behavioral Therapy Approach

CBT is a personalized therapy based on the concept that cognitive actions can be influenced by human behavior. It is assumed that cognitive behavior can be tracked and changed. Furthermore, it is believed that a modification of behavior can be provoked by a change in cognitive behavior. In CBT it is believed that the maladadaption of cognition correlates with misunderstanding leading to experienced danger. CBT has shown success in a lot of different fields of mental health disorders as in obsessive compulsive disorder, PTSD, and the reduction of depression or anxiety symptoms [8]. Classical CBT is applied for ten to 20 weeks [34] which has been shown to be similar effective then a therapy of antidepressants [32].

As being the most evidenced classical psychological intervention, mobile- and internet intervention applying this approach have been investigated to assist users to boost their emotional awareness and support them in coping with stress. Rathbone et al. analyzed studies with the aim to evaluate the performance of CBT based mobile intervention coming to the result that the applications seem to be able to improve mental issues like depression and stress [33]. Furthermore, a review came to the result that internet CBT was as effective as face-to-face CBT in panic disorders [35]. An overview about different mHealth intervention based on CBT is given in table 2.1 and an overview about the effects can be seen in table 2.2.

Function	"Living with Heart" (CBP)	"Be Good To Yourself"	"Mood Prism"	"Mood Mission"	"Mood Kit"	"Virtual Hope Box"
Mood Tracking	✓		✓		✓	
Messages	✓	✓				✓
Rewards	✓					
Reminder	✓	✓				
Audio Material	✓					✓
Coping Strategies	✓					✓
Relaxing Strategies	✓					
Psychoeducation	✓	✓				
Diary			✓		✓	

Mindfulness Strategies		✓				✓
Cognitive Strategies		✓				
Activation Strategies		✓				
Social Competence Strategies		✓				
Time Limit		✓				
Thought Control					✓	
Hope Box						✓
Video Material						✓
Gamification						✓
Quotes	✓					✓
Self Compassion Strategies						
Inventory for Values and Activities						
Planing Activities						
Assistance to Complete Activities						
Homework						
Identify Values of Life						
Feedback						
Emergency Help						
Social Support						

Sleep Hygiene						

Table 2.1: Functions of CBT mHealth interventions. A ✓ means that the function is not included and a blank field means that no information was given regarding the corresponding function in the examined resources.

Mak et al. developed the mobile and web-based application "Living With Heart" (LWH) containing three different programs with 28 sessions each: a mindfulness-based program (MBP) (described in section The Mindfulness Approach), a self-compassion program (SCP) (details are given in section The Self-Compassion Approach) and a cognitive behavioral psychoeducation program (CBP). All programs include a mood tracking function based on the training the user applies, well-being messages once a day, receiving of stickers when making improvements which can be shared on social platforms, and an alarm users can set to remember applying the intervention. To allow the use of the application when the user is not able to read everything is audio-recorded. In a user study Mak et al. examined the intervention programs within 3 groups. Participants assigned to one group tested one program. Participants were supposed to use each program every day for 10-15 min. In the CBP patients learn different strategies to handle stress (methods to solve problems, to control moods, and to identify thoughts related to stress), to relax (progressive muscle relaxation, breathing strategies, and pictorial relaxation), and they are educated on mental health, stress, and the cognitive behavioral method. On average 34.08% of the CBP participants completed the 28 sessions. Considering all participants in all three application groups, a significant increase of well-being and mindful awareness could be found. The psychological distress significantly decreased in all program groups. After 3 months a significant difference could be found in mental well-being and psychological distress but not in mindful awareness compared to baseline in every application group. CBP increased self-compassion significantly, but no significant effect could be identified between baseline and 3 months after the intervention was used. Looking at participants who completed the interventions, a significant increase of well-being and a significant decrease of distress could be identified from baseline to post program and from baseline to 3 months after the interventions were applied. Mindful awareness showed no significant effect of time and self-compassion was significantly increased after post treatment to baseline but not 3 month after the treatment [33].

"Be Good to Yourself" is a CBT mobile phone intervention which offers 40 self-help methods and tasks of the types cognitive methods, mindfulness-based tasks, social-competence know-how, and activating tasks. Screenshots of the application can be seen in figure 2.3. Every exercise is explained with a maximum of 150 words and can be performed in a few minutes in everyday life. Additionally, the exercises contain psychoeducational information. When using "Be Good to Yourself", every participant has to complete the tasks in the same sequence, whereby exercises of the different categories

vary. When the user gets to the next task, he/she can either apply the task or decide to avoid this one and go to the next exercise for three times. If the user applies a task, the description is displayed together with a time limit in which the participant cannot close the task, resulting in a time period the user has to apply the exercise. After every exercise, the intervention tries to encourage the participant to take time for his/her well-being. Furthermore, the user can set times and the number of reminding messages he/she would like to receive for taking time for him-/herself. In Lüdtke et al.'s study 84% of the participants finished the treatment and 39% used it on a regular base. Depressive symptoms decreased over time in the intervention group and in the wait list group without a significant difference. Lüdtke et al. explains the decrease in the wait list group by the possible use of different interventions, due to the time passed by, spontaneous remission, or self-efficacy. This study could not find an increase in self-esteem or quality of life related to "Be Good to Yourself". For further improvements, feedback on the intervention was token. Some users felt that the countdown given in each task was too long or useless. Moreover, the quality of the audio files did not satisfy everyone. One participant did not like the reward messages as they were repetitive [25].

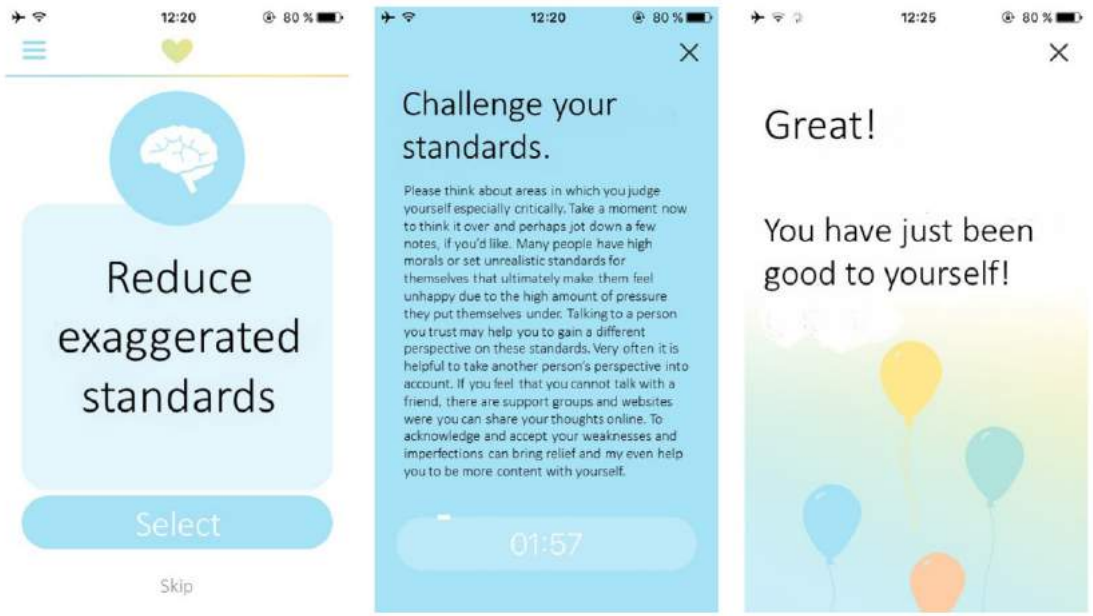
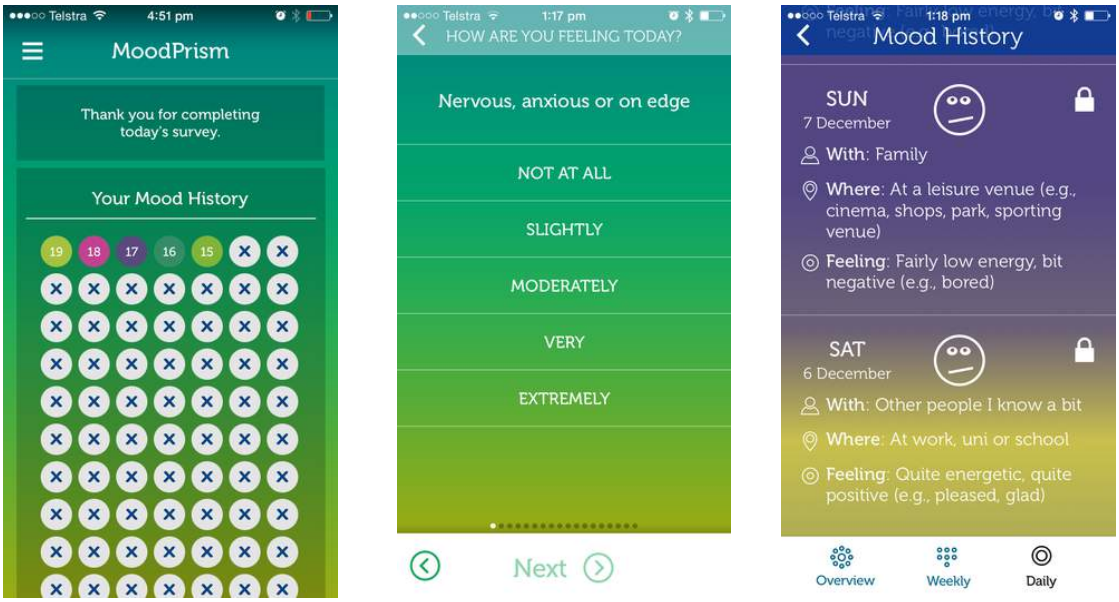


Figure 2.3: Screenshots of "Be Good To Yourself". On the left, the title of a task which can be selected by the user is displayed. In the middle, the task together with the countdown is shown. On the right, the motivation message which is shown to the participant after finishing a task is visualized. [25]

"MoodPrism" is a CBT mobile phone intervention, which has the aim to improve emotional self awareness (ESA), mental health literacy (MHL), and coping self-efficacy (CSE) by a mood diary. Figure 2.4 gives an insight in the intervention. Users can track their

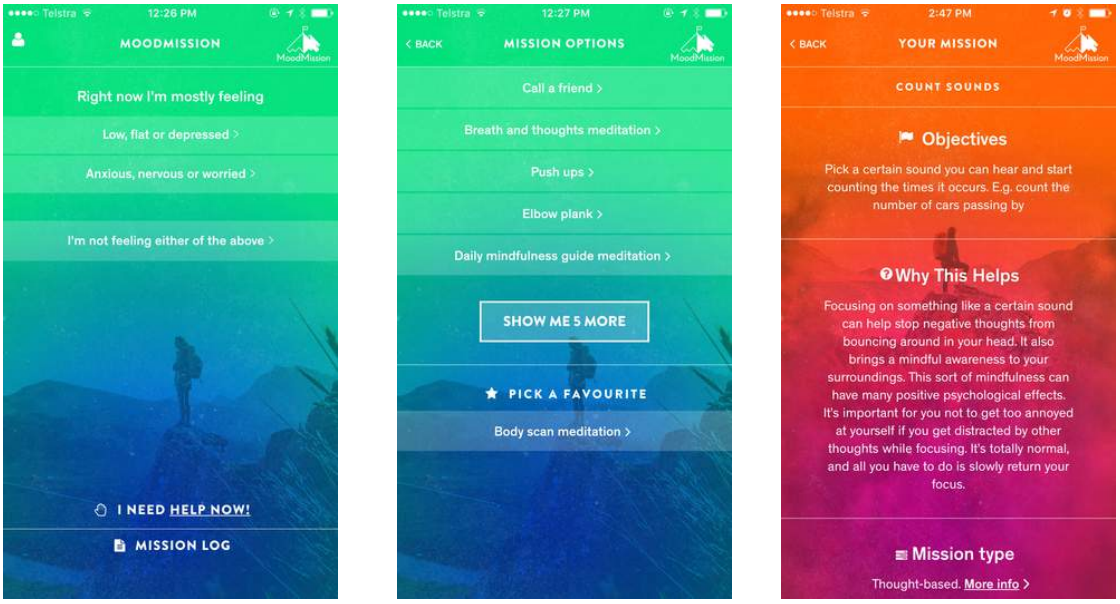
moods and get an overview about their mood development. It has been identified that the engagement to "MoodPrism" correlates to the decrease of depression, anxiety, and the increase of well-being. Bakker et al. could show in their study that participants using "MoodPrism" significantly increased their well-being compared to a wait list control group but did not significantly change depression or anxiety compared to a control group. Furthermore, ESA increased significantly but CSE and MHL did not [11].



(a) (b) (c)

Figure 2.4: The intervention "MoodPrism". 2.4a: An overview of the mood history in "MoodPrism". 2.4b: A question on the feelings in "MoodPrism". 2.4c: Detailed view on the mood history of a specific day [36].

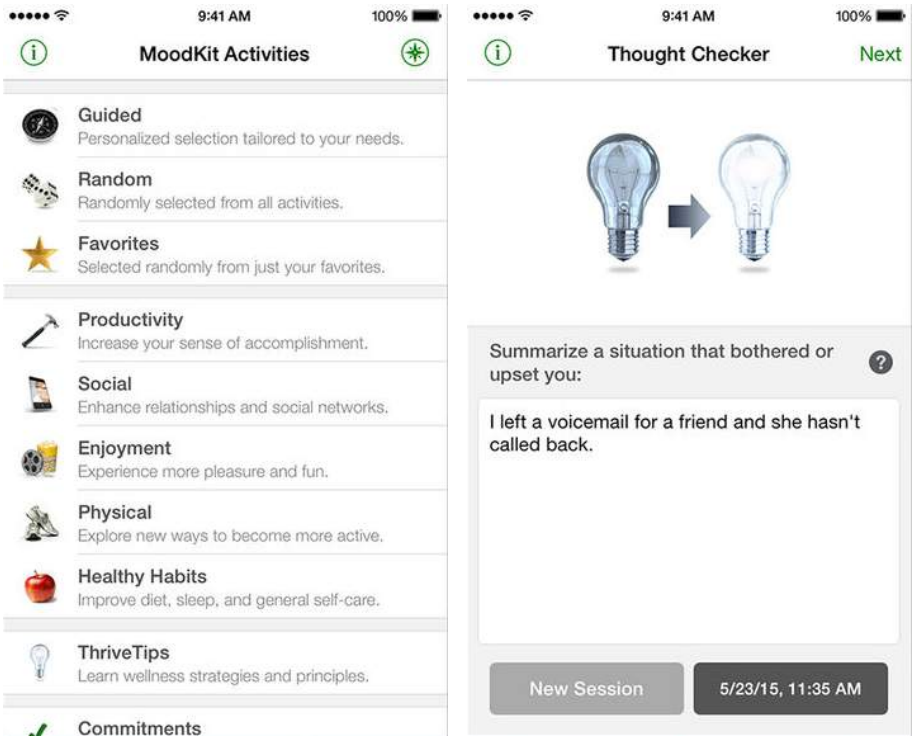
The smartphone intervention "MoodMission" offers five CBT based strategies, adapted to the users described emotions, to choose of. These strategies are called "Missions" and aim to increase CSE and self-conscious regarding the handling of stressors. The goal of "MoodMission" is to increase ESA, MHL, and CSE. Screenshots of "MoodMission" can be seen in figure 2.5. It has been shown that advancements on mental health connected to "MoodMission" are due to CSE. A study conducted by Bakker et al. could show that "MoodMission" can significantly increase well-being and decrease depression but does not significantly decrease anxiety compared to a wait list control group. Additionally, the CSE increased significantly in participants using this application, but ESA and MHL did not [11].



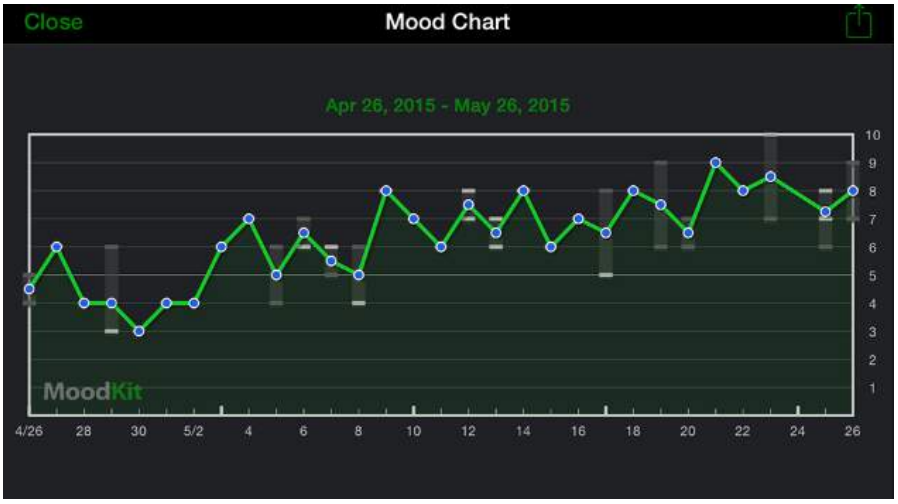
(a) (b) (c)

Figure 2.5: Mobile application "MoodMission". 2.5a: User has to describe his/her emotions in "MoodMission". 2.4b: Based on the feelings "MoodMission" offers the user five "Missions". 2.4c: Example of a "Mission" in "MoodMission".

"MoodKit" is a CBT based intervention aiming to enhance ESA, MHL, and CSE. The application contains four different types of exercises: a mood tracking, a thought control, and a diary one. Screenshots of "MoodKit" are displayed in figure 2.6. A study of Bakker et al. came to the result that "MoodKit" can increase well-being and decrease depression significantly compared to a wait list control group but does not significantly change anxiety. CSE improved significantly in participants using this application but ESA and MHL did not [11].



(a) (b)



(c)

Figure 2.6: Screenshots of the application "MoodKit". 2.6a: Screenshot of different activities the user can choose of in "MoodKit" [37]. 2.4b: The user can record his/her thoughts and feelings in the thought checker of "MoodKit" [37]. 2.4c: A Screenshot of the mood chart in "MoodKit" [38]. The user is able to see the development of his/her mood from the past month.

Hope boxes are boxes applied in CBT where patients can keep positive memories, coping strategies, distraction methods, or reminders why its worth to live. These boxes are then supposed to assist in difficult moments. In principle "Virtual Hope Box" (VHB) is the same except it is a mobile phone application. The intervention consists of six different parts which try to assist the user by audios, videos, games, mindfulness tasks, messages, inspirational quotes, or coping support. Bush et al. investigated in a two armed randomized controlled trial that VHB users significantly increase their skills of coping feelings and thoughts compared to the control group who received a book to overcome difficult periods [39].

Results	"Living with Heart" (CBP)	"Be Good To Yourself"	"Mood Prism"	"Mood Mission"	"Mood Kit"	"Virtual Hope Box"
Increased Self Compassion	✓					
Decreased Depressive Symptoms		✓	o	✓	✓	
Increased Quality of Life		o				
Increased Self Esteem		o	✓	✓	✓	
Increased Well-Being	✓		✓	✓	✓	
Decreased Distress	✓					
Increased Mindfulness Awareness	✓					
Decreased Anxiety			o	o	o	
Increased Psycho-Education			o	o	o	
Increased Self Awareness			o	o	o	

Increased Coping with Feelings/ Thoughts						✓
Decreased Suicidality						
Decreased Impulsivity						
Decreased Cortisol Concentration						
Decreased Emotional Reaction to Stressor						
Decreased Heart Rate						
Increased Mood						
Decreased Arousal						
Reduced Breathing Rate						
Reduced Electrodermal Activity						
Increased HRV						

Table 2.2: Overview about the effects of different CBT mental health interventions. A ✓ means that the effect could be shown, o means that the effect could not be shown, and a blank field means that no information was given on the effect in the examined resources.

The Behavioral Activation Treatment for Depression Approach

In behavioral activation treatment for depression (BATD) the patient and therapist define activities based on important values of life of the patient. He/she is supposed to integrate

these activities in his/her daily life. The patient has to fill in forms on the activities every day. Completing these forms every day can cause difficulties for some patients. Also, it can be challenging for therapist to connect activities and patient's moods. "Behavioral Apptivation" is a BATD mobile intervention which tries to overcome these issues by transforming the challenging part of BATD into a smartphone application. "Behavioral Apptivation" together with an online platform is an intervention where the patient and the therapist use an intervention additionally to the regular therapy sessions. In table 2.3 and overview about the function of "Apptivation" is given. The patient can complete the daily monitoring in the app. He/she can access a module to identify important values in his/her life or define and view planed activities for the day in a calendar. The therapist can view the platform connected to "Behavioral Apptivation" and is able to connect activities with mood. The therapist is able to view a graph on the daily mood ratings of the patient. The therapist also can intervene if he/she notices that a patient has troubles with an activity. Therapists and patients who tried the intervention in a study reported positive feedback on their experiences with "Behavioral Apptivation". A decrease on depression consistent with the decrease of traditional BATD could be identified [40]. An overview of the results can be seen in table 2.4.

The Mindfulness Approach

Mindfulness training is based on developing consciousness while events are unfolding. One point of the mindfulness approach is the transience of thoughts and feelings. Based on that, it focuses on teaching self-regulation of being aware and having an open attitude regarding the moment [33] with a non judgmental attitude. Current experiences like thoughts or feelings are supposed to be realized [41]. Mindfulness based therapy could show its effectiveness in mental health. A meta-analysis resulted that it has a medium effect size in decreasing anxiety, depression, and stress compared with a wait list control. In the last years, mindfulness internet based intervention have been investigated and could show positive effects on well-being, sleep disturbance, distress, life satisfaction, anxiety, and depression [33].

Mak et al. developed the LWH intervention which contains a MBP, a CBP (details in section The Cognitive Behavioral Approach) and a SCP (for details see section The Self-Compassion Approach). An overview about the functions of the MBP is given in table 2.3. Overall details and results valid for all programs can be seen in section The Cognitive Behavioral Approach. The MBP was adapted from an internet-based mindfulness training which has been developed by Mak et al. This program contains exercises like body scan, mindful breathing, mindful eating, mindful walking, 3-min breathing space, and thought distancing practices. As in CBT, the MBP contains audio material as well as reading material. Participants are taught about mindfulness and its difficulties. MBP could not significantly change self-compassion from baseline to post-treatment, considering all participants as well as only participants who fully finished the program [33]. An overview of the results can be seen in table 2.4.

The Self-Compassion Approach

Self-compassion training teaches looking after oneself in situations of experienced inequity and to be aware that those experiences and mistakes are common in humans. A balanced handling of emotions and thoughts can lead to an understanding of these emotions, and thus, it lightens the ability to turn negative feelings into positive ones. It has been shown that self-compassion training can lead to a better well-being due to a decrease in depression, self-criticism, stress, shame, and anxiety [33].

The LWH intervention consisting of three programs SCP, CBP (described in section The Cognitive Behavioral Approach), and MBP (information can be find in section The Mindfulness Approach), whereby an overview and results valid for all programs is given in section The Cognitive Behavioral Approach. The SCP is based on training, which consists of compassionate body scan, affectionate breathing, loving-kindness meditation for beginners, compassionate walking, soften-allow-soothe, self-compassion break, and self-compassion writing. Information is available in audio and text format. Further, the participant is educated about self-compassion. An overview about the functions of SCP is given in table 2.3. Looking at all participants SCP could increase self-compassion from baseline to post-treatment. The same result could be found when considering only participants who fully completed the intervention [33]. An overview about the results can be seen in table 2.4.

The Problem Solving Approach

The problem solving therapy (PST) was one of the first treatments of depression established in the 1970s. PST is based on adaptive problem solving perspectives and techniques. It focuses on increasing participants' well-being by teaching the handling of stressful situations [42].

The web-based-guided intervention "Taking Control" [43] based on PST was examined in a randomized control trial (RCT) on patients waiting for a face-to-face therapy. One group in the trial received the intervention and the control group received a self-help intervention book. The aim of the intervention was to assist patients to manage their problems by teaching skills. An overview about the functions of this intervention can be seen in table 2.3. Users of the intervention can work on five weekly sessions including homework. The first one supports the participants to identify things that matter in their life and assigning problems to the categories: not important, important and not solvable, and important and solvable. In sessions two to four the user can learn different coping strategies to each type of problem. The last session focuses on long term aims and to accomplish these aims. A coach gives feedback on the homework. The goal of the feedback was twofolded. First, the participants were supposed to become familiar with applied techniques. Second, the aim was to encourage the users to stay motivated to continue the treatment. After the exercise of one session was uploaded to a website and the participant received feedback on it, he/she could explore the next session. 36%

of participant in the intervention group completed at least 4 sessions. In both groups symptoms of depression decreased from baseline to post-treatment and there were no significant differences between the groups [5]. An overview of the results can be seen in table 2.4.

The Acceptance and Commitment Therapy Approach

The acceptance and commitment therapy (ACT) has its origin in the relational frame theory (RFT). The RFT states that with language and cognition one can learn the competence to assign events to each other. Furthermore, this ability allows one to alter the purpose of certain events upon the background of the relation of these events to others. A consequence of RFT is that relationships between objects resolved by speech can change and restrict behavioral procedures. Thus, ACT was investigated to change the interrelation under which the behavior arises. In ACT the aim is that the patient accepts undesired emotions and thoughts. It attempts to change the attitude toward events which are avoided, like the avoidance of negative rated feelings, unwanted physical events, or thoughts. Therefore, ACT uses acceptance, cognitive defusion, being present, self as context, values, and committed actions as methods. [44]

An application which works with ACT is "ibobbly" developed at Black Dog Institute in partnership with the indigenous community members in Western Australia addressing indigenous people. An overview about its functions can be seen in table 2.3. The app was designed to work on three content modules and three exercises within six weeks. The first module teaches the users to identify and distance oneself from certain thoughts, emotions, and behavior. In the second part users learned to control their feelings by mindfulness techniques, acceptance, and self-soothing activities. The last module assists users to detect important, meaningful things in their lifes and supports to follow those thing. Redoing tasks is requested. All material is given as text and audio recorded. Furthermore, users evaluate their emotional state on a frequent base and can check their development. Additionally, information on receiving 24-hour emergency help is given. A two armed randomized control trial with an intervention group and a wait list group came to the result that the intervention is able to decrease depression symptoms and distress but could not show a significant effect on suicidality and impulsivity [45]. An overview about the results can be seen in table 2.4.

The Attention Bias Modification Training Approach

Attention bias modification training (ABMT) is a training where the participant learns to avoid paying attention to a threat. Thus, the sense of threat is supposed to decrease. On the one hand a meta-analysis found that ABMT can significantly reduce anxiety and stress over a placebo group when applied for four to six weeks. On the other hand another analysis identified that the outcomes of ABMT are variable. It is possible that they depend on the individual and the treatment. Also it has been found that ABMT may have an impact on female behavior but not on male behavior when facing a stressor

[46].

Dennis-Tiwary et al. invented an application based on ABMT, containing video game elements like animated characters and sound named "Personal Zen". An overview about the functions in "Personal Zen" can be seen in table 2.3. In "Personal Zen" two characters appear and disappeared in a hole. One of the characters has a pleasant and the other one has an angry expression. In the ABMT version grass is growing over the hole of the non-threat character. The user is supposed to trace the grass with his finger. In the placebo version the trace of grass occurred on both holes with the same probability. The user gets points depending on the speed and accuracy of tracing the grass. The application was tested in a study conducted on pregnant women with the goal to identify if the intervention can reduce stress and anxiety when applied for one month. The intervention was supposed to be used four days a week for ten rounds each day. As cortisol being a biomarker of stress, Dennis-Tiwary et al. measured the cortisol concentration in the ABMT and in the control group. Additionally, event-related potentials (ERPs) (ERPs are voltages occuring in the relationship with certain events [47]) were measured at baseline. Using ERPs can detect individual differences influencing the outcome of ABMT. It was found that the cortisol secretion decreased when stressors were faced in the ABMT group in contrast to the placebo group after the training period in a lab setting. In participants where the ERP showed later visual processing of threat, their reported anxiety was reduced in the ABMT group compared to placebo group. Nonetheless, Dennis-Tiwary et al.'s study resulted also in zero findings as the subjective emotional reaction to a stressor did not decrease [46]. An overview about the results can be seen in table 2.4.

Function /Intervention Approach	"Living with Heart" (MBP)	"Living with Heart" (SCP)	"Behavioral Apptivation"	"Taking Control"	"ibobby"	"Personal Zen"	"Intelli Care"
Intervention Approach	Mindfulness	Self-Compassion	BATD	PST	ACT	ABMT	combination
Mood Tracking	✓	✓	✓		✓		✓
Messages	✓	✓					
Rewards	✓	✓				✓	
Reminder	✓	✓					
Audio Material	✓	✓			✓		
Coping Strategies				✓	✓		✓

Relaxing Strategies							✓
Psychoeducation	✓	✓					✓
Diary							
Mindfulness Strategies	✓				✓		
Cognitive Strategies							✓
Activation Strategies							✓
Social Competence Strategies							
Time Limit							
Thought Control					✓		✓
Hope Box							✓
Video Material							
Gamification						✓	
Quotes	✓	✓					
Self Compassion Strategies		✓					

Inventory for Values and Activities			✓				
Planing Activities			✓				
Assistance to Complete Activities			✓				
Homework				✓			
Identify Values of Life				✓	✓		✓
Feedback				✓			
Emergency Help					✓		
Social Support							✓
Sleep Hygiene							✓

Table 2.3: Overview about functions of different mental mHealth interventions. A ✓ means that the function is not included and a blank field means that no information was given on the corresponding function in the examined resources.

Results	"Living with Heart" (MBP)	"Living with Heart" (SCP)	"Behavioral Apptivation"	"Taking Control"	"ibobby"	"Personal Zen"	"Intelli Care"
Increased Self Compassion	o	✓					

Decreased Depressive Symptoms			✓	o	✓		✓
Increased Quality of Life							
Increased Self Esteem							
Increased Well-Being	✓	✓					
Decreased Distress	✓	✓			✓		
Increased Mindfulness Awareness	✓	✓					
Decreased Anxiety							✓
Increased Psycho-Education							
Increased Self Awareness							
Increased Coping with Feelings/ Thoughts							
Decreased Suicidality					o		
Decreased Impulsivity					o		

Decreased Cortisol Concentration						✓	
Decreased Emotional Reaction to Stressor						o	
Decreased Heart Rate							
Increased Mood							
Decreased Arousal							
Reduced Breathing Rate							
Reduced Electrodermal Activity							
Increased HRV							

Table 2.4: Overview about the effects of different mental mHealth interventions. A ✓ means that the effect was identified, o means that the effect could not be shown, and a blank field means that no information was given regarding the effect in the examined resources.

The Biofeedback Approach

Biofeedback is based on the ability of humans to learn based on physiological signals. Within the concept of biofeedback physiological parameters, which are usually not observable directly, are measured with electronic or electromechanical devices and are reported to the user. By making the user aware of the signals he/she can learn to influence corresponding body functions [48]. Typical measured parameters are heart rate, respiration, muscle activity, or skin temperature [49].

Biofeedback has been identified as an important therapy in treating attention-deficit-

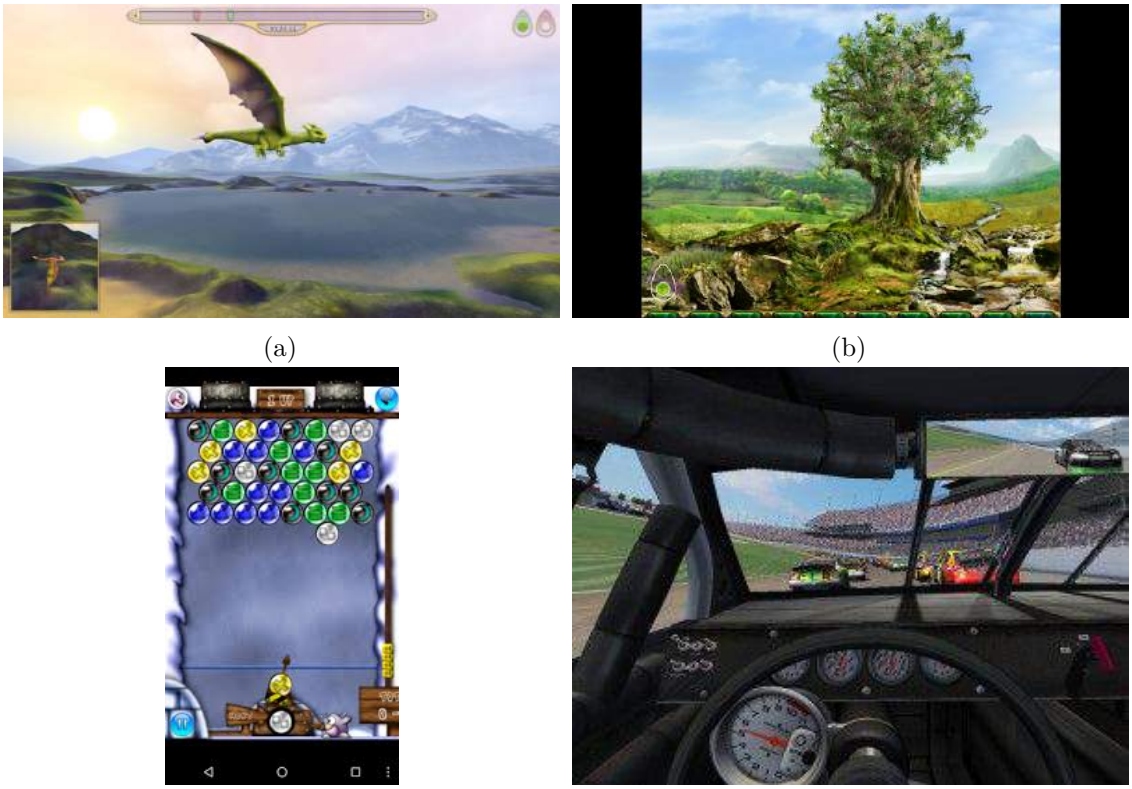
hyperactivity disorder, headaches, high blood pressure, digestive system disorder, anxiety, and depression. In the therapy of stress related circumstances biofeedback has recently become a computer-linked conditioning training [50]. Applied in several stress treating programs, the biofeedback approach can be an useful opportunity in stress reduction. Participants of these programs learn - when they are stressed - by being aware of their measured vital parameters how to reduce their stress level and their symptoms [49]. Heart rate and skin temperature are the main physiological markers of stress [50]. There are studies of applications and games which lead to the assumption that applications in combination with biofeedback can reduce stress [10]. Biofeedback games measure physiological parameters and adjust the game according to those parameters to motivate the player to maintain a physiological state [49]. In table 2.5 an overview about the functions of different biofeedback interventions is given, followed by a more detailed insight in applications and games working with biofeedback. Table 2.6 shows an overview about the results of different biofeedback interventions.

Function	"Relax and Race" / "The Loom"	"Frozen Bubbles"	"Live for Speed"
Mood Tracking			
Messages			
Rewards			
Reminder			
Audio Material			
Coping Strategies			
Relaxing Strategies			
Psychoeducation			
Diary			
Mindfulness Strategies			
Cognitive Strategies			
Activation Strategies			
Social Competence Strategies			
Time Limit			
Thought Control			
Hope Box			
Video Material			
Gamification	✓	✓	✓
Quotes			
Self Compassion Strategies			

Inventory for Values and Activities			
Planing Activities			
Assistance to Complete Activities			
Homework			
Identify Values of Life			
Feedback			
Emergency Help			
Social Support			
Sleep Hygiene			

Table 2.5: Different functions of biofeedback interventions. A ✓ means that the function is not included and a blank field means that no information was given on the corresponding function in the examined resources.

Dilon et al. introduced two biofeedback games: "Relax and Race" and "The Loom" which can be seen in figures 2.3.7a and 2.3.7b. "Relax and Race" is a racing game, where the user is a dragon and competes against his/her recent best result. The user influences the speed of the dragon by relaxing (the dragon is faster when the user is relaxed). The relaxation is measured via the permeability of the skin as a biofeedback signal with Pip, a stress management sensor (Galvanic Ltd, Dublin, Ireland). "The Loom" works with the same biofeedback measure (Pip) as "Relax and Race". The user has to turn a winter wonderland into a summer scenery. The velocity of the transformation depends on the state of relaxation (permeability of the skin). In a study Dilon et al. investigated the efficacy of "Relax and Race" and "The Loom". Participants in the intervention group played both games for 15 minutes. Participants in the control group played "Flow Free" (Big Duck Games) - a non biofeedback puzzle game. The relaxation achieved by the interventions was measured based on a visual analogue scale (a measure for subjective conditions) and based on the heart rate via the Wireless Puls Oximeter (iHealth®, Paris, France). Playing "Relax and Race" and "The Loom" showed a significant short term reduction in stress and heart rate [49].



(a) (b)

(c) (d)

Figure 2.3.7: 2.3.7a: "Relax and Race" [49]: A racing game where a dragon, controlled via biofeedback, is competing against the dragon with the recent best result of the player (lower left corner). 2.3.7b: Screenshot of "The Loom" [49]: a winter screen has to be turned into a summer scenery. 2.3.7c: Screenshot of "Frozen Bubble" [51]: the user has to shoot bubbles at the top of the display to burst bubbles with the same color. 2.3.7d: "Live for Speed" [52]: a racing game where the car speeds up depending on the players level of stress.

"Frozen Bubble" was adapted by Parnadi et al. with the aim to reduce stress by linking the game to biofeedback. In the game the user shoots colored bubbles at bubbles sticking to the game's environment ceiling (see figure 2.3.7c). If three bubbles with the same color stick together, they burst. Bubbles shoot automatically if the user is stressed, which makes it more unlikely that three bubbles with the same color are grouped together and burst. How frequently bubbles are shot automatically depends on the level of arousal compared to baseline. The relation can be seen in figure 2.3.8 [22].

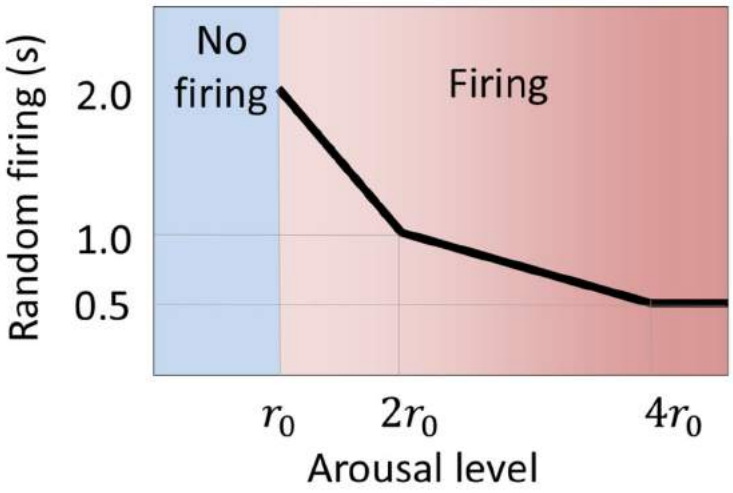


Figure 2.3.8: Piecewise, linear relationship between the frequency bubbles are shot automatically (y-axis) and the level of arousal (x-axis). When the arousal increases, the frequency increases. r_0 describes the arousal at baseline at relaxed state [22].

In a study, Parnadi et al. examine three biofeedback responses on the game "Frozen Bubble", whereby their study contained five study groups. In one group the game was correlated with the heart rate as stress measure, measured with the Bioharness BT chest strap sensor (Zephyr, Annapolis, MD, United States). In the second group "Frozen Bubble" was connected with the breathing rate measured with Bioharness BT chest strap. In the third group the biofeedback was provided by electrodermal activity measured with the Shimmer sensor (Shimmer, Dublin, Ireland) and disposable AgCl electrodes. Furthermore, there was a group without biofeedback, but with a breathing exercise and a group which played the game without biofeedback and without any other instructions. To test the impact of relaxation playing “Frozen Bubble”, the heart rate variability, the breathing rate, and the electodermal activity were measured during the treatment on all participants. Parnadi et al. concluded that biofeedback games can support relaxation, whereas the breathing rate as biofeedback was the most effective method in the study [22].

By developing the "BioPad", Wang et al. made it possible to adopt the controller outputs on a game console of biofeedback games like "Live for Speed". One can see the game in 2.3.7d. "Live for Speed" is a car racing game which is back looped to the breathing rate measured by the BioHarness 3 (Zephyr, Annapolis, MD, United States). The intensity I at which the game is influenced depends on the breathing rate R (breathing cycles per minute) as described in equation 2.1 below [52].

$$I = \begin{cases} 0 & R < 8 \\ (R-8)/12 & 8 \leq R \leq 20 \\ 1 & R > 20 \end{cases} \tag{2.1}$$

Two game modifications were examined in a study: steering sensitivity created by a graphic overlay and adapting the speed of the car implemented via "BioPad". The steering sensitivity increased linearly to the intensity I. The car speed was adapted as it can be seen in equation 2.2 and 2.3 [52].

$$G = \max(G - 150 * I, 0) \tag{2.2}$$

$$B = \min(B + 30, 100) \text{ if } I > 0 \tag{2.3}$$

G describes the adoption of the gas pedal and B the adoption of the brake pedal depending on the intensity. The level of stress over time was detected via breathing rate, HRV, and electrodermal activity. Breathing rate and HRV were measured with the BioHarness 3 chest, and electrodermal activity with the FlexCompInfinity (Thought Technology Ltd. Montreal, Canada). The study showed that the breathing rates of both biofeedback groups were significant lower than the rates of the control group (playing the game without biofeedback) during treatment. The HRV of the biofeedback groups was higher than the HRV of the control group but with a small statistical effect. No statistically differences could be detected in the electrodermal activity. Therefore, Wang et al. concluded that breathing rate can be reduced as well as the stress [52].

Results	"Relax and Race"/ "The Loom"	"Frozen Bubble"	"Live for Speed"
Increased Self Compassion			
Decreased Depressive Symptoms			
Increased Quality of Life			
Increased Self Esteem			
Increased Well-Being			
Decreased Distress	✓		✓
Increased Mindfulness Awareness			

Decreased Anxiety			
Increased Psycho-Education			
Increased Self Awareness			
Increased Coping with Feelings/ Thoughts			
Decreased Suicidality			
Decreased Impulsivity			
Decreased Cortisol Concentration			
Decreased Emotional Reaction to Stressor			
Decreased Heart Rate	✓		
Increased Mood	✓		
Decreased Arousal		✓	
Reduced Breathing Rate			✓
Reduced Electrodermal Activity			o
Increased HRV			o

Table 2.6: Overview about the effects of different biofeedback mental mHealth interventions. A ✓ means that the effect was identified, o means that the effect could not be identified, and a blank field means that no information was given regarding the effect in the examined resources.

Intervention that Combine Different Therapeutic Strategies

Another strategy of mHealth treatment is to combine different evidence-based treatments in one mobile treatment. "IntelliCare" can be seen as an example combining different therapeutic approaches. Actually it is not one intervention, rather it is a collection of treatments applied on the mobile phone the user can choose of. There is the hub application on which the user can see what applications belonging to the "IntelliCare" family he/she has downloaded. Investigating several apps with different approaches (for

example from CBT, problem solving therapy, or commitment therapy) the developer aimed to keep users engaged and let them experience newness with every app. The apps are designed not taking up much time, and focus on providing tasks instead of psychoeducation. To evaluate if "IntelliCare" can reduce symptoms of anxiety and depression, a singel-arm trial was conducted. The study was guided, whereas the coach functioned as a person who supported the user on technical issues, questions regarding the usage or the benefit of an application, and encouraging the users to try interventions. An overview about the functions and the results is given in tables 2.3 and 2.4. The intervention was supposed to be used by the participants for eight weeks resulting in a significant decrease of anxiety and depression symptoms [53].

2.4 Techniques of mHealth Interventions

Different features can be applied in mHealth interventions. Reminders, supportive text messages, personalization, peer support, case-enhanced learning (give a solution due to the demonstration of an example to an identified issue), material available for download, homework, symptom tracking, online diary, video material and illustrations, and summaries for reflection are some features identified in mHealth interventions. Reminders are assumed as important and cost-effective component to increase users engagement, adherence, and motivation. Integrating guidance in a mHealth program via text messages is thought to increase the openness of the participant in terms of persuasion. Wahle et al. described peer support as another technique which can be used in interventions. Using online forums and platforms to discuss with other people might assist patients affected by feelings of stigmatization to leave them behind. Additionally, an advantage is that they are independent of time and location. The effect of online peer support needs to be identified. In literature there is an inconsistance of the gainfulness of discussion platforms. The impact of such services depends on the individual and how involved somebody gets on a platform [34].

Some people prefer reading on paper in favor of an electronic device. Fulfilling this preference in terms of having materials available for download and print out might have an impact on the efficacy of the intervention. Homework tasks are frequently used in traditional CBT. They can be an effective tool in enhancing the results of a CBT. Thus, homework has a potential to be a valuable tool in mHealth interventions [34].

Monitoring mood may give an insight in the performance of an illness like the duration or the intensity of the symptoms. Thus, one could possible early intervene before the symptoms will become severely. Monitoring symptoms is traditionally used via paper in bipolar disorders. Faurholt-Jepsen et al. found in their review that electronic self-monitoring is a possible accurate tool in depression compared with mania [54]. Furthermore, the participant of a treatment can record his/her accomplishments and progress on archiving goals by monitoring symptoms. Wahle et al. describes two methods to monitor symptoms: tracking by applying sensors or self-reporting [34].

Further research is suggested to determine the effect of these components on treatments. Moreover, gamification, serious games, animations, and virtual assistants could be find in studies conducted on mHealth interventions as described below.

2.4.1 Gamification and Serious Games

Gamification means that elements which usually occur in games exist in different environments or interventions normally not related to a game [25]. Serious games are games which aim to fulfill serious functions.
Serious games and interventions with a gamified aspect target to rise the effect of mental health interventions. The strategy how they attempt to reach this is threefolded. First, applying an mHealth intervention in a serious game or within gamified elements might reach people who usually do not seek help. Second, they try to increase the engagement of the user [55]. Previous studies found that CBT based interventions are affected by dropout. Thus, Lüdtke et al. suggest to use gamification to enhance the engagement to applications [25]. The user wants to see how the story of the game goes on, he/she wants to win, or the game is amusing [55]. Applying a reward system can result in stimulating positive thinking. Thus, it can support users to take part in a treatment for a long time [34]. Third, gamified interventions have a potential to be effective by providing the possibility for education and behavioral change due to different methods [55].

Gamified interventions can have exergame [55] (games, where the player has to be physically active to play [56]) character, which are based on sport or movement. The interventions can be based on Virtual Reality (VR) or Augmented Reality (AR). There the user experiences and interacts in a virtual or augmented world aiming to rise the users engagement and might have a therapeutic effect. CBT based gamification and serious games are another type of gamified interventions which show promising findings. Then there are entertainment computer games investigating the impact on mood. Different studies have shown promising results on improving mood or depression, whereby the opposite was also found. These games are proposed to have an impact on mood by emotional regulation, stress release, or social support pathways [55].

An example of an entertainment game proposed to support traumatic flashbacks in PTSD is "Tetris" by affecting memory strengthening played when memories are active. The last type of gamified interventions are biofeedback games. In these games users practice relaxation by obtaining feedback on physiological markers [55].

Christoforou et al. performed an RCT on participants with agoraphobia symptoms on the interventions "Agoraphobia Free" (Health eLiving Partnership Ltd), and "Stress Free". Both applications include gamified elements. "Agoraphobia Free" is based on an avatar who suffers from agoraphobia. The user has to guide the avatar supported by a virtual therapist through therapeutic assignments based on CBT. Learning different therapeutic methods by guiding the avatar, the user is supposed to apply these strategies

in his/her own life. "Agoraphobia Free" is designed particular for people suffering from agoraphobia. "Stress Free" is based on the education of relaxation and CBT skills. This intervention uses games with the purpose to distract the user assisting in acute anxiety situations. The RCT was conducted with the aim to identify if an application designed particular for people with agoraphobia are more effective than games designed in general for users suffering from stress or anxiety. The study resulted in no significant difference on the outcome of the interventions between the groups but both groups showed significant improvements on their symptoms after the intervention has been applied for 12 weeks. Approximately 24% of the participants replying to surveys and questionnaires were not counted as completer (one is counted as a completer if he/she completed 80% or more of the intervention). Christoforou et al. do not give an explanation on the reasons and if these rates are related to a gamification aspect remain unknown [35].

2.4.2 Animations and Virtual Assistants

Virtual avatars could appear in interventions as a chance to integrate persuasive system design in interventions [34].

"eSMART-MH" is an avatar based intervention aiming to reduce depressive symptoms. The intervention tries to encourage users to become more comfortable to talk to healthcare providers about their depression and depression symptoms. A screenshot can be seen in 2.4.1. The user is guided through a virtual health provider's environment meaning that he/she has to talk to a receptionist, an assistant, and the actual virtual health care provider. Additionally, the user is supported by a virtual mentor who encourages the user to communicate with the healthcare provider using SBAR3, a cognitive behavioral-structured communication strategy. It could be shown that people using "eSMART-MH" could decrease their depressive symptoms within three month [57].

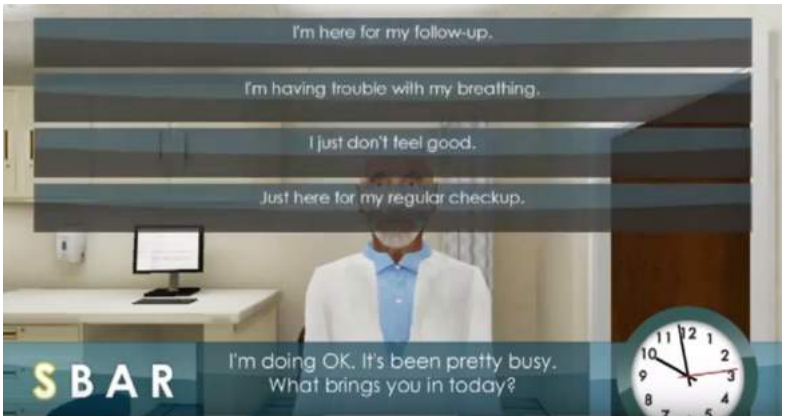


Figure 2.4.1: Screenshot of the avatar based digital therapeutic intervention. The user is having a virtual healthcare provider appointment and is asked typical questions one is asked being at a real healthcare appointment [58].

2.5 Wearables

In the last years, technology has been improved in a way that it is possible to connect smartphones with wearable sensors wirelessly [59] and smartwatches have become available for the general public. Wearables are used to monitor health in a variety of fields like telehealth, telehealthcare, telemedicine, telecare, telehomecare, or mHealth [2]. Many smartwatch producers offer their products on the market. One of them is Fitbit™, belonging to the top five based on the market share [60].

As Fitbit™ allows easy access to real time physiological data [61, 62, 63, 64, 65] it was an aim of this master thesis to integrate Fitbit™devices into the system of the competence unit Digital Health Information Systems of the Austrian Institute of Technology (AIT) (Vienna, Austria). Thus, a deeper look was taken into devices provided by Fitbit™ and into developing applications for Fitbit™. Fitbit™ offers smartwatches as well as fitness trackers online [66].

2.5.1 Fitbit™ Fitness and Activity Tracker

At the time starting with the master thesis the fitness trackers Fitbit Charge 3, Fitbit Charge 2™, Fitbit Alta™, and Fitbit Alta HR™ were available for adults in the Fitbit™ online shop [66]. Details of these trackers can be seen in table 2.7.

2.5.2 Fitbit™ Smartwatches

At the time starting with this master thesis Fitbit™offered two smartwatches in their online shop: The Fitbit Ionic™ and the Fitbit Versa™ [66]. Details of these two devices are given in table 2.7

Model	Company	Display Size [mm]	Resolution [px]	Sensors	Real Time Data Access for Third Parties	Compatibility	Prize [€]
Fitbit Ionic™[67]	Fitbit™	29.232*21 [67]	348 * 250 [67]	altimeter, heart rate sensor, acceleration, gyroscope, GPS, light sensor [67]	heart rate [63], accelerometer [64], barometer [61], gyroscope [62], orientation [65]	iPhone®, Android™, Windows®	299.95[1] [66]
Fitbit Versa™[68]	Fitbit™	29.232*21 [69]	348 * 250 [69]	altimeter, heart rate sensor, acceleration, gyroscope, GPS, light sensor, SpO2 [68]	heart rate [63], accelerometer [64], barometer [61], gyroscope [62], orientation [65]	iPhone®, Android™, Windows®	199.95[1] [66]
Fitbit Charge 3 [70]	Fitbit™	19.9 * 34.5 [70]	100 * 150 [71]	altimeter, heart rate sensor, acceleration, SpO2 [70]	not available [72]	iPhone®, Android™, Windows®	149.95[1] [66]
Fitbit Charge 2™[73]	Fitbit™	38 (diagonal) [74]	not available	altimeter, heart rate sensor, acceleration [73]	not available [72]	iPhone®, Android™, Windows®	159.95[1] [66]
Fitbit Alta™[75]	Fitbit™	35.56 (diagonal) [76]	128 * 36 [76]	accelerometer [75]	not available [72]	iPhone®, Android™, Windows® Phone	119.95[1] [66]
Fitbit Alta HR™[77]	Fitbit™	35.56 (diagonal) [78]	128 * 36 [78]	heart rate sensor, accelerometer [77]	not available [72]	iPhone®, Android™, Windows®	149, 95[1] [66]

Table 2.7: Features and technical information of Fitbit™ devices.

[1] prize from 16.11.2018

2.5.3 Developing Applications for Fitbit™ Devices

Fitbit™ provides its own software development kit (SDK) Fitbit Studio to develop applications and watchfaces for the Fitbit Ionic™ and the Fitbit Versa™ [72]. As scripting language JavaScript and React are used [79].

An application can have at max 10 MB when it is installed. Having an installed application the maximum space it can take is up to 15 MB. This includes resources and files written during the use of the application [79].

Architecture of a Fitbit™ Application

Fitbit™ application have a certain architecture comprising of five project folders. The architecture is shown in figure 2.5.1. The app and the resources folder are mandatory to build an application. The app folder contains the code which is executed on the device and has access to the device application programming interface (API), can interact with the presentation layer, communicate with the companion, and read or write files. The app, companion, and common folders can contain multiple JavaScript or TypeScript files. The app folder and the companion folder, if existing, need to contain a file named "index.js" or "index.ts". The companion folder contains the code executed on the mobile device, whereby it has access to the companion API, can make internet requests and communicate with the device. The setting folder should contain a single React JSX file which is named "index.jsx". The code can provide modifications for the user and has access to the settings API. Files in the common folder can be shared between the app and the companion and need to be created as ES6 modules. The resource folder has to contain a file named "index.gui" and one named "widgets.gui". In the "index.gui" file the user interface markup is defined, and the "widgets.gui" file controls the available widgets for the "index.gui" file. Then, the resources folder can contain a cascading style sheets (CSS) file which can be linked into the "index.gui" file. Furthermore, the resources folder can contain "png" or "jpg" images which can be included in the user interface of the application [79].

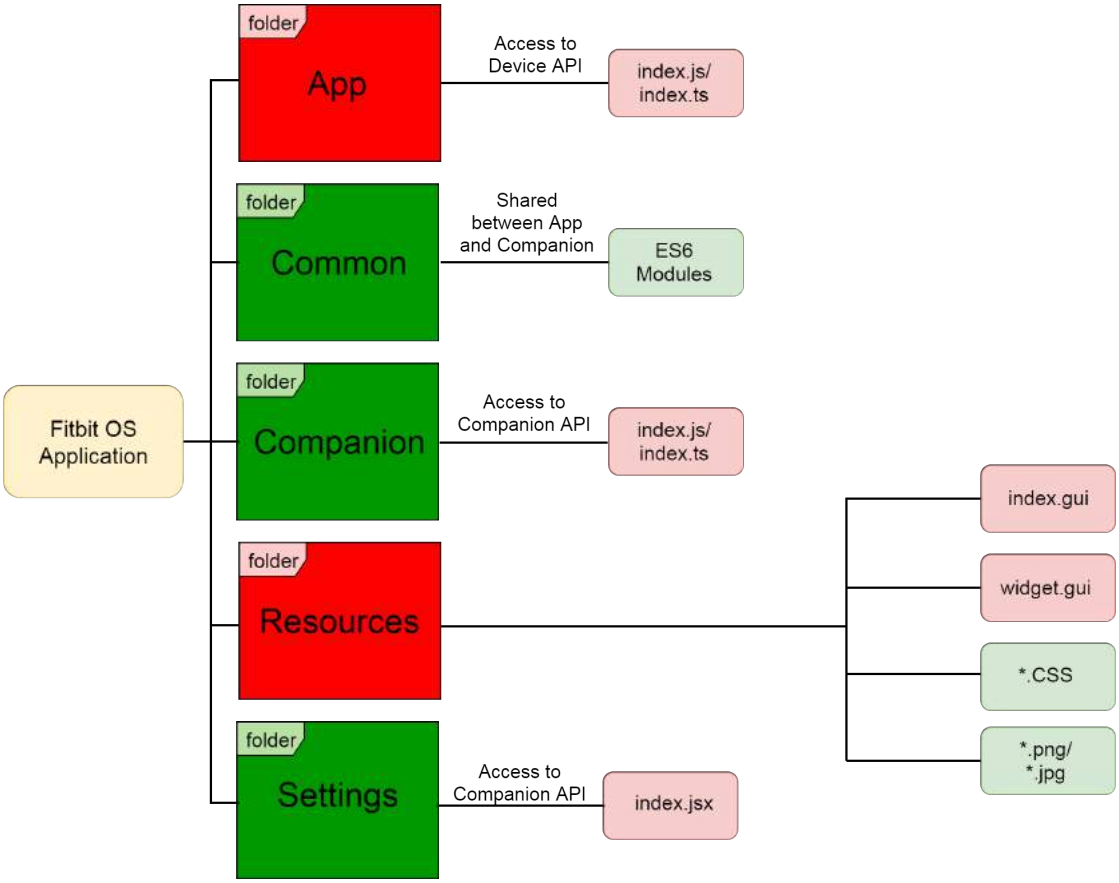


Figure 2.5.1: The figure shows an diagram visualizing the architecture of an Fitbit OS application [79]. Green boxes in the diagram describe that the project folder is optional. A red folder means that the project folder is compulsory if the project folder parent project folder exists.

Application Programming Interfaces of an Fitbit™

Fitbit provides several APIs as it was already mentioned before and can be seen in figure 2.5.1. Following a more detailed look will be taken into the device, companion, web, and settings APIs.

Device API

The device APIs can be accessible by applications which run on a Fitbit™ device only. With the Fitbit OS SDK 3.1 [80] access to real time data of the sensors within the accelerometer API [64], the barometer API [61], the heart rate API [63], gyroscope API [62], and orientation API [65] is provided. Moreover, one can use APIs like the file transfer API [81] or the messaging API [82] to communicate with the companion, the file

system API [83] to read or write files, the haptic API [84] to control the vibration motor, or the body-presence API to detect if the device is on the user's wrist [85].

Companion API

The Companion API is accessible by applications which run on the Fitbit™ mobile application only. Within the Fitbit OS SDK 3.1 [86] the file transfer API [87] and the messaging API to communicate with the device [88], the settings API to access live settings [89], the fetch API to perform POST or GET requests [90], or the local storage API to store pairs of keys and values are some companion APIs available [91].

Settings API

The settings API can be used to allow the user to configure the application. Therefore, some components which can be used are buttons, toggles, sliders, text inputs or lists [92].

Web API

The web API allowing anybody to receive data from Fitbit™ activity trackers, Aria scale, and manually entered logs. To use one of the web APIs one needs to register his/her application to receive API client credentials. To give users the possibility to give permissions to access data, OAuth 2.0 authorization flow has to be implemented. The data can be received via a HTTP request. Heart rate time series [93], information about the user's friends [94], food logging data of the food locales where the user might choose to search, log, and create food in [95], or activity data are some data types available. A summery of activity data can be accessed for a certain period of time, but no detailed data is provided [96].

CHAPTER 3

Methodology

3.1 Literature Review

At the beginning of this master thesis a literature research was conducted to gain insights in the human response process of stress, in biomarkers which can be used to identify stress, anxiety, anxiety disorders, into different approaches for the treatment of mental disorders and how these approaches are transferred to mHealth, into technical information and third party development access of smartwatches apps. Thus, the research question, how can wearable interventions have an impact to reduce stress, and the first research sub-question, how already existing interventions can affect mental disorders, were examined. To obtain this information books, articles, webpages, journals, and databases like PubMed [97] were screened. The sources used where scientific as well as non scientific. The results of the literature review can be found in chapter 1 and chapter 2.

3.2 Smartwatch and Biomarker Selection

Based on the literature review, wearables from the company Fitbit^{TM} were evaluated as it was an aim of this master thesis to integrate the Fitbit^{TM} system into the system of the Competence Unit Digital Health Information Systems of the AIT (Vienna, Austria). Moreover, information for developing Fitbit^{TM} device applications was collected. Based on this evaluation and the literature review possible biomarkers which are compatible with Fitbit^{TM} devices to identify stress were analyzed. Combining both, the evaluation of the smartwatches and the one of the biomarkers, a smartwatch in combination with a biomarker was chosen to develop prototype applications. Thereby, the focus was layed on the technical specification as well as on the needs of the users.

3.3 Idea Development of Stress Reducing Prototype Applications for a Smartwatch

During the literature review the ideas of the smartwatch prototype applications "Flying Boxes", "Seasons", "Vibes", "Visual Cue", "Walk with Me", "Pack Your Suitcase", "Take a Breath", "Find Me", "Connect by Numbers", "Swipe the Pattern" were generated in collaboration with Mag. Karl Kreiner (Scientist at AIT) and DI Kurt Edegger (Research Engineer at AIT). To visualize the ideas, sketches of each application were made. Thereby, the research questions, how mental health applications for smartwatches can be designed and which limitations and possibilities exist for smartwatch interventions reducing stress, were identified.

3.4 Implementation of Prototypes Applications for Stressful Situations according to the Human-Centered Design Process

There are a lot of systems available which have deficits in design and usability and therefore, low compliance and usage. A usable system can lead to an increased productivity, a decrease in errors, less required training and support, an enhanced acceptance, and improved reputation of the developers/company. Applying the user-centered design approach is a way to reach a higher usability. In the user centered design method the user‘s perspective is included in the developing process to reach the benefits mentioned above. The ISO 13407 describes five important steps performed iterative in the user-centered design process: First, plan the human-centered process, second, understand and specify the context of usage, third, specify the user and organizational requirements, fourth, produce design solutions, and fifth, evaluate design against requirements [98]. The process is visualized in figure 3.4.1.

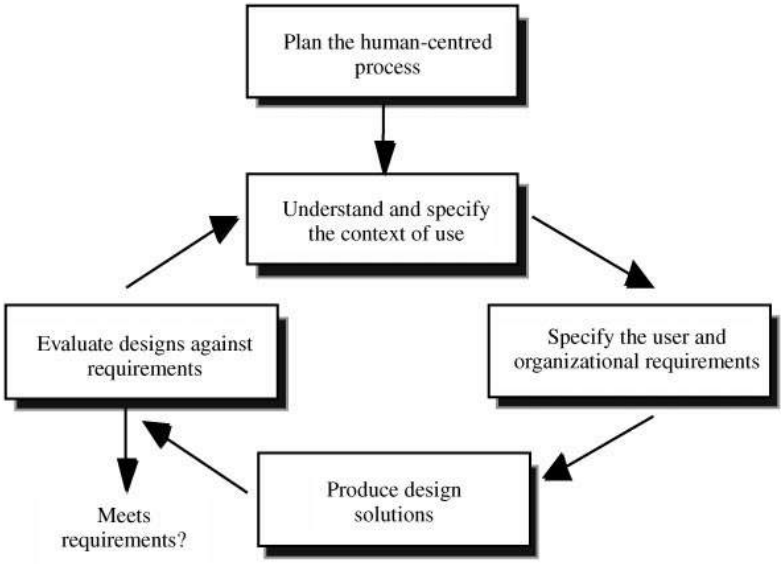


Figure 3.4.1: The human-centered design process according to ISO 13407 [98]

After application ideas were collected, it was chosen to develop the prototype applications "Flying Boxes", "Seasons", "Vibes", "Visual Cue", and "Walk with Me". The interventions were developed to gain further insights of possibilities, limitations, and the design of possible smartwatch stress reducing interventions. As an aim of this master thesis was to examine biofeedback, the main focus was laid into the development and implementation of the application ideas "Flying Boxes" and "Seasons" as they are based on biofeedback. A human-centered design process was realized to create the relaxation prototypes mentioned before for the smartwatch Fitbit Versa^{TM}, focusing on the needs of users. Following, the used methods of the human-centered design approach and the proceedings for the different prototypes are described. During the design process, feedback was collected from one research developer and one scientist working at the AIT.

3.4.1 Process of Developing "Flying Boxes", "Visual Cue", and "Walk with Me"

To develop the prototypes "Flying Boxes", "Visual Cue", and "Walk with Me" personas and scenarios were created. Then, more detailed sketches were prepared. These sketches were implemented in Fitbit Studio for the Fitbit Versa^{TM}. First, the user interface was realized by scalable vector graphics (SVGs). Then the functionality was implemented using JavaScript. The implementation was conducted applying the Fitbit^{TM} guides [1]. According to the ISO 13407 solutions of the prototypes "Flying Boxes", "Visual Cue", and "Walk with Me" were reviewed within the human-centered design process. Before starting a user study as described in section 3.5 a scientist of the AIT tested "Flying

[1] https://dev.fitbit.com/build/guides/

Boxes" for one week to identify further improvements which can be made.

To collect data during a user study a login function was implemented in "Flying Boxes" using React JavaScript XML (JSX). A hypertext transfer protocol (HTTP) request was implemented in the companion application to send these data to the System "Redbox" (AIT, Vienna, Austria) via JavaScript object notation (JSON) Web Tokens.

For the app development different APIs and components were used in the different parts of the code. They can be seen in table 3.1. Furthermore, code provided by DI Kurt Edegger to send data to a possible mobile phone application was integrated as ES6 modules in a common file and as a POST request in the companion file.

Application	API/Component	Part of the Application
"Flying Boxes"	messaging, haptics, mathjs, appbit, device, display, fs, heart rate, body-presence, user profile, document, cbor, file tranfer, system	app: index.js
"Flying Boxes"	document	App: RandomBlock.js
"Flying Boxes"	local-storage, messaging, settings, companion, cbor, file transfer	companion: index.js
"Flying Boxes"	select, toggle, test input	settings: index.jsx
"Visual Cue"	document, messaging, display, appbit, file-transfer, fs, heart rate	app: index.js
"Visual Cue"	settings, file transfer, image, peer, messaging, cbor, crypto	companion: index.js
"Visual Cue"	image picker	settings: index.jsx
"Walk with Me"	document, clock, user-profile, geolocation, appbit, messaging, haptics, heart rate, user activity	app: index.js
"Walk with Me"	messaging, settings, cbor, crypto	companion: index.js
"Seasons"	device, document, messaging, heart rate, body-presence, user profile, appbit, system, display, fs, file-transfer, cbor	app: index.js
"Seasons"	messaging, settings, local-storage, file-transfer	companion: index.js
"Seasons"	text input	settings: index.jsx
"Vibes"	document, haptics, fs, appbit	app: index.js

Table 3.1: Overview about the variety of APIs and components used to implement the different parts of the applications.

3.4.2 Process of Developing "Seasons" and "Vibes"

The first part of developing "Seasons" and "Vibes" was the same than for developing "Flying Boxes", "Visual Cue", and "Walk with Me". First, personas and scenarios were invented to gain insights under which circumstances these prototypes may be used in the future. Second, a functional implementation were conducted to prove that the realization of the prototypes "Seasons" and "Vibes" is possible on the Fitbit Versa™. The functional implementation was conducted with JavaScript in Fitbit Studio. Then, the user interfaces of the prototypes were sketched to get an idea how they can be designed and implemented. The different summer and winter elements occurring in "Seasons" were established with Adobe Illustrator® CC 2019 (Adobe Systems, San José, California, USA), the other elements were created as SVGs directly in Fitbit Studio. In between the implementation process the prototypes were reviewed according to the ISO 13407 by two persons. Before starting a user study as described in section 3.5, one scientist tested "Seasons" for one week to identify further improvements which can be made.

To collect data during a user study a login function was implemented in "Seasons" using React JSX. A HTTP request was implemented in the companion application to send data to the System "Redbox" (AIT, Vienna, Austria) via JSON Web Tokens.

For the app development different APIs and components were used in the different parts of the code. They can be seen in table 3.1. Furthermore, code provided by DI Kurt Edegger to send data to a possible mobile phone application was integrated as ES6 modules in a common file and as a POST request in the companion file.

3.4.3 Personas

Personas are characters created to illustrate the most important groups of users. Each character has a name, a personality and a picture [98].

In this master thesis project three personas were created in order to identify the needs and requirements of potential users on the prototype applications. The first persona was created to realize the prototype "Flying Boxes" and "Vibes". A second persona was investigated for the implementation of the prototype "Seasons" and "Visual Cue". Finally, a third persona was investigated to develop the prototype "Walk with Me".

3.4.4 Scenarios

Scenarios visualize how and under which circumstances a user applies the system which will be developed, whereby the visualization is realized via a realistic description. The user can be represented by the created personas. Using scenarios help developers to detect usability issues before code is implemented. Due to a scenario the developer can understand the requirements on the system [98].

Five different scenarios are created to extract features and the circumstances under

which the prototypes "Flying Boxes", "Visual Cue", and "Walk with Me", "Seasons", and "Vibes" might be used in the future. Thereby, two personas took part in two scenarios.

3.4.5 Sketches

Sketches are the fastest form of prototyping to represent parts of a system. Most prototypes begin with a sketch before they become more complex [99].

The different ideas gained during the literature review were sketched in more detail with having the personas and the scenarios in mind. Thereby, it was aimed to gain insights into how the prototypes can be designed and implemented.

3.4.6 Prototyping

Prototypes are a representation of a part of the whole system. Prototypes are created to visualize ideas and reflect on them. A higher fidelity prototype looks and acts similar to the end-product. A part of the system is implemented to provide functionality like clicking buttons or swiping, whereas other parts of the system are not finished [100]. A functional prototype is a prototype where the functionality is implemented, but the functional prototype does not have to appear like the future product. It can be used to prove or disprove a theory [101].

In this master thesis the prototypes were implemented in JavaScript in the Fitbit Studio SDK for the smartwatch Fitbit Versa^{TM}. Depending on the kind of prototype the sequence of implementing the functional or the high fidelity prototype varied. The prototyping was conducted to investigate how the needs of potential users can be realized and which limitations and possibilities exist for stress reducing smartwatch applications.

In "Flying Boxes", "Visual Cue", and "Walk with Me" the higher fidelity prototype was implemented before the function of the prototype was added. Thereby, it was aimed to identify how the prototypes can be designed. As it was not clear if animations and vibrations can be used, which are elements of "Seasons" and "Vibes", first a functional prototype was implemented to prove if the prototypes are realizable on the Fitbit Versa^{TM}.

3.5 User Study

In a user study the two biofeedback prototypes "Flying Boxes" and "Seasons" were tested by people who face stressful conditions in everyday life with the aim to identify if the prototypes are user friendly and are able to support the participants in stressful situations. The interventions were tested in stressful situations and not in anxiety causing situation because anxiety is a form of stress [3]. For detailed information see the study protocol in the appendix.

3.5.1 Research Questions and Hypothesis

The aim of the study was to analyze the research question which effects stress reducing interventions can have and how they are used. This question was specified into more detailed questions, which were aimed to answer, within the user study as following:

The **primary study questions** were:

- How is the usability of the biofeedback apps "Flying Boxes" and "Seasons"?
- Does the use of "Flying Boxes" and "Seasons" reduce the heart rate?

The **secondary questions** were:

- Does one of the prototype application "Flying Boxes" or "Seasons" is able to reduce the heart rate significantly in favor of the other one?
- In which situations is which prototype application used?
- How do the prototype applications effect stress?
- Is it supportive to display the heart rate in the prototype applications?

Janson et al. investigated that a higher degree of distraction coping predicted a steeper and straighter cortisol decrease after high values of salivary cortisol up to 60 min after stress. The salivary cortisol is a measure of the hypothalamic-pituitary-adrenal axis stress responses [102]. As "Flying Boxes" provides higher distraction opportunities while facing a stressor, it is hypothesized that the intervention "Flying Boxes" is able to be more effective in reducing stress than "Seasons".

3.5.2 Participants

Five people who are older than 18 years old, owning an Android™ or iOS smartphone, and facing stress in everyday life measured with a questionnaire based on the perceived stress scale [103] (see the study protocol in appendix 7.7) were included in the study. Participants were excluded if they have mental health issues or diseases, diseases which affect the heart, using a smartwatch frequently, or were not familiar with computers measured with a questionnaire based on the computer user self-efficacy score [104] (see the study protocol in appendix).

3.5.3 Study Intervention

Each participant received the Fitbit Versa™ with the prototype interventions "Flying Boxes" and "Seasons" installed for one week. Every participant was advised to apply one intervention in stressful situations and note the circumstances under which the prototype

was applied and the subjective stress level on a scale between 0 and 10. During the use of an intervention, data types like the heart rate were collected and saved in "Redbox" (for more information see the study protocol in appendix). After the testing period was finished, every participant answered the system usability scale (SUS) questionnaire [105] and participated in an interview (see SUS questionnaire and interview questions in the study protocol in appendix).

3.5.4 Data Analysis

To answer the study research questions and verify the validity of the hypothesis, a quantitative and a qualitative data analysis was conducted.

Analysis of the SUS Questionnaire

The scores of each question of the SUS were added and multiplied by 2.5. Thus, the final score of the questionnaire is given in percent.

Quantitative Data Analysis of the Subjective Stress Level

The stress scores gained by the notes of the participants were separated into two groups based on the intervention which was used. The differences of the subjective stress level scores before and after each time an intervention was used were calculated resulting in one data set of differences D_S for each intervention.

Each D_S was tested for normal distribution with the Shapiro -Wilk test. As neither the data set connected to "Flying Boxes" nor the data set connected to "Seasons" were normally distributed and did not follow a continuous distribution function the sign-test was applied to compare the stress level before and after the use of an intervention.

Quantitative Data Analysis of the Heart Rate Data

The collected heart rate data was used to evaluate if the heart rate was reduced after the use of the prototype applications. Therefore, only data sets, which could be connected to stressful situations, the participants noted in a table were used. A data set HR_{data} contains the heart rate measures over time belonging to one stressful situation and one intervention. These data sets HR_{data} in connection with the notes were used to eliminate further unappropriated data sets. If a physical activation was noted or if the heart rate difference between resting heart rate and the heart rate when starting with the intervention was less than 10 bmp, the data sets HR_{data} were excluded. When two interventions were used in the same stress situation, only the data set HR_{data} corresponding to the first intervention was further included in the data analysis. This was done as the starting situation for the second intervention is not comparable to the starting situation of the other situations without an intervention used before.

The remaining data sets HR_{data} were grouped into two groups: heart rate data sets of

"Flying Boxes" and heart rate data sets of "Seasons". In every data set HR_{data} the average heart rate was calculated in 30 s time intervals. The average heart rate was calculated by 5 measurements: 2 measurement were taken before, 2 measurements were taken after, and one measurement was taken at each 30 s interval time step.

Heart rate differences of the average heart rates at times $t > 0$ s and $t = 0$ s were calculated for every situation resulting in several sets of differences D_t for both interventions.

Every data set D_t was tested with the Shapiro -Wilk test for normal distribution. Then, the t-test was applied to data sets D_t which could be assumed to be normally distributed and to fulfill the assumptions of the t-test. The data sets D_t which could not be assumed to be normally distributed are checked for skewness which is an assumption of the Wilcoxon sign-rank test. If the assumptions for the Wilcoxon signed-rank test could be assumed to be fulfilled, this test was applied, otherwise the sign test was applied to the data sets D_t.

Qualitative Data Analysis

For the qualitative data analysis the interviews were transcribed and paraphrased. Then, the paraphrases were written into codes. The different paraphrases of all interviews belonging to the same code were grouped together. Based on this, categories were found and the code-paraphrase combinations were assigned to categories. Finally, the code-paraphrase combinations of one category were summarized.

CHAPTER 4

Results

4.1 Smartwatch and Biomarker Selection

There were two possible devices available by Fitbit™ which allow third party app development - the Fitbit Ionic™ and the Fitbit Versa™. Thus, the other devices offered by Fitbit™ were excluded of further considerations. Both, the Fitbit Ionic™ and the Fitbit Versa™ provide access to the same real time data, and there are no differences in available APIs. Thus, due to financial reasons the Fitbit Versa™ was selected to develop stress reducing apps. The Fitbit Versa™ is 1/3 cheaper than the Fitbit Ionic™. Thus, the prototypes will be affordable for more people suffering from stress and anxiety, having in mind that having a lower education and income can be risk factors for anxiety. Both devices allow access to the real time heart rate data on the device which can be used to determine stress. As this is the only available marker for stress in the Fitbit™ system, the heart rate is chosen as a biomarker for the implementation of the prototype applications.

4.2 Idea Development of Stress Reducing Prototype Applications for a Smartwatch

During the literature review the ideas of different smartwatch prototype applications to reduce stress arose. Following the different ideas are presented.

4.2.1 "Flying Boxes"

As the research in the literature yields to the biofeedback method as a promising way to reduce stress and gamification as an opportunity to engage people, the idea of "Flying

Boxes" was born. The prototype idea was inspired by the smartwatch game "Red Blue Red!" (Javier Rizo, Mexicali, Mexico) which is available in the Google Play Store [106]. In the prototype application "Flying Boxes" the user has to match the color of the box, which "flies" to the bottom, with the color of the beam like in "Red Blue Red!". The innovation of the prototype intervention "Flying Boxes" is that the difficulty of the game is connected with a biomarker for stress. The game becomes easier when the user becomes relaxed. The aim of "Flying Boxes" is to reduce stress by conditioning and distraction of the stressful situation. A first sketch can be seen in figure 4.2.1.

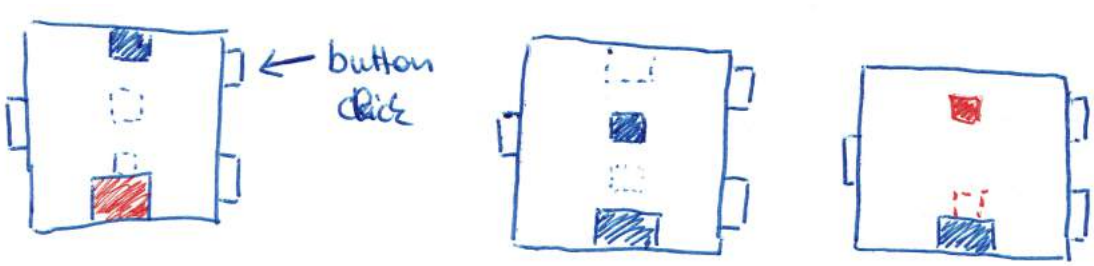


Figure 4.2.1: Sketch of the prototype idea "Flying Boxes", three screens are visualized. On the left hand side a blue box falls down from the top of the display and the beam on the ground of the display is red. By pressing a button the user can switch the color of the beam which results into the sketch displayed in the middle. If the blue box hits the blue beam, a new box can fly down as it is displayed on the right hand side. If the color of the box does not match the color of the beam, the game is lost.

4.2.2 "Seasons"

The prototype idea of "Seasons" is shown in figure 4.2.2. Like "Flying Boxes" "Seasons" is based on biofeedback and gamification. The user is supposed to transform a winter landscape in a summer landscape. The transformation is achieved by lowering the stress level identified by a biomarker. The intervention is similar to "The Loom" [49]. Using the game element of changing the season via a reduced stress level, the aim of the intervention is to engage and reduce the stress level by conditioning and focusing on oneself.

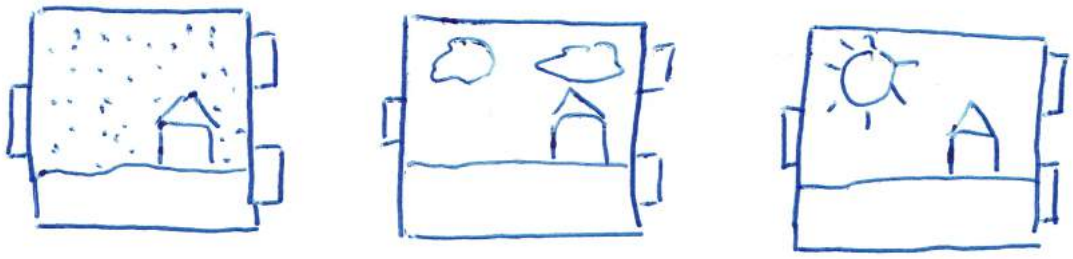


Figure 4.2.2: Prototype idea of "Seasons". On the left side a winter landscape is shown. By lowering the level of stress the landscape changes into a summer landscape, as it can be seen in the sketch in the middle and on the right hand side.

4.2.3 "Vibes"

"Vibes" is an idea which does not contain biofeedback, but gamification. A sketch of the idea can be seen in figure 4.2.3. In "Vibes" the user can experience a haptic vibration pattern which he/she has to repeat by clicking on the screen. If the user clicks the pattern in a correct way, he/she can experience the next pattern. The idea is based on the "Vibrette", an object which looks like a cigarette and is able to vibrate. The user has to repeat this vibration pattern. The aim of the "Vibrette" is to assist in quitting smoking [107]. The aim of "Vibes" is to become distracted of a stressful situation and relaxed by gaining a state of meditation due to clicking patterns.

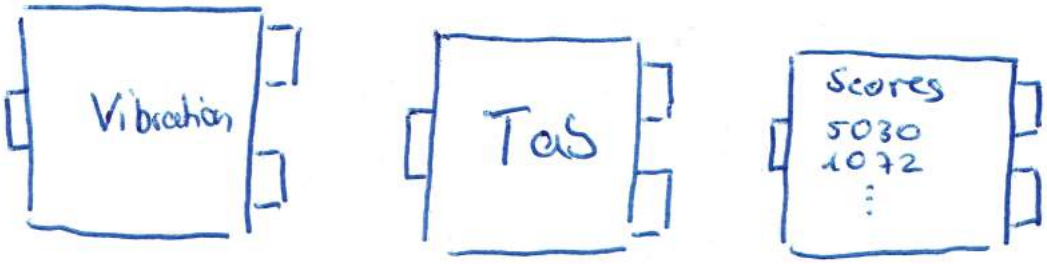


Figure 4.2.3: First sketch of the prototype "Vibes". First, the vibration pattern is played (left sketch). Then, the user has to repeat the pattern by clicking on the screen (middle sketch). When the pattern is not clicked correctly a list with high scores can be seen, as it is visualized on the right.

4.2.4 "Visual Cue"

In the prototype idea "Visual Cue" the user can look at pictures with the aim to transfer the user into another situation, at least within the mind. Either the user can look at pictures which are pre-installed or on pictures he/she has installed on the watch. Thus,

the user can dream about another situation or remember a situation he experienced in the past. The goal of this prototype idea is to distract the user by looking at a picture and confronting him/her with a positive event. A sketch of this prototype idea can be seen in figure 4.2.4.

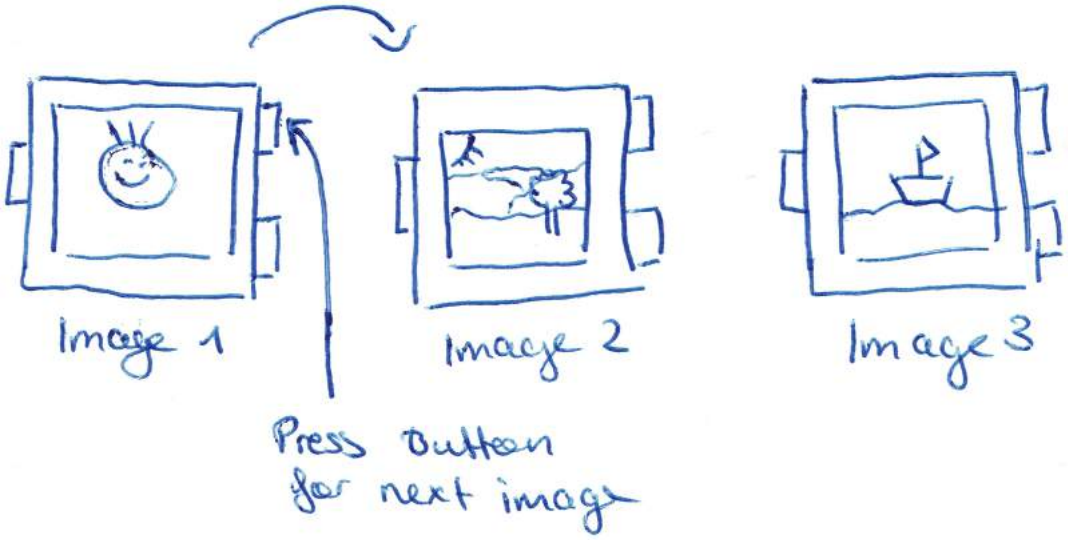


Figure 4.2.4: In the prototype intervention "Visual Cue" the user can click through different images. Three different images are shown in the sketch: A situation with a friend on the left hand side, a landscape the user has taken a photo off in his/her last vacation in the middle, and a photo of a sailing boat, the hobby of the user on the right hand side.

4.2.5 "Walk with Me"

"Walk with Me" is a prototype intervention constructed like a watchface. A sketch can be seen in figure 4.2.5. The user sees the time, his/her heart rate and the steps he/she has gone that day. If the user becomes stressed or a situation turns out to be good or better than expected, the user can press the "critical" or the "good" button. The watch saves the location and the time of the situation. Later, the user can reflect this situation on his/her phone and maybe find a method to turn critical situations in better ones in the future by identifying what makes them critical.

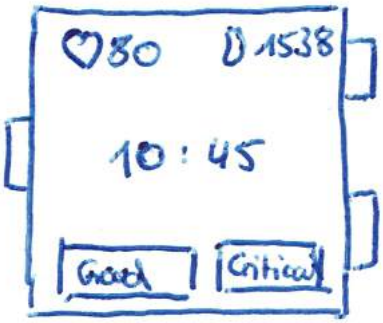


Figure 4.2.5: A sketch of "Walk with Me". The user can see the time in the middle of the display like at a normal watch. Additionally, he/she can see his heart rate, and the steps he/she has gone on the same date. Moreover, at the bottom of the display there are to buttons which can be clicked: a "positive" and a "negative" one. The "positive" one can be clicked in positive situations and the "negative" one in negative situations.

4.2.6 "Pack your Suitcase"

In "Pack your Suitcase" the user goes on a vacation. Thus, he/she has to pack his/her suitcase with certain objects which are displayed to the user at the beginning of a game round. The user has to remember these objects and their order. After all objects which needs to be packed in the suitcase were shown on a screen, different objects are displayed on the watch. The user has to click on the objects which need to be packed in the suitcase in the right order to fit them all in the suitcase. In every round the user is playing, the list of devices which need to go into the suitcase becomes longer. A first sketch of the application is shown in figure 4.2.6. The aim of "Pack your Suitcase" is to be distracted by having to remember objects and, thus, to become more relaxed and calm down.

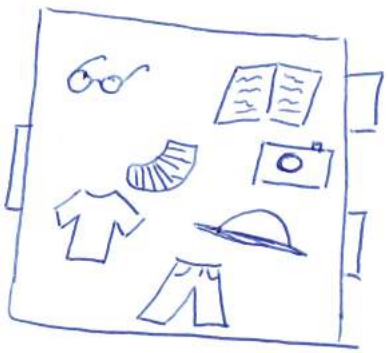


Figure 4.2.6: First impression of the prototype application "Pack your Suitcase". The screen of the watch shows different objects which can be clicked to put them in the suitcase.

4.2.7 "Take a Breath"

The idea of "Take a Breath" is that the user is guided through his/her breathing by providing elements which line out when the user should inhale and exhale. If the user reached his/her optimal breathing frequency or if the breathing frequency is too high and the user is able to reduce it, he/she gains points. As breathing is connected to the HRV the aim of this prototype is to become relaxed by reaching the optimal breathing frequency or reducing it. A sketch of the idea can be seen in figure 4.2.7.

Figure 4.2.7: Prototype application idea: "Take a Breath". When seeing this screen the user has to inhale (image from [108]).

4.2.8 "Find Me"

In the "Find Me" App the user has to find a symbol, which is displayed on the screen, via an audio signal. If the symbol is not on the screen, the user has to press a button on the watch. The user has a certain time frame to click on a symbol which can be connected to a biomarker of stress. If the user is able to click on the symbol within this time frame, he/she gains points. Thus, the user could be distracted from a stressed or anxious situation by listening to an audio signal and performing an activity. A sketch of the prototype "Find Me" is visualized in figure 4.2.8.

Figure 4.2.8: Visualization of the prototype application "Find Me". The screen of the watch displays different symbols. The user can hear a symbol and has to click on it on the screen or press a button if it is not displayed.

4.2.9 "Connect by Numbers"

The idea of "Connect by Numbers" is that different numbers are shown on the display of the smartwatch. Tipping on the number in an increasing order, the number connect to each other and result in an image. This can be connected to biofeedback. The numbers only connect if the user presses the different numbers in a certain frequency, whereby the frequency can be connected to a biomarker. Thus, the user might become more relaxed by being distracted from the situation and by gaining a state of mediation by tipping on the watch in a certain frequency. A sketch of "Connect by Numbers" is displayed in figure 4.2.9.

Figure 4.2.9: Sketch of the prototype application "Connect by Numbers". The user has to tip on the numbers in an increasing order. By clicking in a certain frequency connected to a stress biomarker, the numbers connect to each other and result into an image.

4.2.10 "Swipe the Pattern"

In the prototype application "Swipe the Pattern" the user is supposed to follow a pattern, displayed on the watch, with one finger. The velocity of following the pattern can be adjusted to a biomarker of stress. Archiving to follow the pattern in the right velocity, the user gains points and the next pattern will become more difficult. Thus, it aims to distract from stressful or anxiety causing situations and calm down by follow the pattern in slow motion. A sketch of "Swipe the Pattern" can be seen in figure 4.2.10.

Figure 4.2.10: Visualization of "Swipe the Pattern". One can see a pattern, which the user has to follow with one finger in a velocity adapted to a biomarker of stress.

4.3 Implementation of the Prototype Applications for Stressful Situations according to the Human-Centered Design Process

In this master thesis project the human-centered design process was applied to implement the prototype ideas "Flying Boxes", "Seasons", "Vibes", "Visual Cue", and "Walk With Me" which can be used in stressful situations to reduce stress. The aim was to create these prototypes for a smartwatch to identify how stress reducing smartwatch interventions can be designed and which limitations and possibilities exist. Following, the results of the development process until the implementation is described.

4.3.1 Personas

Three personas were created to represent possible users of the future smartwatch applications "Flying Boxes", "Walk with Me", "Visual Cue", "Seasons", and "Vibes". Thus, insights of the users needs were gained.

Persona 1: Representing the User Group for the Applications "Flying Boxes" and "Vibes"

Figure 4.3.1: Picture of Ben Weiss, Persona 1.

Name: Ben Weiss

Age: 32

Residence: 62 m^2 apartment in Favoriten, Vienna

Civil Status: in a relationship, no children

Education and Occupation: After finishing school, Ben apprenticed as car mechanic and works as one until now. He enjoys working in his job and likes his colleagues.

Personality: Ben is not a social person, but he likes to spend time with his girlfriend. But as they do not live together Ben prefers that she visits him over visiting her. To reach her apartment Ben has to take public transportation which stresses him, as it can become crowded. Ben's girlfriend is annoyed by having to visit Ben more often than the other way around. Thus, his girlfriend suggested Ben to read a book while taking the public transportation to maybe forget the other people. Ben has tried it, but he is not really enjoying reading.

Hobbies: Ben's hobbies are to watch movies with his girlfriend at home and play video games on a gaming console or on the computer with his best friend. He enjoys playing games as they relax him after work. Furthermore, he likes to go into a gym which is five minutes away from his home.

Technology experience: Ben knows how to use his computer as he uses it for playing games and watching movies. He also owns a smartphone which he uses to chat with his girlfriend and friends, to play little games on it, and to order food.

Persona 2: Representing the User Group for the Applications "Seasons" and "Visual Cue"

Figure 4.3.2: Picture of Emily Lang, Persona 2.

Name: Emily Lang

Age: 26

Residence: 65 m^2 apartment in Simmering, Vienna

Civil Status: in a relationship with Johannes Ebert, no children

Education and Occupation: After finishing school, Emily did not know what she would like to do in her future. Thus, she started to work in a restaurant as a waitress. With 20 she decided to become a physical therapist and started the apprenticeship. Being very shy she has troubles to talk to the patients, which made the job very challenging for her, but Sophie already improved a lot since she started the job. Three month ago her boss decided to close the physical therapy office because he wanted to move closer to his children who live in Bregenz. Thus, Emily lost her job.

Personality: Emily is a very introverted person. She likes to spend time at home with her dog and with Johannes Ebert. Since she lost the job, communicating with people she does not know has become again more challenging. This is leading that far that she becomes stressed when taking the metro or going in the supermarket as there is the chance that she has to talk to another person who might be in the way.

Hobbies: Emily likes to watch movies, reads blogs, and watches YouTube videos at home. Furthermore, she likes to spend time with her dog and go out for a walk with him. She enjoys spending time and cooking together with Johannes Ebert or her parents. Since she lost her job, talking to people she does not know stresses her even more. She does not visit her parents as often anymore as taking the metro stresses her as well.

Technology experience: Emily owns her own laptop on which she follows YouTubers and bloggers. She uses it to browse the internet and to watch movies. Furthermore, she uses her smartphone to follow the same blogs and to communicate with Johannes and her parents.

Persona 3: Representing the User Group for the Application "Walk with Me"

Figure 4.3.3: Picture of Sophie Fischer, Persona 3.

Name: Sophie Fischer

Age: 34

Residence: 100 m^2 apartment in Josefstadt, Vienna

Civil Status: married to Fritz Fischer, two children

Education and Occupation: After finishing school, Sophie studied at Vienna University to become a primary school teacher. After finishing her study, she started working at a primary school in Josefstadt until today. Every day in school Sophie is facing a lot of stressful situations, and after work she has to prepare the classes for the next day. Besides that she looks after her children. As she teaches in the same district as she lives, she sometimes meets students or parents of students when she goes out to fulfill errands. Meeting them, sometimes stresses her.

Personality: Sophie is a very caring and perfectionist person. Thus, she wants to be a very good teacher and mother. With all her tasks in everyday life she becomes stressed easily. As she is a reflective person, she wants to find out under which circumstances and in which situation the stress occurs. Her husband has suggested her to write a diary. But when she finds time to do so, Sophie has forgotten a lot of the situations where she was stressed.

Hobbies: Sophie likes to spend time with her family going to the zoo, in the park, or playing games at home. Besides family time she enjoys reading a book or meet friends. Having time with her husband without the children, she likes to go into the theater or out in a restaurant.

Technology experience: Sophie owns a laptop on which she prepares the classes for the next day. Moreover, she uses the laptop to research new activities she can do with her family or theater plays which will be performed in the future. She also owns a smartphone. This she mainly uses to communicate with her husband or friends and to look up things when she is not at home.

4.3.2 Scenarios

To receive a better understanding of the users needs for every prototype application a usage case was created. Thereby, "Ben" and "Emily" play a role in two scenarios and "Sophie" in one.

Scenarios with Ben Weiss Describing Use Cases for "Flying Boxes" and "Vibes"

By seeing a documentation about applications for relaxation, Ben has heard about the smartwatch application "Flying Boxes" and "Vibes". Since he has thought about buying a smartwatch anyway for quite a while, he decided to do this now and uses this possible chance to be more relaxed when visiting his girlfriend. After receiving and setting up the watch Ben directly installs the applications "Flying Boxes" and "Vibes". After the installation was finished, he gets the instructions of the game on his phone. Then he calls his girlfriend and asks her if he can come by for a visit, which makes her really happy. Ben is getting ready and very excited. At the metro station there are many people which makes Ben nervous. Waiting on the next metro, Ben opens ...

... "Flying Boxes"

The display on the watch tells Ben to connect the watch with his phone. As he already did that while setting up the watch, Ben waits what happens next. The screen tells him he can start the game. As he read in the instructions on the phone how the game works, Ben presses the start button. Exact at this moment the metro arrives. Seeing all the people makes him hesitant and a bit stressed, but he enters the metro. While entering, he could not focus on the watch. Thus, the display shows game lost when he found a not so crowded place to stay and watches on the watch again. On the same display he can click "play again". He tries it. As he is quite stressed because there are quite a lot of people, the game shows a heart rate of 140 beats per minute. Boxes in different colors from the top of the screen fall down on a beam at the button of the screen. By pressing the upper right button, Ben can adjust the color of the beam to the color of the boxes. As the game is quite fast Ben looses after three or four boxes fell down every round. But he

has the goal to catch more boxes with the right color, which engages him into the game. Furthermore, he has read in the instructions that he can change the settings to play the game in different difficulty modes. Thus, Ben changes the setting to easy. He also sees that he can add a circle falling down, but this he wants to try later when he has become better in the game. He starts to play again. This time he can play for a longer time without loosing, and Ben forgets the people around him completely. Playing for a while, he notices that the heart rate which is shown on the display decreases, and in connection with the reduction of the heart rate the game becomes easier. This achievement motivates him further to play again, but the metro already reaches the station where Ben has to get off. He closes the game and reaches the apartment of his girl friend very happy to tell her that the metro ride was stressful at the beginning, but by being longer on the metro and playing "Flying Boxes" he became more relaxed.

... "Vibes"

The display on the watch tells Ben that he can choose a vibration pattern which he has to follow. He chooses pattern two. He feels his watch vibrating two times with a short period of time in between and then three time with a longer period of time in between. He notices that the pattern repeats afterwards and Ben taps the pattern with his fingers. The watch stops vibrating and tells Ben to tip the pattern on the display now. Ben starts to tip the pattern. The metro arrives. Ben concentrates on tipping the pattern while entering the metro. He can tip and enter the metro at the same time as he does not have to look on the screen while walking. He really likes that because this makes him focus not on the people standing around him, and he can enter the metro more relaxed. Ben finds a seat where he can sit and take a look on the watch again. There another screen appears: He has lost and can play again if he wants. Ben is a little disappointed because he thought he tipped the pattern quite well and was focused on the game. This distracts him and makes him pay attention to all the people around him. Ben becomes quite nervous. He starts to play another round. This time he chooses pattern three. The watch vibrates, then Ben is advised to repeat the pattern. He tries it, and this time the watch does not show the lost screen for quite a while. A high score opens and Ben sees that he gained a much longer gaming time as before. He wants to top this one and plays again. Again he chooses pattern three. He tips the pattern for a while and then the metro is at the station he has to get off. As Ben reached a state where he got into tipping the pattern, he does not stop while getting off. The metro ride was not the most relaxed thing in his life, but it was better than he has expected. When reaching his girlfriend's flat, Ben is excited to share his experience with her. Thus, she becomes happy as she sees it as an opportunity Ben will visit her more often.

Scenarios with Emily Lang Describing a Use Case for "Seasons" and Use Cases for "Visual Cue"

Emily got for her birthday a smartwatch from her parents. After she sets the watch up, she browses for applications she can install and try out. One of them is ...

..."Seasons"

Emily reads the instruction and becomes very interesting as it says that the app will make you more relaxed in stressful situations. Emily wants to try it when she takes public transportation. She downloads the app, and at the next weekend she is on the way to her parents. She feels a little crumbly when leaving her home. Thinking "How can I talk to someone who is in my way easily? - Maybe "Seasons" really is going to help, but what am I going to do if not?" Emily reaches the metro station and enters the next one arriving. She sits down and gets stressed as the metro gets more crowded after some stations and the way to the door is crowded as well. Emily starts "Seasons". She has to transfer a winter landscape in a summer landscape by becoming relaxed. On the watch she sees a house covered with snow. She tries not to think about the people who will be in her way when getting out. Emily thinks about the last winter and how it has become spring and the birds started to sing, and then she sees how the snow is melting on the roof of the house. A group of loud teenagers is entering the metro and Emily looks up and becomes more stressed right away: "What if they are still in the metro when I have to get out? - Don't think about that! Maybe they get off before me or I can tell them that I need to get off." The roof on the house is full of snow again. Emily tries to keep focused on the watch and tries to think about the nice things of spring as she has done before. It has helped again. When Emily has to get off, the winter landscape has turned in a spring landscape. She has not reached the summer landscape yet, but she has calmed down. She also manages to tell the woman who sits next to her that she has to get out. The woman smiles and lets her out. The group of teenager is still there, but Emily does not even have to say something. When they see her coming, they give the way free. Emily is really happy. The metro ride was not the most relaxed thing, but much easier than at times before, and she managed to talk to someone she did not know.

..."Visual Cue"

Emily reads the instruction and downloads the application "Visual Cue". She goes through the images which are preinstalled. Some of them she likes and some of them are not that nice in her opinion. But she can transfer images from her phone to the watch as she read in the instructions. Thus, she searches on the phone for photos. Some of them show her dog, two show Johannnes and her, and the other photos display her family or nature. She follows the instruction to install the images and a little time later she sees the images on her watch. Since she does not have anything planed for the day, she decides to try the application and do a little trip to the Danube together with her dog. To reach it she has to take the metro. Once she reaches the station she becomes nervous, thinking of how she can get out of the metro when someone blocks the door. She does not want to enter the metro, but she also thinks: "try it!". The metro arrives, hesitating Emily enters it. It is that crowded that she does not find a place to sit. But in a corner she finds enough space to stand and to have a look on the watch without other people distracting her. She tells her dog to sit down and opens "Visual Cue". The first photo she sees is one of her dog playing on a field. She really likes this photo and thinks of

the time it was taken. She went out for a long walk with her parent, and they took the dog with them having a lot of fun. Her dad was playing silly games that day and made everybody lough. Emily is smiling remembering this. She looks at the next photo. It shows Johannes together with her at the last weekend. They were cooking together her favorite meal. Emily imagines what they could cook together the next time: "Spaghetti carbonara, or maybe better ratatouille? ... ". She is very distracted remembering the situations she sees on the watch. Then, she already has to get out of the metro. Some people are in her way, thus she says: "Sorry" without thinking about talking to someone because she still remembers the last weekend. Not before leaving the metro, she thinks that she just talked to someone without thinking about it. Even it was not much what she said, it was very easy. She is very happy and walks with a smile on her face the last distance to the Danube.

Scenario with Sophie Fischer Describing a Use Case for "Walk with Me"

"Walk with Me"

Sophie has told her friends that she wishes to get a method to remember stressful situations really easy to reflect on them. She tells them that she already tried to write a diary about her stressful situations during the day, but when she has time to do so she already forgot a lot of the stressful events. Then one of her friends tells her about the Fitbit^{TM} smartwatch application "Walk with Me". She says that in "Walk with Me" you can detect the location and time of a stressful situation, and later when you find time you can reflect on them. Sophie gets very interested about the application and when she is at home she searches for "Walk with Me" and the smartwatch on the internet. Spontaneously she orders the Fitbit Versa^{TM} on the internet. Some days later the watch arrives, and she finds time to set it up and install "Walk with Me" in the evening. At the next day she takes her children into kindergarten and school and then goes to her class for teaching. She notices that she forgot her preparation notes for the subjects of the whole day. Hence, she becomes stressed. In a few minutes she writes down some notes and remembers to press the "negative" button on the watch. At 11 am the kindergarten calls because her daughter got sick. As she has to teach another class, she cannot take her up. She calls Fritz and the grandparents, but they are not reachable. Then she reaches a friend who has time to pick her up. Sophie presses the "negative" button again. In the lunch break of her class a student forgot his lunch. Another student suggests that everyone can give him a bit of his/her lunch, then everyone has something to eat. Hearing this makes Sophie very happy, and she presses the "positive" button. In the evening the teachers have a conference where they discuss a new teaching concept. The conference is not bad, but Sophie did not have a break the entire day which makes she really exhausted and the conference is tiring for her. She presses the "negative" button again. When she comes home, Fritz already prepared dinner. Sophie presses the "positive" button. After taking the kids to bed and watching TV, Sophie falls asleep. At the next day some more situation happen where she presses the "negative" and "positive" button. This night she takes some time to open the data on her phone and reviews the

situations. Her conclusion is, that the watch is very helpful in reviewing the situations. The reviewing process is faster than taking notes, and she does not forget that many situations except sometimes when she forgets to press a button. After the second day, Sophie resumes to try to take more little breaks.

4.3.3 Developing of "Flying Boxes"

Sketches

After the persona and scenario describing "Flying Boxes" were created, sketches of the prototype applications "Flying Boxes" (see 4.3.4) were developed to get an impression how the interface of this prototype applications could look like.

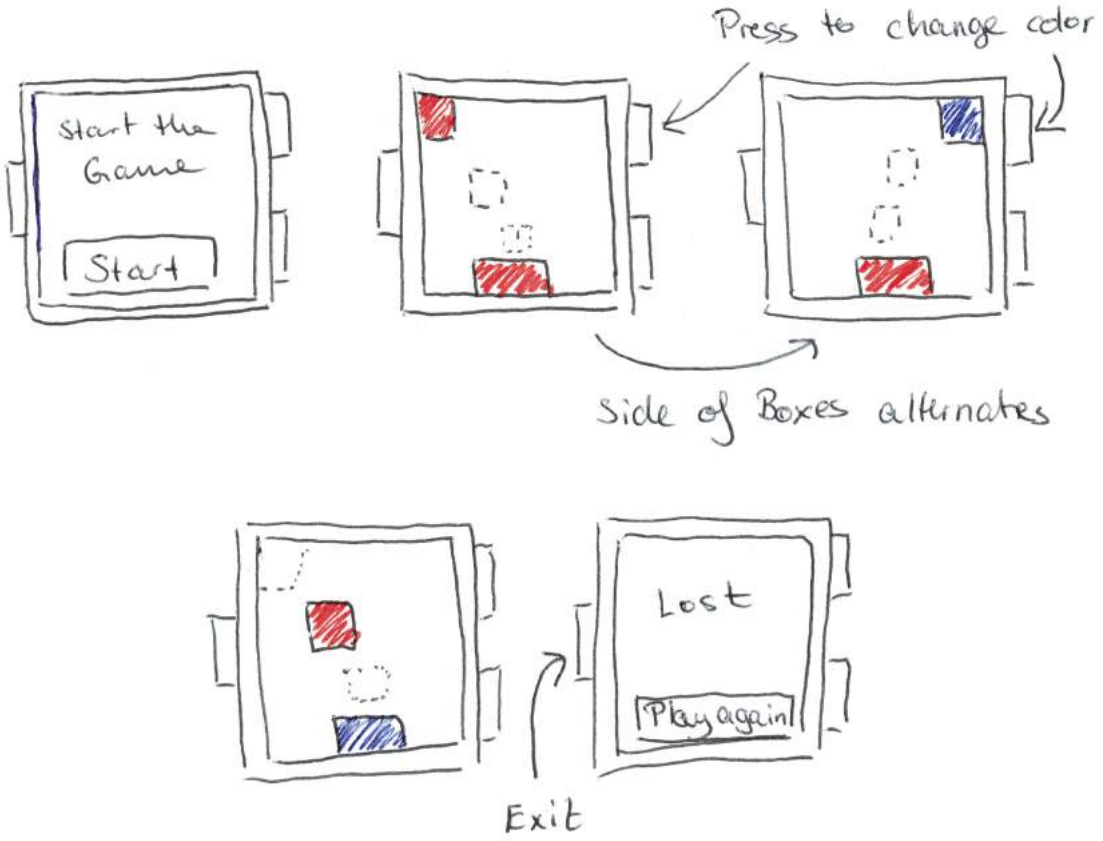


Figure 4.3.4: Sketch sequence of "Flying Boxes". The first image shows the start screen. The second to fourth one visualize a game, whereby the corner from where the boxes start falling is alternating. The last sketch shows the screen when a game is lost and one can press a button to play again.

First Implementation of "Flying Boxes"

In the first implementation of "Flying Boxes" (see figure 4.3.5), boxes "fly" down alternating from both corners of the top. On the bottom a beam was implemented which can change the color by pressing the upper right physical button. The level and a count of reached points are displayed.

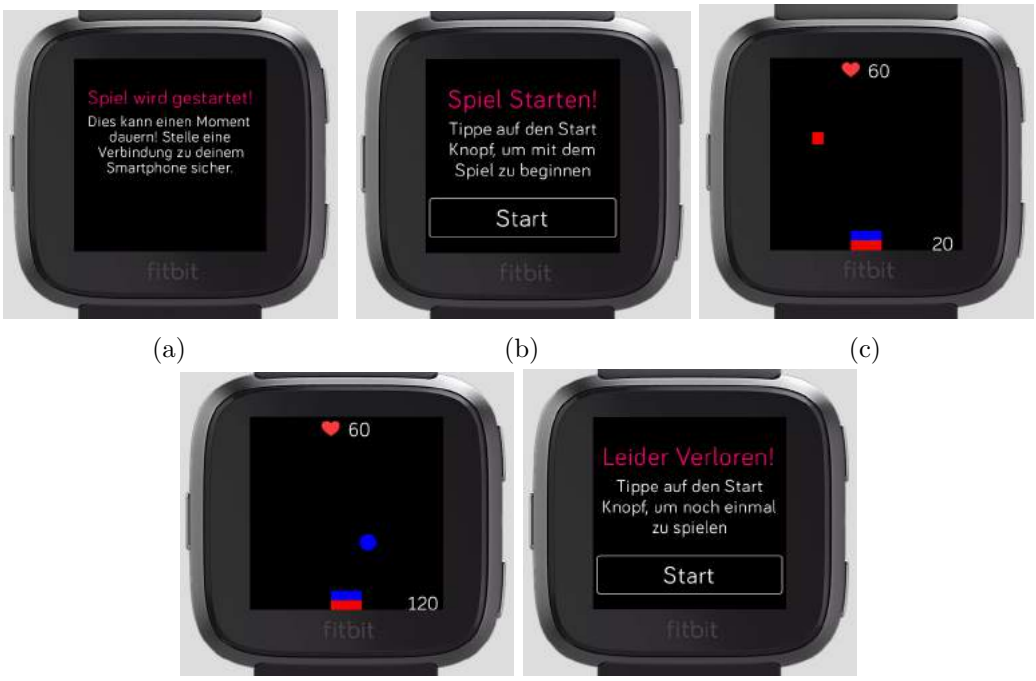
Figure 4.3.5: First implementation of the prototype "Flying Boxes". Boxes flying down from both corners in an alternating matter. By pressing the button on the upper right corner the beam changes its color from blue to red and vise versa.

Results of Reviewing "Flying Boxes" According to the ISO 13407 Human-Centered Design Process

The review conducted according to the ISO 13407 human-centered Design Process resulted in the suggestion to increase the user friendliness and appearance by dividing the beam and display it in two colors. Moreover, it was suggested not to alternate the side of the flying boxes, but let them change the sides randomly. Thus, the intervention could become more interesting and more engaging as the side of the box is not predictive.

Implementing further Improvements of the User Interface and Functional Aspects of "Flying Boxes"

Based on the suggestions of the review, the user interface of the prototype "Flying Boxes" was further improved to increase usability and appearance. Implementations were conducted to include functionality into the prototypes. Screenshots of "Flying Boxes", after the implementation steps were conducted as described below, can be seen in figure 4.3.6.



(a) (b) (c)

(d) (e)

Figure 4.3.6: Screenshots of the prototype intervention "Flying Boxes". 4.3.6a: First screen when opening "Flying Boxes". 4.3.6b: Screen to start the game. 4.3.6c: Box falling down in "Flying Boxes". 4.3.6d: Circle falling down in "Flying Boxes". 4.3.6e: Screen when a game is lost. The user has the option to restart a new game.

Biofeedback was integrated into "Flying Boxes". Details of the biofeedback model and the link between the heart rate and the game is given in section 4.3.8. The velocity of the flying boxes was connected to the heart rate. As the heart rate slows down, the velocity of the boxes decreases. Moreover, the flying boxes were implemented to fly randomly either from the right or from the left corner. How often the side and the color of the flying boxes changes randomly is based on the heart rate. At higher heart rates the side and the color changes more often than at lower heart rates. One can see a flying box falling from a corner of the screen in figure 4.3.6c.

Besides the biofeedback aspect a symbol of a heart to display the heart rate was included in the prototype. As suggested the beam was divided into a red and a blue part which rotates when pressing the upper right button. It was decided to not include the feature of levels further and include the gaming element points only to prevent a confusion which might occur having two different counts. When a box with the same color of the upper part of the beam hits the beam the count of points is increased by ten and a new box falls down. When the colors do not match, the game is lost and a display which says "play again" is displayed. The "play again" screen was implemented with a button to

restart a new game. This can be seen in figure 4.3.6e.

For players who reached 100 points a new object - a circle - can fall down in red or in blue. Only boxes are supposed to hit the beam. Pressing the lower right physical button, one can change the circle to a box. A flying circle can be seen in figure 4.3.6d. If one does not like to play with circles, he/she can disable this function on the setting page. A screenshot of the setting page can be seen in figure 4.3.7.

Furthermore, a function where one can change the difficulty level was implemented within the setting page. There one can select one of six difficulty levels. The difficulty level adjusts the basic velocity of the boxes and the basic frequency how often a new color and a side of a flying object is chosen. This basic frequency and basic velocity is then adopted via biofeedback as described before and in section 4.3.8. The settings were saved on the local storage of the companion and transferred to the phone via messaging. If there are no user defined settings available, predefined settings are used.

To enable communication between the companion and the device, a screen telling the user to make sure the watch and device need to be connected is shown at the beginning of opening "Flying Boxes". The screen is displayed in figure 4.3.6a. If there is no connection between the phone and the device detected, the user can start the game after five seconds to provide usability of "Flying Boxes". This can be seen in figure 4.3.6b.

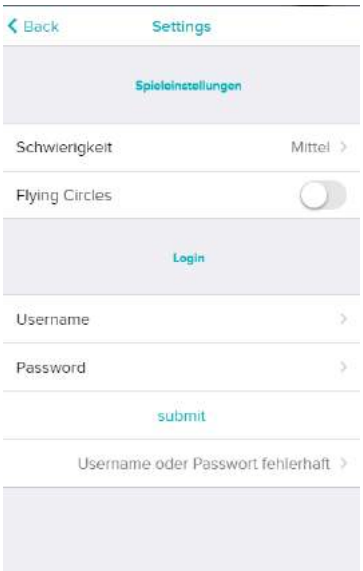


Figure 4.3.7: Screenshot of the setting page of "Flying Boxes". In the top one can see how the difficulty level can be adjusted. Below that flying circles can be enabled or disabled via a toggle. At the bottom the login function can be seen to allow the sending of data sets to "Redbox".

For the user study data gained while playing "Flying Boxes" is saved as JSON in the local storage of the device every time a game is lost or the application is closed. The file is sent via file transfer to the companion application. When the device receives the information "transferred", the file is deleted on the device. To send data to "Redbox" and to identify all data sets belonging to one person, a login function was implemented within the settings page. A HTTP request was implemented to receive JSON web tokens based on the login data from "Redbox". Thus, the data sets can be sent to "Redbox" and saved after they were received by the companion application. The login interface of the setting page can be seen in figure 4.3.7.

Finally, an icon of "Flying Boxes" was designed, which can be seen in figure 4.3.8.

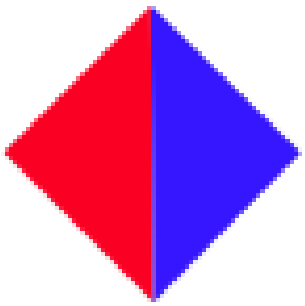


Figure 4.3.8: Icon of the prototype application "Flying Boxes".

Results of Testing "Flying Boxes" for one week

To identify further improvements of "Flying Boxes" one person tested the intervention for one week prior to the user study. After "Flying Boxes" was tested for one week by one person, it was suggested to use a symbol which visualizes the trend of the heart rate instead of showing the heart rate as number on the screen. The test person felt that seeing the actual heart rate leads to focus on the heart rate which causes stress. Furthermore, playing with circles was a challenge for the test person when applying "Flying Boxes" the first times. Thus, it was suggested to set the predefined settings to no circles.

As the heart rate data sets of the test person could be viewed in the system "Redbox", it was assumed that the data transfer worked.

Implementation of "Flying Boxes" after Testing

Based on the suggestions of the testing period the predefined settings were changed to no circles.

No other symbol visualizing the trend of the heart rate was implemented as it would be

an aim of the user study to identify how the participants feeling is about seeing the heart rate as a number.

4.3.4 Developing of "Visual Cue"

Following the results of the development process of "Visual Cue" are presented.

Sketches

Based on the persona and the scenario created for "Visual Cue" sketches of the prototype applications "Visual Cue" (see 4.3.9) were designed to get an impression how the interface of "Visual Cue" could look like.

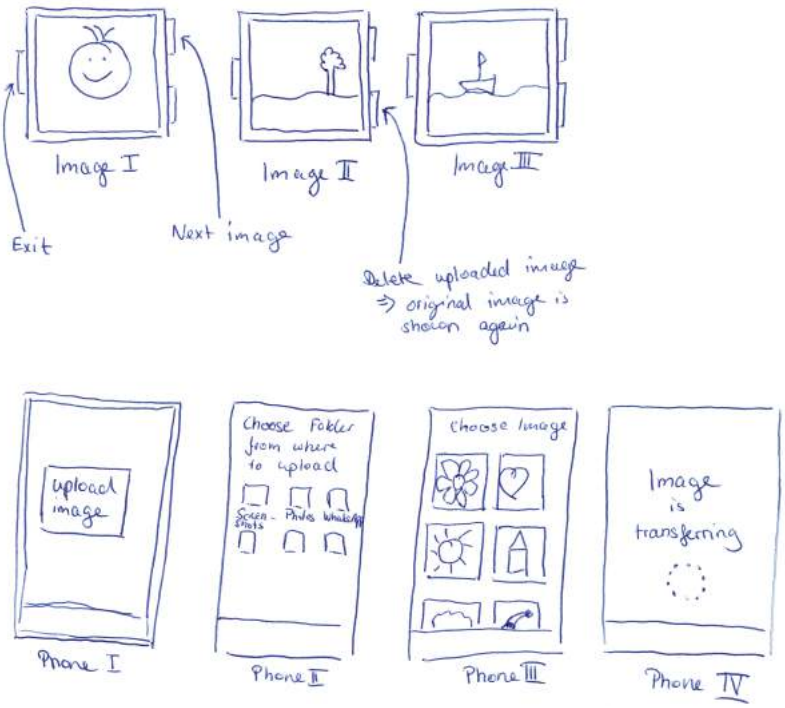


Figure 4.3.9: Sketches of the smartwatch prototype "Visual Cue". The user can see an image when pressing on the upper right button another image appears. The user can upload his/her own pictures from the phone. This pictures can be deleted which is achieved by pressing the lower right button. The upload of a picture on the phone can be seen in the lower part of the figure. The screen of a phone is visualized. By clicking the button "upload image" on the left sketch one can see the second sketch of the phone. There the user chooses from where an image should be selected (screenshots, photos, ...). Clicking on one folder, the folder opens and the pictures of this folder appear which is sketched in the third image on the bottom. By choosing one image which should be transferred to the watch, an image is shown which says "Image is transferring" (fourth sketch on the bottom).

First Implementation of "Visual Cue"

In "Visual Cue" images were selected and added to the smartwatch. In total nine images were pre-installed and every image as assigned to a number from 0 to 8. By pressing the upper right button the number of the image count is switched to the next number and the image connected to this number is displayed. Thus, the user can click through the images. A screenshot of an image displayed on the watch can be seen in figure 4.3.10.

Figure 4.3.10: A pre-installed image of "Visual Cue".

Results of Reviewing "Visual Cue" According to the ISO 13407 Human-Centered Design Process

The review of "Visual Cue" did not lead to any suggestions.

Further Implementations of the User Interface and Functional Aspects of "Visual Cue"

The function to upload photos from the smartphone was added within a setting page. Fitbit^{TM} provides the "image picker". The "image picker" was implemented in the settings, and the user is guided to upload a photo to the watch. One can see a screenshot of the implemented settings page of "Visual Cue" in figure 4.3.11. The companion application sends the image via file transfer to the watch. The uploaded image will receive the number zero and the numbers of all other uploaded images increase by one. Furthermore, a deleting function was implemented in the device's code. Pressing the lower right physical button an uploaded image is deleted. The image numbers of the images with a number higher than the image number belonging to the deleted image are subtracted by one. Thus, the first images are always the ones the user uploaded followed by pre-installed images. If the user uploads more than nine images without deleting an image, the image with the number eight is deleted automatically.

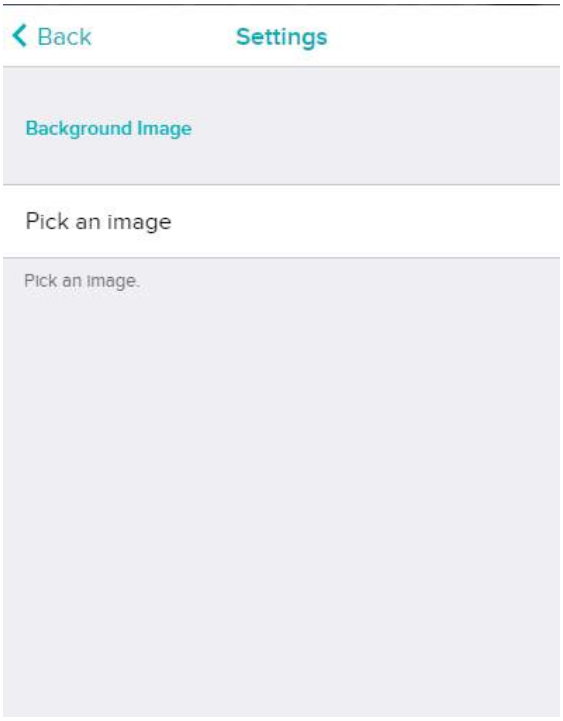


Figure 4.3.11: Screenshot of the settings page of the prototype application "Visual Cue". One can click on the image picker to upload an image from the phone to the watch.

Finally, an icon of "Visual Cue" was developed which can be seen in figure 4.3.12.

Figure 4.3.12: Icon of the prototype application "Visual Cue". The icon is generated by two icons based on [109] and [110].

4.3.5 Developing of "Walk with Me"

Following, the results of the development process of "Walk with Me" are shown.

Sketches

Based on the persona and the scenario for "Walk with Me", sketches of the prototype applications were developed to get an impression how the interface of this prototype applications could be designed. See figure 4.3.13 for viewing the sketches.

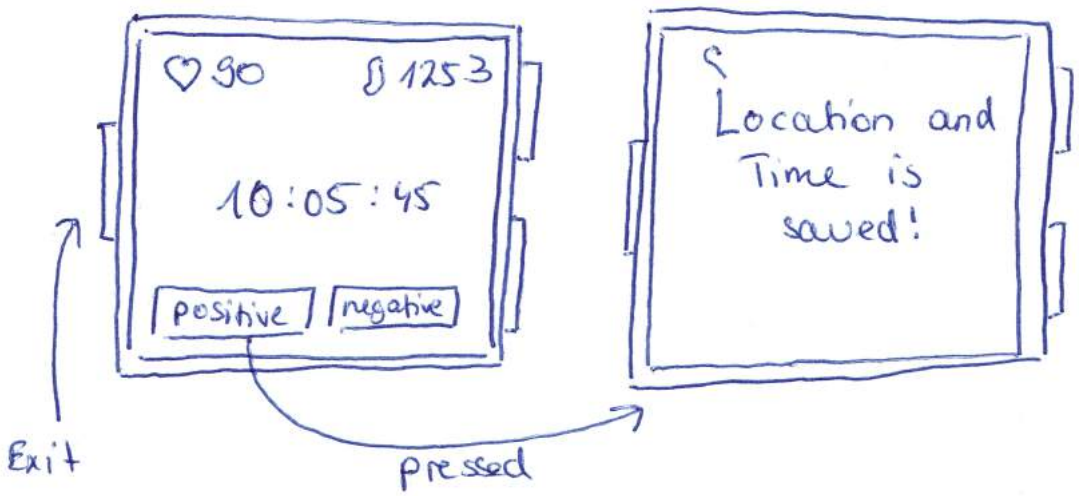


Figure 4.3.13: Visualization of the prototype application "Walk with Me". The app is structured like a watchface. One can see the time in the middle of the screen, at the top the heart rate and a step count is shown. At the bottom of the screen, there are two buttons: one positive and one negative one to save a location and the time. Pressing either the positive or the negative button the user sees the second sketch for a short moment, where he/she is informed, that the time and the location is saved.

First Implementation of "Walk with Me"

In "Walk with Me" (see figure 4.3.14) the time and two buttons to save a positive or negative location were implemented. Furthermore, the heart rate and the steps walked at that date are displayed.

Figure 4.3.14: Screenshot of the first implementation of "Walk with Me". The time, walked steps, the heart rate, and two buttons where a positive or negative situations can be saved are displayed.

Results of Reviewing "Walk with Me" According to the ISO 13407 Human-Centered Design Process

The reviewing process, conducted to increase the usability and to include further requirements of potential users, led to the suggestion to integrate a function to let the phone ring as in stressful situation it can happen easily that one does not remember where he/she put his/her phone.

Implementing further Improvements of the User Interface and Functional Aspects of "Walk with Me"

The positive and negative buttons were changed to combo buttons. The positive button was displayed with an icon showing thumbs up in green. This button was positioned in the upper right corner. The upper right physical button of the watch was connected with the same function. The negative combo button was visualized with a thumbs down icon in a red color. It was placed in the lower right corner of the screen, whereby the lower right physical button of the device was connected with the same function as the red combo button. A third combo button in the lower left corner showing a phone was implemented. By pressing the button the user's phone starts to ring. The code for the functional implementation leading to a ringing phone was provided by DI Kurt Edegger. The prototype application "Walk with Me" can be seen in figure 4.3.15.

Figure 4.3.15: Screenshot of "Walk with Me". One can see the time, the walked steps, the heart rate, and three combo buttons to mark a situation or to ring the phone. The icon of the combo button to ring the phone was provided by DI Kurt Edegger, and the basis for the icon of the combo button of the thumbs was taken from [111].

Additionally, an icon of the prototype application "Walk with Me" was developed which can be seen in figure 4.3.16b. The icon is based on the image which can be seen in figure 4.3.16a.

(a) (b)

Figure 4.3.16: 4.3.16a: Image the icon of "Walk with Me" is based on [109]. 4.3.16b: Icon of the prototype application "Walk with Me".

4.3.6 Developing "Seasons"

Based on the idea for "Seasons", the persona, and the scenario the implementation of the prototype "Seasons" can be seen below.

Functional Prototype of "Seasons"

In "Seasons" first a functional prototype was implemented to prove if and how the application can be realized. Thus, a random "gif" was chosen to display it on the watch. It was possible to animate the "gif" on the Fitbit OS simulator, but not on the watch directly. Then it was tried to select 6 images and display them, switching every few milliseconds. This was working on the Fitbit OS simulator, but not on the device itself. Switching between images in a slower frequency worked on the simulator as well as on the device. Thus, it was decided to use different images where one element appears or disappears compared to the next image following to provide a transformation between a winter and a summer landscape.

Sketches

Based on the functional prototyping the sketches of "Seasons" were created to identify how the prototype "Seasons" can be designed. The sketches can be seen in figure 4.3.17.

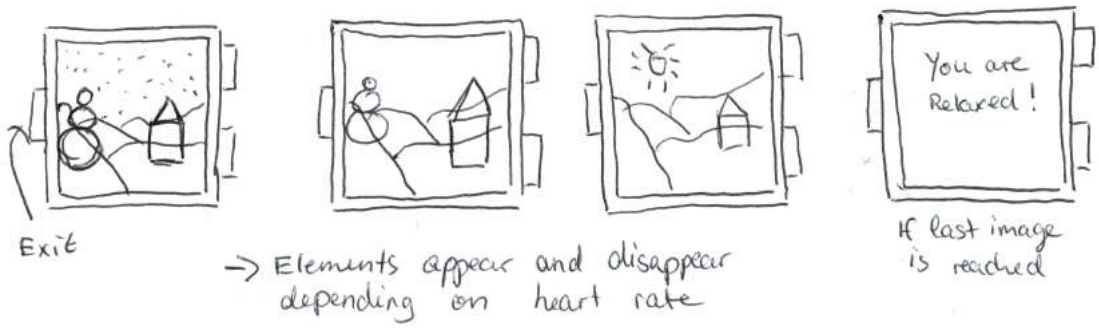


Figure 4.3.17: Sketch of what happens when opening "Seasons": The sketch on the left hand side shows a hilly winter landscape with a snowman, a house, and snow is falling. When the heart rate decreases, the winter landscape turns stepwise in a summer landscape. The snowfall has stopped in the second sketch, and the sun is shinning and the snowman melted in the third one. The fourth sketch is displayed after the user has reached the summer landscape and the heart rate did not increase again.

Implementation of the User Interface and Further Improvements of Functional Aspects of "Seasons"

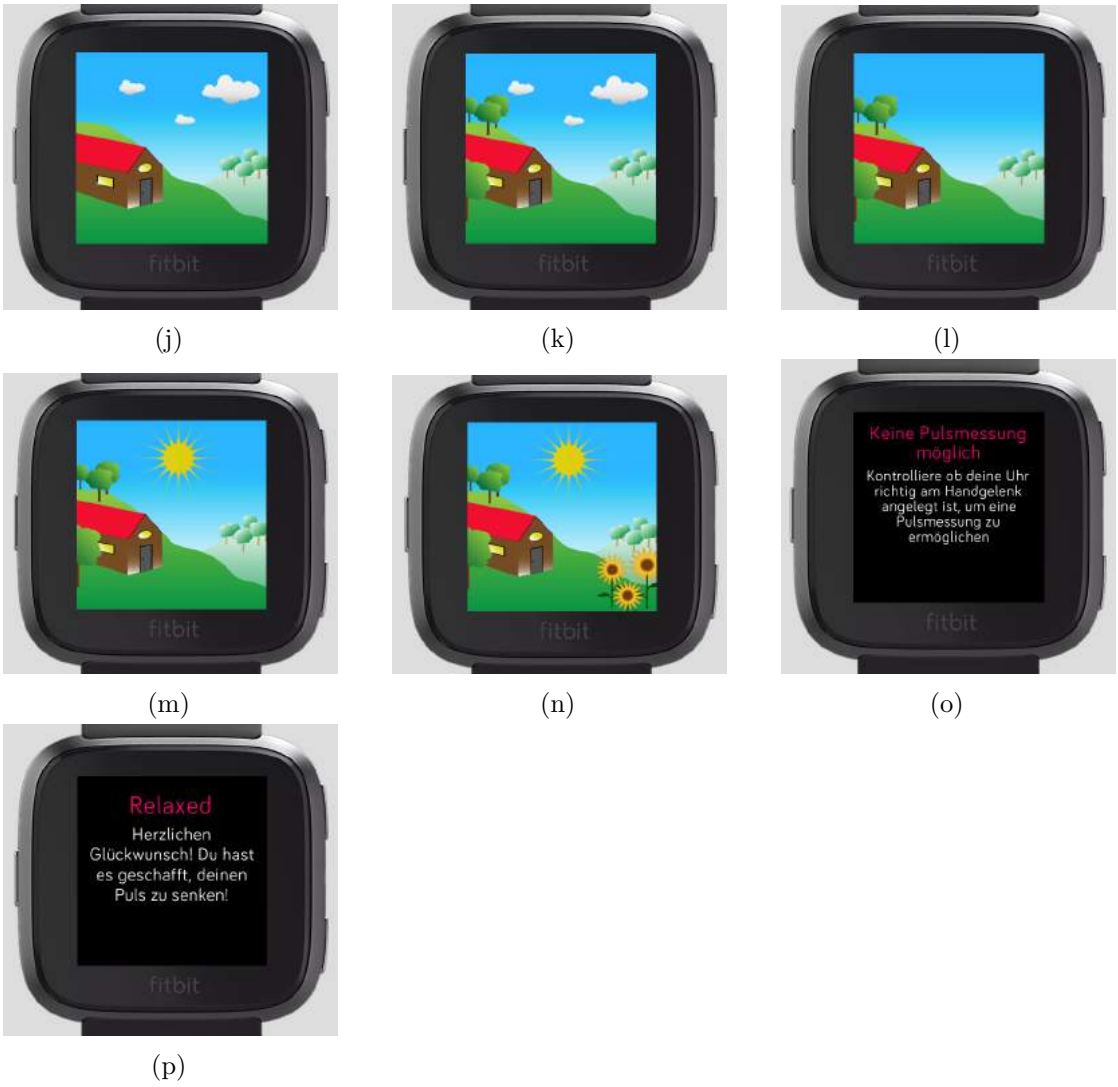
The results of implementing the sketched user interface and further functionality of "Seasons" are described in this section.

First, images where the user can see transforming a winter landscape into a summer landscape were created with Adobe® Illustrator CC 2019 as it can be seen in figure 4.3.18. To provide a functionality which connects the heart rate with switching an image, a biofeedback model as it is described in section 4.3.8 was implemented in the prototype. When the heart rate is measured to calibrate the first image, which is seen when the game starts, a screen is implemented informing the user about this. Besides this, another information screen was implemented which tells the user to put on the watch in case he/she takes it of. At the end of the game, when the user reached the final summer image, a screen was developed to let the user know that he has decreased his/her heart rate. The implementations are visualized in figure 4.3.18.

(a) (b) (c)

(d) (e) (f)

(g) (h) (i)



(j) (k) (l)

(m) (n) (o)

(p)

Figure 4.3.18: Prototype "Flying Boxes" after implementing the user interface and functionality. 4.3.18a: Screen which the user can see after starting the application. It tells the user that the game is calibrating. 4.3.18b: Final winter landscape. 4.3.18c - 4.3.18m: Winter landscape is transformed into a summer landscape or vise versa. 4.3.18n Final summer landscape. 4.3.18o The screen the user sees when he takes of the watch from his/her wrist. 4.3.18p: Final screen which can be seen after the final summer landscape was reached and the heart rate decreased further or stayed low.

Moreover, an icon of "Seasons" was designed, which can be seen in figure 4.3.19.

Figure 4.3.19: Icon of the prototype application "Seasons".

Results of Reviewing "Seasons" According to the ISO 13407

No suggestions were made within a review.

Further Implementations of "Seasons"

To collect data during the user study, data sets gained while applying "Seasons" are saved as JSON files in the local storage of the device and send via a file transfer to the companion application every 5 minutes. Upon closing the application another JSON file is saved in the local storage of the device. This file will be sent when the application is opened again. To send data to "Redbox" and to identify all the data sets belonging to one person a login function was implemented in the settings (see figure 4.3.20). A HTTP request was implemented to receive JSON web tokens based on the login data from "Redbox". Thus, the data sets can be sent to "Redbox" and saved after they were received by the companion application due to the file transfer.

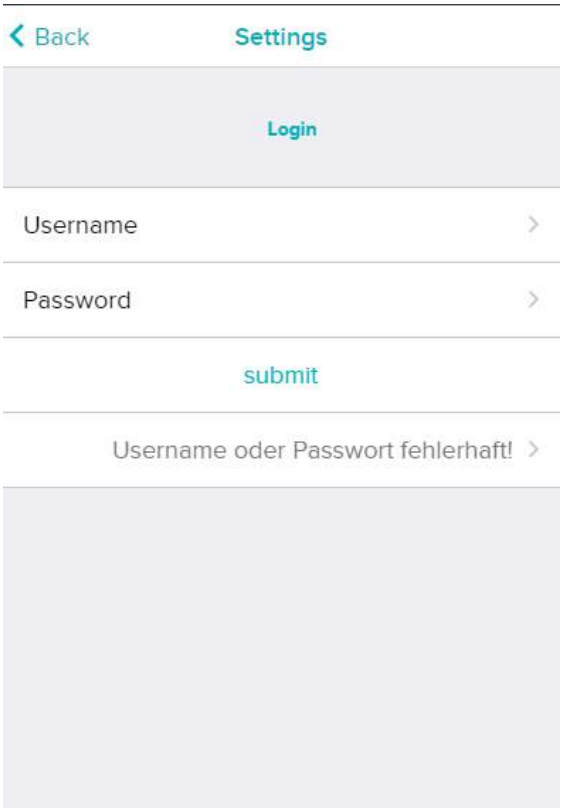


Figure 4.3.20: Screenshot of the setting page of "Seasons" with the login function.

Results of a One Week Testing Period

To identify further improvements which can be made, "Seasons" was tested by one person for one week. It was recommended to integrate a symbol which reflects the status of the heart rate.

Further Implementations of "Seasons" after a Testing Period of One Week

There were not any further implementation done after the testing period as it was decided to check how the acceptance of "Seasons" is within the user study without a symbol for the heart rate.

4.3.7 Developing "Vibes"

Following the developing process of "Vibes" is described based on the persona and scenario developed for "Vibes".

Functional Prototyping of "Vibes"

The functional prototyping was conducted to identify how "Vibes" is realizable. Implementing vibrations patterns and touchscreen click event, where the time of one touchscreen click was measured, showed that playing vibration patterns and the detection of repeating them by tipping on the screen is possible. But after 500 ms of touching the screen, the touch event is interrupted automatically. Thus, to compare the tipping pattern with the played vibration pattern, the vibration events of the watch need to be shorter than 500 ms. This is possible by applying the "confirmation-max" vibration available due to the haptics API. The time between the vibrations is not limited.

Sketches

Based on the functional prototyping, sketches of "Vibes" were developed as it can be seen in figure 4.3.21.

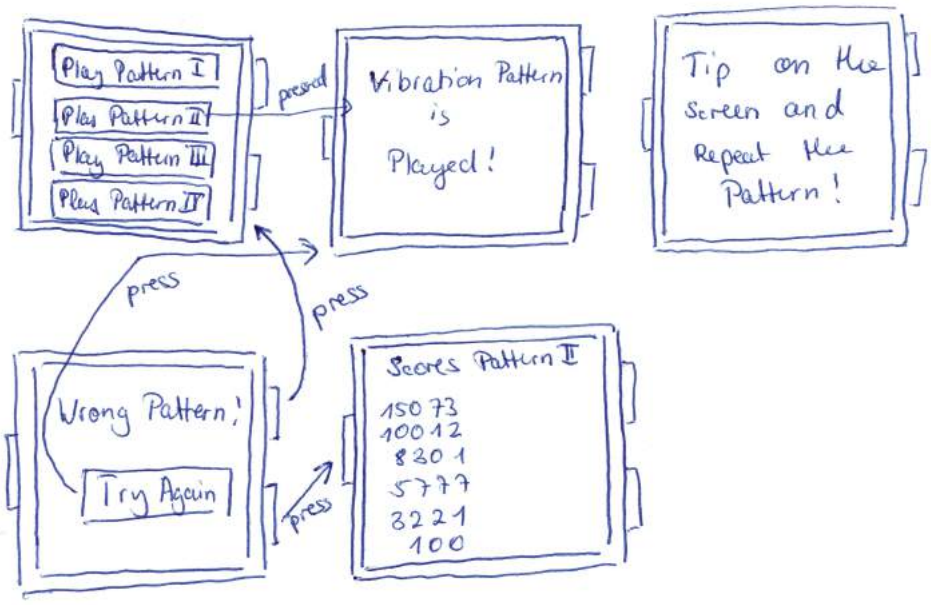


Figure 4.3.21: Sketch of the prototype application "Vibes". On the top left side: Screen with different buttons, the user can choose one of four vibration patterns which will be played. Second sketch: Screen after the user chose a pattern and the device vibrates. The top right: Screen to inform the user that it is his turn to tip the pattern. If the user is not able to repeat this pattern the game is lost and the screen which is sketched in the bottom left corner appears. There the user has the option to play again by pressing the button in the middle of the screen. Pressing the upper right button leads to the first sketch to choose a new pattern. Using the lower right button results in seeing high scores of the user's reached repeating times tipping the pattern.

Implementation of the User Interface and Further Improvements of Functional Aspects of "Vibes"

Based on the sketch, the user interface and more functionality like choosing different patterns were integrated in the first functional prototype of "Vibes". The result of this implementation can be seen in figure 4.3.22. Within the first vibration pattern the device vibrates in a constant frequency. The second vibration pattern contains of three vibrations with a time period of 700 ms in between and then another vibration followed after 400 ms. In the third vibration pattern there are two vibrations with a 300 ms time period in between, followed by three vibrations with a time period of 500 ms in between. The fourth vibration pattern consists of three vibrations with a 300 ms time period in between and three vibrations with a 600 ms time period in between. After opening "Vibes", a screen with four buttons to choose one of the four patterns described before is displayed (see figure 4.3.22a). The user can click on a pattern and the vibration is played while showing the screen 4.3.22b. Afterwards the user is invited to repeat the pattern by clicking on the screen which can be seen in figure 4.3.22c. If the user makes a mistake repeating the pattern, the game is over and the high score screen is shown. A screenshot is provided in figure 4.3.22d. The score reached in the last game is displayed in green. Pressing on the upper right physical button the user is redirected to the first screen to choose a pattern to play again (figure 4.3.22a). Pressing the lower right physical button of the watch the screen shows 4 buttons to review the high scores of the different patterns. This screen can be viewed in figure 4.3.22e.

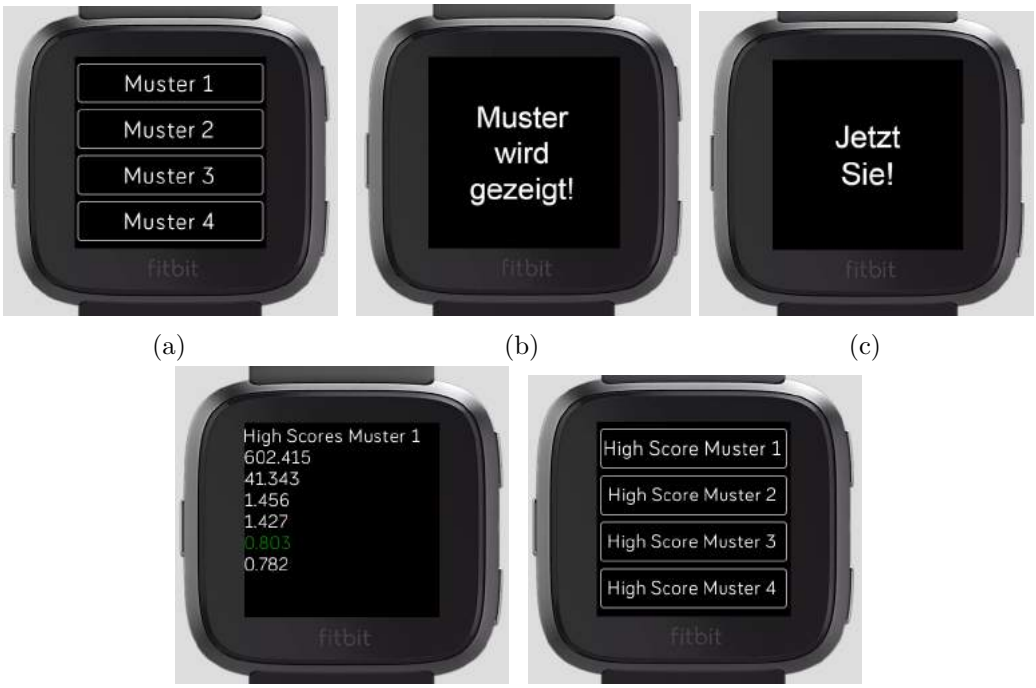


Figure 4.3.22: First implementation of "Vibes". 4.3.22a: First screen when "Vibes" is opened. A vibration pattern can be chosen. 4.3.22b: The device is vibrating to show the vibration pattern. 4.3.22c: The user gets informed that it is his/her turn now to tip the pattern. 4.3.22d: The user can view the high score and compare his/her achievements with scores he/she has reached earlier. 4.3.22e: The user can chose to view another high score.

Furthermore, an icon of "Vibes" was developed, which can be seen in figure 4.3.23.

Figure 4.3.23: Icon of the prototype application "Vibes". The icon was generated based on [109].

Results of Reviewing "Vibes" According to the ISO 13407 Human-Centered Design Process

"Vibes" was reviewed to gain further insights into the usability and how the requirements of potential users can be included further. The review resulted in the advise to implement a "Zen Mode" (the game cannot be lost), instead of stopping the game when there was a mistake in repeating the vibration pattern. Thus, one can reach a meditative state and is not disrupted withing the taping every time a mistake occurred. It was recommended to provide some feedback to the user how he/she repeats the pattern. When the pattern is not clicked in a correct way, the user could have the opportunity to feel the pattern again.

Further Implementations of "Vibes"

The suggestions gained due to the review were implemented in "Vibes". Screenshots can be seen in figure 4.3.24. The first part of the prototype intervention (until the user is instructed to repeat the pattern) was not changed. Screenshots of these implementations are shown in figure 4.3.22a - 4.3.22c. When repeating the pattern, every five seconds feedback is provided to the user: If the repeated pattern deviates from the original pattern up to 30 %, the screen shows "Weiter so!" meaning "Go on like this!". See figure 4.3.24a. If 30% $<$ deviation $>$ 50%, the screen shows "In Ordnung!" meaning "It is OK!". See figure 4.3.24b. When the deviation is above 50%, the screen tells the user that he/she can feel the vibration pattern again by clicking on the lower right button. See figure 4.3.24c. Testing this prototype within the Fitbit OS simulator turned out to be functional, but testing "Vibes" on the Fibtit Versa^{TM} turned out not to be functional all the time. Sometimes the intervention displays a black display without a feedback message for the user. According to the log file the touch events are detected and compared with the original pattern when the display is turned black.

(a) (b) (c)

Figure 4.3.24: Implementation improvements which were made after receiving feedback according to the ISO 13407. 4.3.24a: Screen when the tipped pattern matches the original pattern more than 70%. 4.3.24b: Screen when the tipped pattern matches the original pattern between 50% and 70%. 4.3.24c: Screen when the tipped pattern dismatches the original pattern more than 50%.

4.3.8 Biofeedback Models

To link the prototype applications "Flying Boxes" and "Seasons" with the heart rate as a biomarker of stress for each prototype application a biofeedback model was investigated.

Biofeedback Model for "Flying Boxes"

In "Flying Boxes" the time the boxes need to reach to the beam at the bottom is connected to the measured heart rate as:

$$\mathrm{t} = \begin{cases} \mathrm{K} + 1000ms & \overline{\mathrm{HR}} < \mathrm{HR}_{\mathrm{rest}} \\ \mathrm{K} + \frac{\mathrm{HR}_{\mathrm{rest}}}{\overline{HR}} * 1000ms & \mathrm{HR}_{\mathrm{rest}} \leq \overline{\mathrm{HR}} \leq 150 \\ \mathrm{K} + \frac{\mathrm{HR}_{\mathrm{rest}}}{150} * 1000ms & \mathrm{HR}_{\mathrm{rest}} > 150 \end{cases} \tag{4.1}$$

K is a parameter in ms which is adjustable, HR_{rest} is the resting heart rate, and $\overline{HR}$ is the average heart rate. In the implementation of "Flying Boxes" $\overline{HR}$ is calculated from five heart rate measures every five seconds. In "Flying Boxes" K can be set within the settings by choosing the difficulty level of the game. The values of K for the different difficulty levels can be seen in table 4.1. The frequency of changing the color and the side of the incoming boxes is determined by the heart rate. The frequency how often a new random color and side is generated can be seen in table 4.2. This frequency is related to the time t the boxes need to reach the beam. The frequency is constant for a certain time frame to make the intervention not too hectic. The frequency how often a new frequency is chosen to determine a new color and random side is defined by the parameter M which can be seen in table 4.1. M is set by choosing a difficulty level in the settings.

Difficulty Level	K [ms]	M [ms]
"Sehr Langsam"	1500	1000
"Langsam"	1100	1000
"Mittel"	900	2000
"Schnell"	600	3000
"Sehr Schnell"	300	3000
"Ultra Schnell"	0	3000

Table 4.1: Different values for K and M dependent on the difficulty level chosen in "Flying Boxes".

Condition of Heart Rate	Interval of Choosing a New Random Color and Side [ms]
$\overline{\text{HR}} \leq \text{HR}_{\text{rest}} + 15$	4t
$\text{HR}_{\text{rest}} + 15 < \overline{\text{HR}} \leq \text{HR}_{\text{rest}} + 25$	3.5t
$\text{HR}_{\text{rest}} + 25 < \overline{\text{HR}} \leq \text{HR}_{\text{rest}} + 35$	2.5t
$\text{HR}_{\text{rest}} + 35 < \overline{\text{HR}} \leq \text{HR}_{\text{rest}} + 45$	1.5t
$\overline{\text{HR}} > \text{HR}_{\text{rest}} + 45$	t

Table 4.2: Heart rate dependency which determines the interval of choosing a new random color and side of the flying boxes in "Flying Boxes".

Biofeedback Model for "Seasons"

For the biofeedback prototype application "Seasons" a model connecting the heart rate with the prototype was developed. The model can be seen in equation 4.2, n describes the number of the new image, whereby, n = 0 describes the final winter landscape and n=N-1 describes the final summer landscape. N is the number of images available. n_{old} is the image number of the current image. $\text{p}_{\overline{\text{HR}}}$ is the weight of the effect of the average heart rate $\text{E}_{\overline{\text{HR}}}$ and p_{σ^2} is the weight of the effect of the normalized variance of the heart rate E_{σ^2}. In the implemented prototype "Seasons" there are N = 13 images available, the image number of the final winter landscape is 0 and the image number of the final summer landscape is 12.

$$n = \begin{cases} \text{n}_{\text{old}} + 1, & \text{if } \text{p}_{\overline{\text{HR}}} * \text{E}_{\overline{\text{HR}}} + \text{p}_{\sigma^2} * \text{E}_{\sigma^2} > 0 \text{ and } \text{n}_{\text{old}} < N \\ \text{n}_{\text{old}} - 1, & \text{if } \text{p}_{\overline{\text{HR}}} * \text{E}_{\overline{\text{HR}}} + \text{p}_{\sigma^2} * \text{E}_{\sigma^2} < 0 \text{ and } \text{n}_{old} > 0 \\ \text{n}_{\text{old}}, & \text{otherwise} \end{cases} \tag{4.2}$$

In "Seasons" p_{σ^2} was set to 0, and $\text{p}_{\overline{\text{HR}}}$ to 1. Thus, equation 4.2 simplifies to:

$$n = \begin{cases} \mathrm{n_{old}} + 1, & \text{if } \mathrm{E}_{\overline{\mathrm{HR}}} > 0 \text{ and } \mathrm{n_{old}} < N \\ \mathrm{n_{old}} - 1, & \text{if } \mathrm{E}_{\overline{\mathrm{HR}}} < 0 \text{ and } \mathrm{n}_{old} > 0 \\ \mathrm{n_{old}}, & \text{otherwise} \end{cases} \tag{4.3}$$

$\mathrm{E}_{\overline{\mathrm{HR}}}$ is defined as:

$$\mathrm{E}_{\overline{\mathrm{HR}}} = \begin{cases} 1, & \text{if } \overline{\mathrm{HR}}_{\mathrm{old}} - \overline{\mathrm{HR}} > \mathrm{v} \\ 0, & \text{if } -\mathrm{v} \leq \overline{\mathrm{HR}}_{\mathrm{old}} - \overline{\mathrm{HR}} \leq \mathrm{v} \\ -1, & \text{if } \overline{\mathrm{HR}}_{\mathrm{old}} - \overline{\mathrm{HR}} < -\mathrm{v} \end{cases} \tag{4.4}$$

v is a parameter, which was chosen in "Flying Boxes" to 4. Every second a heart rate measure is taken and the average heart rate $\overline{\mathrm{HR}}$ is calculated every seven seconds. Hence, every seven seconds it is checked if the image changes. If the image changes, $\overline{\mathrm{HR}}_{\mathrm{old}}$ is set to $\overline{\mathrm{HR}}$. To make sure to have a value for $\overline{\mathrm{HR}}_{\mathrm{old}}$ at the beginning of "Seasons" there is a calibration time at the beginning in which the first $\overline{\mathrm{HR}}_{\mathrm{old}}$ is calculated as the average of the calibration measurements.

The first image $\mathrm{n_{old}}$ which is seen when starting "Seasons" is based on the difference of the average heart rate of the calibration and the resting heart rate:

$$\mathrm{n_{old}} = \begin{cases} 2, & \text{if } \overline{\mathrm{HR}}_{\mathrm{old}} - \overline{\mathrm{HR}}_{\mathrm{rest}} \geq (\mathrm{N} - \mathrm{u})/\mathrm{v} \\ \mathrm{N} - 1 - \mathrm{round}(\frac{\overline{\mathrm{HR}}_{\mathrm{old}} - \overline{\mathrm{HR}}_{\mathrm{rest}}}{\mathrm{v}}), & \text{if } \mathrm{w} \leq \overline{\mathrm{HR}}_{\mathrm{old}} - \overline{\mathrm{HR}}_{\mathrm{rest}} < (\mathrm{N} - \mathrm{u})/\mathrm{v} \\ \mathrm{N} - 1, & \text{if } \overline{\mathrm{HR}}_{\mathrm{old}} - \overline{\mathrm{HR}}_{\mathrm{rest}} < \mathrm{w} \end{cases} \tag{4.5}$$

u, v, and w are parameters which can be chosen. In "Flying Boxes" the parameters were chosen as following: u = 2, v = 4, and w = 5.

4.4 User Study

A user study with $\mathrm{n_{study}} = 5$ was set up to gain further information on the performance and the usability of the developed prototype applications "Flying Boxes" and "Seasons". Furthermore, the study was conducted to gain further information about the effect on the stress level of the participants of the study of "Flying Boxes" and "Seasons". Following, the results of the user study are given.

4.4.1 Participant Demographics

Five people between 23 and 29 years old were included in the study. All answered the entry questionnaires and were eligible to participate in the study. The mean age of the participants was 26.6 years and the median was 28 years. 20% of the participants were male and 80% were female. Nobody used a smartwatch on a regular base, was affected by mental health diseases or issues, or by diseases affecting the heart.

4.4.2 Results of the Questionnaires Answered before the Start of the User Study

Stress Questionnaire

The scores of the stress questionnaire (see appendix) based on the perceived stress scale [103] ranged from 13 to 26. Everybody reached a score above 10 to participate in the study. The results can be seen in table 4.3. A score of 10 is 25% of the total reachable score. This score was chosen as a prerequisite as it was thought that with a score of 20% enough stressful situations occur in everyday life for sufficient possibilities to use the interventions. The mean score reached in the stress questionnaire was 20 and the median was 20.5.

Participant	Score on Stress Questionnaire	Score on Computer Self-Efficacy Questionnaire
1	17.5	80.77%
2	23.0	86.21%
3	26.0	85.89%
4	13.0	82.69%
5	20.5	92.95%

Table 4.3: Scores of the Stress Questionnaire and the Computer Self-Efficacy Questionnaire.

Computer Self-Efficacy Questionnaire

The score reached on the computer questionnaire (see appendix) based on the computer user self-efficacy score [104] was between 80.77% and 92.95%. Everybody was above the needed value of 60% for inclusion, which was chosen as it was assumed that with a score of 60% a participant is able to handle a smartwatch. The results can be seen in table 4.3. The mean value was 85.70% and the median was 85.89%.

4.4.3 Number of Stress Situations and Interventions Used

In total 28 stress situations in which the interventions were used occurred during the study. The circumstances of the stressful situations can be seen in appendix. An overview

Person	Number of Stress Situations and "Flying Boxes" Used	Number of Stress Situations and "Seasons" Used	Number of Stress Situations and Both Interventions Used	Total Number of Stress Situations and Usage of an Intervention
1	2	1	0	3
2	2	2	0	4
3	3	0	2	5
4	6	7	0	13
5	2	1	0	3

Table 4.4: Amount of stress situations in combination with the use of the interventions.

of the number of sessions and stress situations is given in table 4.4. On Average everybody used "Flying Boxes" 3 times and "Seasons" 2.2 times under stress. The median is 2 for "Flying Boxes" and 1 for "Seasons". A combination of the interventions was used 2 times by one person. The average of combining the interventions in stressful situations is 0.4 and the median is 0.

4.4.4 Results of the System Usability Scale

System Usability Scale of "Flying Boxes"

The participants rated the usability according to the system usability scale (SUS) (see appendix) [105] between 90% and 100%. The mean as well as the median of the answered SUS are 95%. Details are given in table 4.5

SUS of "Seasons"

The usability of "Seasons" was rated between 87.5% and 100%. The mean usability score is 93% and the median is 90%. The results can be seen in table 4.5

Participant	Score SUS "Flying Boxes"	Score SUS "Seasons"
1	97.50%	90.00%
2	92.50%	90.00%
3	90.00%	87.50%
4	100%	100%
5	95.00%	97.50%

Table 4.5: Scores of the SUS of "Flying Boxes" and "Seasons".

4.4.5 Subjective Stress Level

Every participant rated his/her subjective stress level on a scale of 0 to 10 before and after the use of an intervention as it can be seen in appendix 7.7. 0 means no stress and 10 is the maximum stress level. An overview about the means and medians of the subjective stress level is given in table 4.6

	"Flying Boxes"	"Seasons"	Difference Between the Interventions
Mean Before	4.5 (45%)	4.6 (46%)	0.1 (1%)
Mean After	3.2 (32%)	3.4 (34%)	0.2 (2%)
Median Before	5.0 (50%)	5.0 (50%)	0.0 (0%)
Median After	3.0 (30%)	3.0 (30%)	0.0 (0%)
Difference Mean	1.4 (14%)	1.2 (12%)	0.2 (2%)
Difference Median	1.0 (10%)	1.0 (10%)	0.0 (0%)

Table 4.6: Subjective stress levels before and after using "Flying Boxes" and "Seasons".

The average stress level before using "Flying Boxes" was 4.5 and the median was 5.0. After applying the intervention the mean stress level was 3.2 and the median was 3.0. The subjective stress level before and after using "Flying Boxes" decreased on average by 1.4 and with a median of 1.0.

The mean stress level before starting "Seasons" was 4.6 and the median was 5.0. The mean stress level after using "Seasons" was 3.4 and the median was 3.0. On average the subjective stress level decreased by 1.2. The median by which it decreased was 1.0.

Shapiro -Wilk Test to Test the Differences of the Subjective Stress Level for Normal Distribution

The differences of the rates of the subjective stress levels before and after using "Flying Boxes" and "Seasons" were tested for normal distribution with a significance level of $\alpha = 0.05$. Therefore, the hypothesis H_0 and and the alternative hypothesis H_1 were:

H_0 : The differences come from a normally distributed population

H_1 : The differences do not come from a normally distributed population

The H_0 hypothesis is rejected if the test statistic W $<$ the critical value W_α. The results of the Shapiro -Wilk test can be seen in table 4.7. For both samples the H_0 hypothesis was rejected for a significance level of $\alpha = 0.05$. Thus, the H_1 hypothesis is assumed to be true. The differences of the subjective stress levels before and after the interventions "Flying Boxes" and "Seasons" do not seem to come from a normal distribution with a

significance level of $\alpha = 0.05$. Therefore, the paired t-test cannot be used as a prerequisite of the paired t-test is normal distribution of the differences.

Intervention	Number of Samples	Test Statistic W	Critical Value $W_{0.05}$	H_0 rejected
"Flying Boxes"	17	0.865	0.892 [112]	✓
"Seasons"	13	0.806	0.866 [112]	✓

Table 4.7: Results of the Shapiro -Wilk test for the differences of the subjective stress level before and after using the interventions "Flying Boxes" and "Seasons" for a significance level of $\alpha = 0.05$.

Sign Test to Test if the Subjective Stress Level Decreased

As the results of the Shapiro -Wilk tests rejected the hypothesis for normal distribution of the differences of the subjective stress level before and after using "Flying Boxes" and "Seasons", the paired t-test could not be applied. Since the distribution function of the subjective stress level is not continuously, the signed-rank test cannot be applied as a continuous distribution function is a requirement for this test. Thus, the sign test was used to identify a decrease in subjective stress level. The assumptions of the sign test (see [113]) can be seen as fulfilled for the differences of the subjective stress levels gained by the user study. The hypothesis H_0 and the alternative hypothesis H_1 are:

$$H_0 : S_{after} - S_{before} \geq 0$$
$$H_1 : S_{after} - S_{before} < 0$$

S_{before} is the stress level before the intervention and S_{after} is the stress level after the intervention. The hypothesis H_0 can be rejected if the test statistic $B \leq$ the critical value b_α. For a significance level of $\alpha = 0.05$ the H_0 hypothesis could be rejected for both interventions "Flying Boxes" and "Seasons". Thus, it can be assumed that the subjective stress level after using one of the interventions decreased compared to the subjective stress level before using one of the interventions. The detailed results of the test can be seen in table 4.8.

Intervention	Number of Samples	Test Statistic B	Critical Value $b_{0.05}$	H_0 rejected
"Flying Boxes"	17	1	4 [114]	✓
"Seasons"	13	1	3 [114]	✓

Table 4.8: Results of the sign test for the differences of the subjective stress levels before and after using the interventions "Flying Boxes" and "Seasons" for a significance level of $\alpha = 0.05$.

4.4.6 Heart Rate

"Flying Boxes"

Following the results of the heart rate over time when using "Flying Boxes" are presented. In figure 4.4.1 the heart rate over time when using "Flying Boxes" in stressful situations is shown.

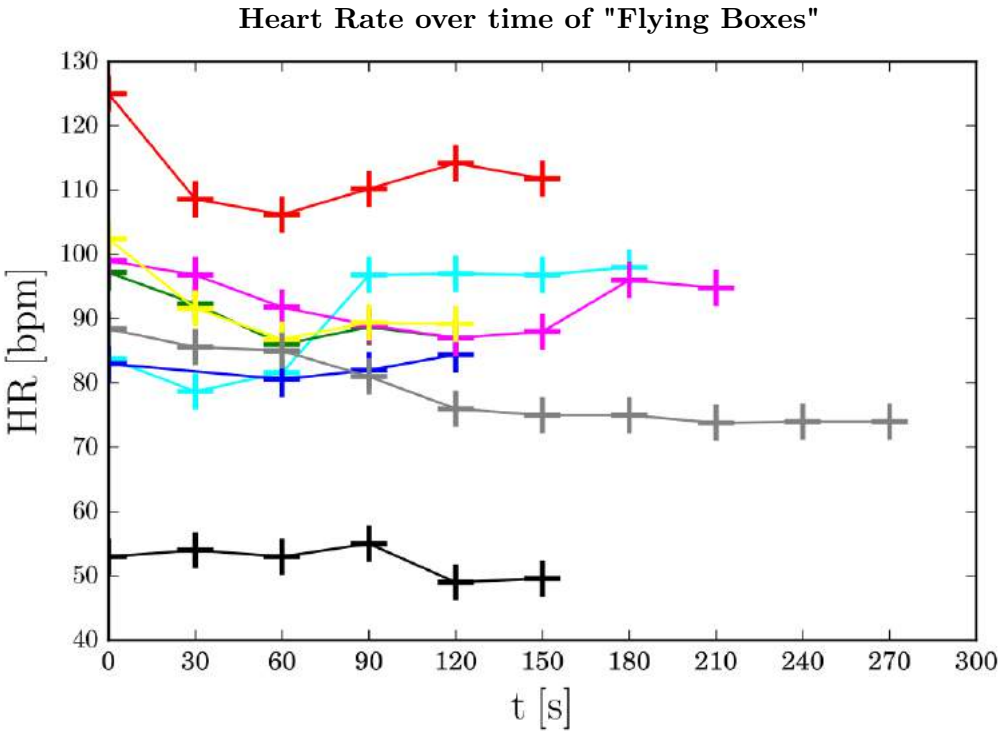


Figure 4.4.1: Heart rate (y-axis) over time (x-axis) when using "Flying Boxes". Every color displays another stress situation in which "Flying Boxes" was used.

Shapiro -Wilk Test: Testing for Normal Distribution of the Heart Rate Differences

With the Shapiro -Wilk test the data set's differences (D_{30}, D_{60}, D_{90}, D_{120}) of the mean heart rate between 30 s, 60 s, 90 s, 120 s and 0 s were tested for normal distribution with a significance level of $\alpha = 0.05$. The results can be seen in table 4.9. Since the sample size of the differences of 150 s and higher compared with 0 s were 4 and below no tests for these samples were conducted. The hypothesis H_0 and the alternative hypothesis H_1 were:

H_0 : The differences come from a normally distributed population

H_1 : The differences do not come from a normally distributed population

The H_0 hypothesis is rejected if the test statistic $W < W_\alpha$. The H_0 hypothesis was rejected for the sets of the mean heart rate differences D_{30}, D_{90}, and D_{120} with a significance level of $\alpha = 0.05$. Thus, the H_1 hypothesis can be seen as valid with a significance level of $\alpha = 0.05$. It can be assumed that the differences do not come from a normal distributed population. For the differences D_{60} the H_0 was not rejected with a significance level of $\alpha = 0.05$. Thus, it is assumed that the differences D_{60} are normally distributed.

Heart Rate Differences	Number of Situations	Test Statistic W	Critical Value $W_{0.05}$	H_0 rejected
D_{30}	7	0.700	0.803 [112]	✓
D_{60}	8	0.934	0.818 [112]	X
D_{90}	8	0.795	0.818 [112]	✓
D_{120}	8	0.794	0.818 [112]	✓

Table 4.9: Results of the Shapiro -Wilk test for the heart rate differences at different time points compared with the initial heart rate when starting "Flying Boxes".

Paired T-test

The differences of the data set D_{60} are assumed to be independent of each other, as the data was gained in different situations or by different participants. Moreover, the heart rate is interval scaled and according to the Shapiro -Wilk test normally distributed. Thus, the assumptions of the paired t-test [115] can be seen as fulfilled. Therefore, the paired t-test is used to test if the heart rate decreased after using "Flying Boxes" for 60 s compared with the initial heart rate. The hypothesis H_0 and the alternative hypothesis H_1 were:

$$H_0 : HR_0 \leq HR_{60}$$
$$H_1 : HR_0 > HR_{60}$$

HR_0 is the initial heart rate when starting the intervention. HR_{60} is the heart rate after 60 s after starting the intervention. The calculated test statistic for the heart rate difference D_{60} s is T = 3.375. The sample size is 8, thus, the critical value for a significance level of $\alpha = 0.05$ is 1.860 [116]. As H_0 can be rejected if $T > T_{0.05}$, which is fulfilled for this sample (3.375 > 1.860), H_0 can be rejected with a significance level of $\alpha = 0.05$. Thus, H_1 can be assumed as valid. The heart rate is decreased 60 s after starting "Flying Boxes" compared with the heart rate at 0 s with a significance level of $\alpha = 0.05$.

Wilcoxon Signed-Rank Test and Sign Test

As the paired t-test could not be used to test if the heart rate was decreased after 30 s, 90 s, and 120 s , because the differences D_{30}, D_{90}, and D_{120} cannot be seen as normally distributed, it was checked if the Wilcoxon signed-rank test can be used. Assumptions for the Wilcoxon signed-rank test are independent differences, metric scaled and symmetric differences, and that the differences follow a continuous distribution [114]. As "Flying Boxes" was used under different circumstances or by different persons the differences in the data sets can be seen as independent of each other. Furthermore, they can be seen as metric distributed and to follow a continuous distribution. To verify if the heart rate differences between 30 s, 90 s, 120 s and 0 s are symmetric, the skewness of the data sets D_{30}, D_{90}, and D_{120} is calculated. For a skewness between -0.5 and 0.5 the differences can be interpreted as symmetric distributed. None of the sets of differences (D_{30}, D_{90}, D_{120}) tested met this criterion. Hence, the differences cannot be seen as symmetric distributed. The results are shown in table 4.10.

Heart Rate Differences	Number of Situations	Value for Skewness	Symmetry Assumed
D_{30}	7	-3.96	X
D_{90}	8	0.73	X
D_{120}	8	1.02	X

Table 4.10: Skewness of the distribution of the heart rate differences D_{30}, D_{90}, D_{120}.

Thus, the sign test which does not require a symmetric distribution is applied to test if the heart rate was decreased at 30 s, 90 s, and 120 s compared to the initial heart rate when using "Flying Boxes". Therefore, the hypotheses were:

$$H_0 : HR_0 \leq HR_t$$
$$H_1 : HR_0 > HR_t$$

HR_0 is the heart rate when starting "Flying Boxes" and HR_t is the heart rate at the times t = 30 s, t = 90 s, and t = 120 s. The test was conducted with a significance level of $\alpha = 0.05$. The values of the test statistic are displayed in table 4.11. The hypothesis

H_0 is rejected when the test statistic $B \leq b_{0.05}$, whereby $b_{0.05}$ is the critical value for the significance level of $\alpha = 0.05$. For non of the three sets of differences the H_0 hypothesis was rejected.

Heart Rate Differences	Number of Samples	Test Statistic B	Critical Value $b_{0.05}$	H_0 rejected
D_{30}	7	1	0 [114]	X
D_{90}	8	2	1 [114]	X
D_{120}	8	2	1 [114]	X

Table 4.11: Results of the sign test for the differences of the heart rate between the times t = 30 s, t = 90 s, t = 120 s and 0 s with a significance level of $\alpha = 0.05$.

"Seasons"

In this section the results of the heart rate measurements, taken during the study when "Seasons" was used, are given. In figure 4.4.2 the heart rate over time when using "Seasons" in stressful situations is shown.

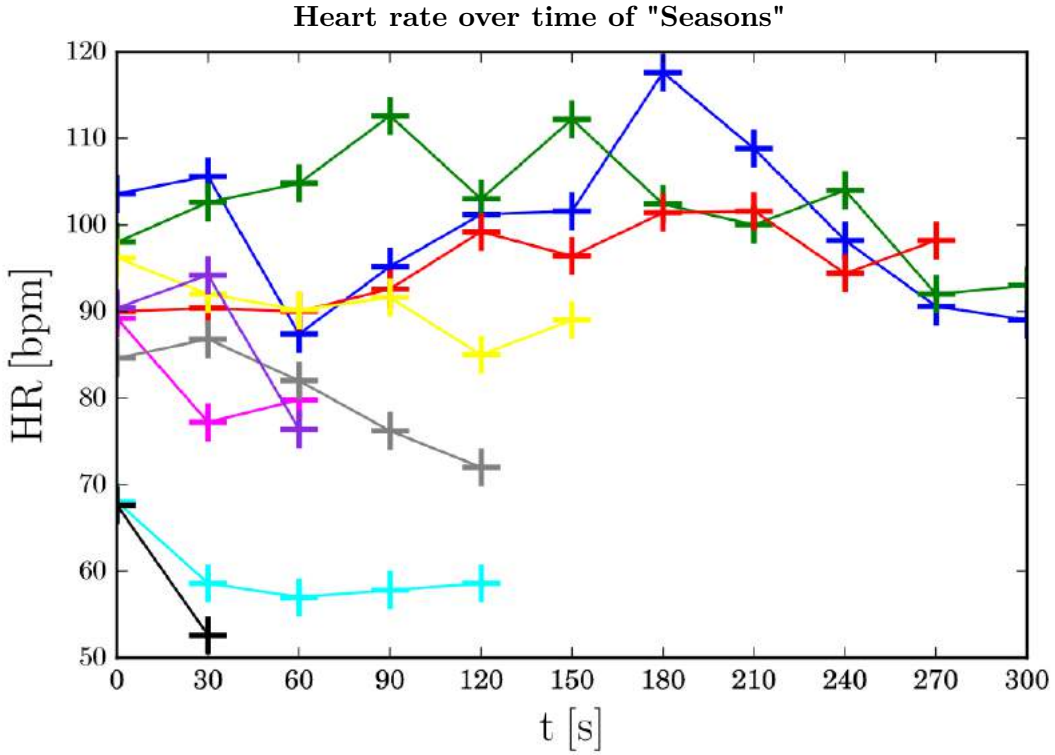


Figure 4.4.2: Heart rate (y-axis) over time (x-axis) when using "Seasons". Every color displays another stress situation under which "Seasons" was used.

Shapiro -Wilk Test: Testing for Normal Distribution of the Heart Rate Differences

With the Shapiro -Wilk test the sets of differences (D_{30}, D_{60}, D_{90}, D_{120}) of the heart rate in "Seasons" between 30 s, 60 s, 90 s, 120 s and 0 s were tested for normal distribution with a significance level of $\alpha = 0.05$. The results can be seen in table 4.12. Since the sample size of the heart rate differences at times of 150 s and higher compared with 0 s were 4 and below, no tests for these samples were conducted. The hypothesis and the alternative hypotheses for the Shapiro -Wilk tests were:

H_0 : The differences came from a normally distributed population

H_1 : The differences did not come from a normally distributed population

The H_0 hypothesis is rejected if the test statistic $W < W_{0.05}$. $W_{0.05}$ is the critical value for $\alpha = 0.05$. The H_0 hypothesis was rejected for the heart rate differences between 90 s and 0 s, and 120 s and 0 s with a significance level of $\alpha = 0.05$. Thus, for these two sets of differences it can be assumed that the H_1 hypothesis is valid and the differences do not come from a normal distribution. As the H_0 hypothesis for the differences after 30 s and 60 s was not rejected, it is assumed that the differences come from a normal distribution.

Heart Rate Differences	Number of Situations	Test Statistic W	Critical Value $W_{0.05}$	H_0 rejected
D_{30}	9	0.850	0.829 [112]	X
D_{60}	8	0.967	0.818 [112]	X
D_{90}	6	0.655	0.788 [112]	✓
D_{120}	6	0.785	0.788 [112]	✓

Table 4.12: Results of the Shapiro -Wilk test for the sets of the mean heart rate differences D_{30}, D_{60}, D_{90}, and D_{120} in "Seasons".

Paired T-Test

As the set of heart rate differences D_{90} and D_{120} cannot be seen as normally distributed, the paired t-test can not be applied for these data sets. Normal distribution can be assumed for the data sets of heart rate differences between 30 s and 0 s, and 60 s and 0 s. Thus, the t-test can be conducted for these two sets of differences as the other assumptions - the metric scale of the heart rate, and that the differences are independent [115] - can be seen as valid for these data sets. The paired t-test was used to test if the heart rate was decreased after using "Seasons" for 30 s and 60 s compared with the initial heart rate. Therefore, the hypotheses were:

$$H_0 : HR_0 \leq HR_t$$
$$H_1 : HR_0 > HR_t$$

HR_0 is the heart rate when starting "Seasons" and HR_t is the heart rate at the time t = 30 s and t = 60 s. The hypothesis H_0 can be rejected with a significance level of $\alpha = 0.05$ when the test statistic $T > T_{0.05}$, whereby $T_{0.05}$ is the critical value for the significance level $\alpha = 0.05$. The H_0 hypothesis could not be rejected for the differences D_{30} and D_{60}. The detailed results of the tests are given in table 4.13.

Heart Rate Differences	Number of Situations	Test Statistic T	Critical Value $T_{0.05}$	H_0 rejected
D_{30}	9	0.169	1.833 [116]	X
D_{60}	8	0.313	1.860 [116]	X

Table 4.13: Results of the paired t-test for the sets of heart rate differences between 30 s and 0 s, and 60 s and 0 s in "Seasons" with a significance level of $\alpha = 0.05$.

Wilcoxon Signed-Rank Test and Sign Test

As the paired t-test could not be used for the sets of heart rate differences D_{90} and D_{120}, the skewness of the differences was calculated to identify if the Wilcoxon signed-rank test can be used to test if the heart rate was decreased after using "Seasons" for 9 s and 120 s. The results of the skewness can be seen in table 4.14. If the value for the skewness is between -0.5 and 0.5, the distribution of the differences can be seen as symmetric. For the differences between 120 s and 0 s the distribution can be assumed as being symmetric, whereas the distribution of the differences between 90 s and 0 s cannot be assumed as being symmetric.

Heart Rate Differences	Number of Situations	Value for Skewness	Symmetry Assumed
D_{90}	6	0.80	X
D_{120}	6	0.30	✓

Table 4.14: Skewness of the distribution of the heart rate differences between 90 s and 0 s, and 120 s and 0 s.

"Seasons" was used in different situations or by different participants. Thus, the heart rate differences in one data set can be assumed as independent of each other. As the heart rate differences between 120 s and 0 s are assumed to be distributed symmetric, the differences are assumed to be independent of each other, and the distribution function can be assumed as continuous the assumption of the Wilcoxon signed-rank test are fulfilled (see [114] for the assumptions). Thus, the Wilcoxon signed-rank test was used to test if the heart rate was decreased after using "Seasons" for 120 s compared to the initial heart

rate. Therefore, the hypotheses were:

$$H_0 : HR_0 \leq HR_{120}$$
$$H_1 : HR_0 > HR_{120}$$

HR_0 is the heart rate when starting the game and HR_{120} is the heart rate after 120 s. For a significance level of $\alpha = 0.05$ and the sample size of 6 the critical value is $W_{0.05} = 3$ [114]. The test statistic is $W = 5$. To reject H_0 the test statistic W needs to be smaller than $W_{0.05}$ which is not fulfilled for $W = 5$ ($5 > 3$). Therefore, H_0 cannot be rejected for the set of differences between 120 s and 0 s.

As the sign test does not require a symmetric distribution (see [113] for assumptions) and the assumptions can be seen as fulfilled for the set of differences between 90 s and 0 s, the sign test is used to test if the heart rate was decreased after using "Seasons" for 90 s. Therefore, the hypotheses were:

$$H_0 : HR_0 \leq HR_{90}$$
$$H_1 : HR_0 > HR_{90}$$

HR_{90} is the heart rate after using "Seasons" for 90 s. The critical value for a significance level of $\alpha = 0.05$ and a sample size of 6 is $b_{0.05} = 0$. The test statistic of the set of differences is $B = 2$. As the H_0 hypothesis can be rejected when $B \leq b_{0.05}$, the hypothesis cannot be rejected in case of the set of differences D_{90}.

4.4.7 Qualitative Results of the Interviews

In the user study, additionally to the data gained for the quantitative analyzes, interviews were conducted with the participants to gain further insights on the usability, the usage, and the effectiveness of the developed interventions "Flying Boxes" and "Seasons" on reducing stress. For the analyses of the interviews, the interviews were transcribed as it can be seen in appendix. Based on the transcribed interviews, paraphrases and codes were worked out. These results were grouped together for all interviews as it can be seen in table 2 in appendix. Based on that information the interviews were further analyzed and the code-paraphrases combinations were categorized into worked out themes and further summarized. The results belonging to the different categories can be seen below.

Standard Methods Facing Stress

In the interviews the participants were asked for their standard methods under stress. Reported strategies were:

- breath deeply
- take a break

- do something else
- distraction
- go to a quite place
- calm down
- take a shower
- go for a walk
- solve the problem
- drink a glass of water
- make a schedule

Looking at these strategies three different types how to handle stress can be identified: Confronting oneself with the stressor to find a solution, distract oneself, and do something to calm down.

Design and Usability

An overview about the information gained through the interviews regarding the design and usability can be seen in table 4.15. The codes which were assigned to this category are "design", "usability", and "tactics". All in all the design was seen as positive in both interventions. In "Flying Boxes" the circles were difficult to distinguish from the boxes. In both the interventions "Flying Boxes" and "Seasons" the usability was described as easy, whereby in "Flying Boxes" the usage of the 2 buttons on the right side of the watch to change the color of the boxes and the shape of the circles were seen as difficult to use.

Code	"Flying Boxes"	"Seasons"
Design	**positive:** • good • simple • appealing • colors and images well visible **negative:** • circles difficult to distinguish from boxes	**positive:** • good • artistic • pretty • colors and images well visible
Usability	**positive:** • easy, only one button to click **negative:** • 2 participants: buttons on side difficult to use • 1 participant: sometimes stumble, but did not change anything	**positive:** • easy, only need to start the intervention
Tactics		2 participants: concentrating on breathing

Table 4.15: Results of the interviews of the category design and usability of "Flying Boxes" and "Seasons". The codes belonging to this category are "design", "usability", and "tactics".

Circumstances of Using the Interventions

The results gained by the interviews regarding the circumstances of using the interventions can be seen in table 4.16. The codes "situation/circumstances" and "best usage of the interventions and standard method" were allocated to this category. In general "Flying Boxes" was used when distraction from the situation was wanted, there was enough time to use the intervention, having enough energy to do an activity, and when the situation was overwhelming. The feelings under which "Flying Boxes" was applied

were frustration, tension, for fun, and sadness. "Seasons" was used when participants wished to calm down, or to do things restful, when they were tired (too tired for an activity), in overwhelming situations, and when no distraction and rather focusing was wanted.

Moreover, the participants thought that the interventions can be used additionally to the calming process. Also, it was thought that the interventions are not usable when facing time related stress. When imagine a situation where a stress situation was caused by an exam, 1 participant would use "Flying Boxes", 2 participants would use "Flying Boxes" in combination with their standard stress method, and 2 participants would use "Seasons".

Code	"Flying Boxes"	"Seasons"
Situation / Circumstances	• distraction wanted • time to use "Flying Boxes" • when having enough energy to do something actively • in overstraining situations • frustration • tension • for fun • sadness	• wish to calm down • wish to do things calmed down and controlled • tired • work overload • in overwhelming situations • no distraction from situation wanted
Best Usage of the Interventions and Standard Method	• can be used additionally of calming process • not usable at time related stress • exam related stress: 1 participant "Flying Boxes", 2 participants "Flying Boxes" and standard method	• can be used additionally of calming process • not usable at time related stress • exam related stress: 2 participants "Seasons"

Table 4.16: Results of the circumstances under which "Flying Boxes" and "Seasons" can be used. The results were gained by the interviews of the user study.

Experienced Effects of the Interventions

In the user study information were gained about the experienced effects of the participants when using "Flying Boxes" and "Seasons". An overview about these results is displayed in table 4.17. Codes belonging to this category are "circle function", "heart rate", and

"described effects".

The interviews resulted that having another object beside the boxes in "Flying Boxes" was seen as too difficult or was not used except by 1 participant. In "Flying Boxes" 2 participants experienced seeing the heart rate as pressure, whereby 3 participants rated the displayed heart rate as good. In "Seasons" two people thought that not seeing the heart rate is good because then it cannot cause pressure or make one nervous. 2 participants would like to see the heart rate displayed in "Seasons".

The experienced effects of the participants when using "Flying Boxes" were calming, stress reduction, eustress, fun and distraction. 1 participant experienced stress and a feeling of failing when using "Flying Boxes". This participant also described that he/she does not like computer games in general. In contrast to that 1 participant developed ambition to lower the heart rate faster and play for a longer time without losing the game "Flying Boxes". Furthermore, a feeling of restlessness was experienced if the heart rate did not decrease continuously.

In "Seasons" a calming and distraction effect was reported. Moreover, happiness was experienced when seeing an image going towards the summer landscape. 2 participants mentioned that they could not play for a longer time because their heart rate was too low. Another negative aspect reported was that it was disappointing when the image changed towards the winter landscape which also caused a nervous feeling. 1 participant did not feel any effect when using "Seasons".

Comparing both interventions 2 participants felt that "Flying Boxes" can reduce the stress in favor of "Seasons". 2 participants thought that the effect of "Seasons" is more distracting and has a higher effect to reduce stress then "Flying Boxes". 1 participant felt that both interventions are effective for relaxing.

Code	"Flying Boxes"	"Seasons"	Comparison "Flying Boxes" and "Seasons"
Circle Function	**positive:** • 1 participant: fun to play with circle **negative:** • 4 participants: use without circle → difficult enough • circle was over-straining	no circle function available	

Heart Rate	**positive seeing heart rate:** • 3 participants: good to see heart rate • 1 participant: if heart rate not shown: restless • 1 person: could not connect heart rate to velocity of intervention if heart rate not visible **negative seeing heart rate:** • 2 participants: pressure seeing heart rate	**positive not seeing heart rate:** • 2 participants: no pressure or getting nervous **negative not seeing heart rate:** • 2 participants: would like to see heart rate	

Described Effects	**positive:** • calming • stress reduction • causing eustress • fun • distraction • 1 participant: only stress reduction during the intervention • 1 participant: developing ambition to reduce heart rate faster and play longer **negative:** • 1 participant: stress because no time to make schedule, feeling of failing and tension because of computer game character • restlessness if heart rate did not decrease continuously	**positive:** • calming • happiness when images goes towards summer or "relaxed" screen • information about the situation • distraction **negative:** • 2 participants could not play for a long time • image goes towards winter: disappointing, nervous • 1 participant did not feel any effect	• 2 participants thought "Flying Boxes" has a more stress reducing effect • 2 participants thought "Seasons" is more distracting and has a more stress reducing effect • 1 participant thought both interventions relaxing

Table 4.17: Results of the effects of "Flying Boxes" and "Seasons" gained by the interviews. The codes assigned to this category are "circle function", "effects of the displayed/ not displayed heart rate", and the "described effects" which occurred during the usage of the interventions.

Overall Impression and Thoughts of the Interventions

One category identified by the interviews is the overall impression and thoughts of the interventions. The overall impression and thoughts of "Flying Boxes" were that it is cool, fun, and a positive experienced as it assists in the distraction from stressful situations. 1 participant did not like "Flying Boxes" as it is a computer game, and he/she dislikes computer games. "Seasons" was thought to be another kind of pulse measure. It was noticed as positive that it is a possibility to relax, to be distracted by focusing on oneself, a good idea, and cool to see how oneself is relaxing. Overall 2 participants liked "Flying Boxes" better than "Seasons", 2 participants liked "Seasons" better than "Flying Boxes" and 1 participant liked both interventions. An overview about the results can be seen in table 4.18.

Furthermore, it was suggested to display the heart rate due to colors (green: low pulse, red: high pulse), or due to a fake pulse as it could be relaxing if one can see how the pulse decreases over time. Moreover, it was recommended not to connect "Seasons" to the heart rate as then the game could last longer.

Code	"Flying Boxes"	"Seasons"	Comparison "Flying Boxes" and "Seasons"
Impression	**positive:** • distraction from stressful situation • cool • fun **negative:** • 1 participant: does not like computer games → "Flying Boxes" is like a computer game	**general:** • another kind of pulse measure • depends on time if positive or negative **positive:** • possibility to relax • to be distracted to be focused on oneself • cool to see how you relax • good idea **negative:** • boring • too less to do • cannot influence it • not playable for a long time • never winter landscape	• 2 participants liked "Flying Boxes" better • 2 participants liked "Seasons" better • 1 participant liked both interventions
Suggestions	• display heart rate with colors: green for low pulse, red for high pulse • display fake pulse: could also be relaxing	• do not connect "Seasons" to heart rate	

Table 4.18: Results of the overall impression and thoughts of "Flying Boxes" and "Seasons" gained by the interviews of the user study.

CHAPTER 5

Discussion

In this chapter the results of identifying a suitable biomarker for smartwatch stress reducing biofeedback applications, of the development and implementation process, and of the user study are discussed.

5.1 Literature Review

Within the literature review a variety of different possible intervention approaches for mental disorders could be identified. By investigating the state of the art and studies conducted on interventions, addressing to support patients with mental disorders, a deeper insight into the research question - how already existing interventions can affect mental disorders - was gained. Thereby, it was identified that it seems to be popular to transform traditional therapeutic methods, as for example CBT, problem solving, or the mindfulness approach, into mHealth interventions. Furthermore, the literature review showed that a variety of functions as for example mood tracking, reminders, or gamification were included showing how existing interventions are designed. Especially the gamification seemed to be a promising aspect for designing interventions for wearables as it might increase engagement. The biofeedback approach is another approach which seems to be promising according to the literature. The intervention "The Loom" uses this approach and showed significant short term stress and heart rate reducing results within a user study. The user has to transform a winter landscape into a summer landscape by becoming relaxed. The level of relaxation is measured by the permeability of the skin. In "The Loom" the user has to be connected to the measurement device Pip [49] which does not seem to be usable on the go. Furthermore, all biofeedback mHealth interventions developed within the literature review seem to need measurement devices to identify physiological parameters as the breathing rate or the HRV. Thus, first the biofeedback prototype intervention idea "Seasons" and later the ideas of "Pack your Suitcase", "Find Me", "Connect by Numbers", "Swipe the Pattern", "Take a Breath", "Flying Boxes",

"Visual Cue", "Walk with Me", and "Vibes" for a smartwatch were born. Smartwatches can provide access to the heart rate and access to the intervention on one device. Thereby, a first insight into the research questions - how can possible interventions for wearables be designed to reduce stress and which limitation and possibilities are there for wearable stress reducing interventions - was gained as discussed in the sections 5.3.1 and 5.3.2.

5.2 Smartwatch and Biomarker Selection

As the only possible biomarker available for stress on a Fitbit™ device is the heart rate there, was no other opportunity than the heart rate, to chose as a biomarker to detect the stress level. According to the literature the heart rate is not a secure biomarker for stress. It might be an even better solution to connect the intervention to the HRV as it is seen as a more secure biomarker for stress [22]. But as this was not possible and the interventions examined in the user study connected to the heart rate as a biomarker showed stress reducing as well as heart rate reducing effects, using the heart rate as a biomarker on stress seems to be functional.

5.3 Development and Implementation of Relaxation Prototype Applications for a Smartwatch

The idea finding and implementation process pointed out possible opportunities of how smartwatch intervention applications can look like and function to reduce stress with and without biofeedback. Thereby, possible limits and possibilities could be identified as discussed in this section. Furthermore, by implementing the prototypes according to ISO 13407, insights in the research question - how can the needs of potential users be fulfilled - were gained. Due to the personas and scenarios, the group of users and usage cases for the interventions where identified. Thus, requirements as distraction where identified. Additionally, the process of reviewing according to the ISO 13407 resulted in the findings of further needs of possible future users, as for example the function to let the phone ring in "Walk with Me".

5.3.1 Possible Limits of Smartwatch Interventions for Stress Reduction

When developing prototype ideas and considering "Pack your Suitcase" and "Find Me" for further development, it was assumed that the size of the display of the smartwatch might be a limitation to display a lot of objects on the display. Moreover, detecting accurate touch events on a lot of different positions on the screen of the smartwatch might be difficult due to its display size as it would be needed for the ideas of "Connect by Numbers" and "Swipe the Pattern".

Considering the development of "Take a Breath", it was thought that it might be difficult to identify the optimal breathing frequency of an individual as breathing can be

connected to the HRV, which is a biomarker which is not accessible on the Fitbit Versa™.

The idea of "Find Me" was to include an audio signal into the intervention. In fact, one can connect the Fitbit Versa™ with Bluetooth earphones, but accessing these earphones as third party developer does not seem to be possible as there is no audio API.

Considering these limitations, within this project the focus of the implementation of prototypes was laid on the intervention ideas "Flying Boxes", "Visual Cue", "Walk with Me", "Seasons", and "Vibes".

Implementing the functional prototype "Seasons", it did not seem to be possible to animate a "gif" on the smartwatch. First, the implemented code showing a "gif" was tested on the Fitbit OS simulator where one could see the "gif" animated. Second, the code was deployed on the Fitbit Versa™ where a static image of the "gif" was displayed. This indicates that the approach of displaying an animated image on the Fitbit Versa™ might not be functional as the code seems to be functional running on the Fitbit OS simulator. Thereby, it remains open if this possible limitation is specific to the Fitbit Versa™, or if it applies at other devices as well.

During the development process of "Vibes", it was found that the Fitbit™ can only detect touch events up to 0.5 s. Thus, the vibration patterns which can be used seem to be limited if the intervention aims to compare the clicked pattern with the original one. When investigating different vibration patterns one has to consider that it might be difficult for some people to differentiate different vibration lengths not lasting longer than 0.5 s. Furthermore, the vibrations which can be played by the Fitbit™ device are specified by Fitbit™. Thus, the possible vibration patterns which can be played on the Fitbit Versa™ seem to be further restricted.

After the recommendation to implement a "Zen-Mode" within "Vibes", where the user cannot loose, but receives a feedback on his clicking, a "Zen-Mode" code was implemented and tested on the Fitbit OS simulator where the code seemed to be functional. When testing the "Zen-Mode" on the Fitbit Versa™, the display of the device turned black when it was supposed to show a feedback message on the screen according to the implemented code. Thus, considering the functionality on the Fitbit OS simulator, it indicates that detecting touch events, comparing these events with a default pattern, and displaying a feedback message synchronously might not be functional on the Fitbit Versa™.

5.3.2 Possibilities of Smartwatch Interventions for Stress Reduction

Even if it does not seem to be possible to display an animated image on the Fitbit Versa™ as discussed above, it is possible to show different images after each other as the implementation process and testing of "Seasons" could show. Furthermore, implementing

"Flying Boxes" and testing it on the Fitbit Versa^{TM} showed that animations of SVG elements within a game are possible.

By developing and implementing "Flying Boxes" and "Seasons" it could be shown that the realization of biofeedback stress reducing interventions connected to the heart rate is possible for smartwatch applications. This could expand the opportunities to assist people in anxiety and stress causing situations. The results regarding the effectiveness of "Flying Boxes" and "Seasons" gained by a user study, are discussed in section 5.4. By the implementation process of setting "Flying Boxes" and "Seasons" up for the user study it could be shown that it is possible to transfer the heart rate data from the device to another system.

By developing the user interface of the smartwatch and the functionality of gaining positive and negative locations of "Walk with Me", the basis to provide a functional prototype application to recognize situations with a smartwatch was created. Thus, it could be shown that collecting positive and negative locations with just one click is possible while seeing the time, the heart rate, and the walked steps at the same time. These findings could provide information for developing stress reducing smartwatch applications which provide support for reflection in the future.

By developing the prototype application "Visual Cue", it could be shown that it is possible to transfer images from a smartphone to the smartwatch, switching between them, and deleting them. As the focus in this master thesis was laid on biofeedback interventions, a user study including "Visual Cue" would have exceeded the limit of this master thesis. Thus, no assumptions can be made regarding the effectiveness of "Visual Cue" in assisting people in stressful situations. But showing that the functionality of "Visual Cue" works, could increase the possibilities and opportunities for possible smartwatch applications aiming to reduce stress.

Implementing the prototype application "Vibes", it could be shown that it is possible to use the vibration motor of the Fitbit Versa^{TM} as a third party developer. Even if it does not seem to be possible to detecting touch events, comparing these events with a default pattern, and displaying a feedback message at the same time, the comparison between the clicked vibration pattern and the original pattern seems to work. The output of the log file of the application indicates that the detection of the length between the touch events and the comparison with the original pattern seems to be possible. How feedback messages can be integrated in a functional way within the "Zen-Mode" remains open.

5.3.3 Biofeedback Models

The prototype applications "Flying Boxes" and "Seasons" are biofeedback applications. For each application one biofeedback model was developed (see section 4.3.8). For the "Flying Boxes" biofeedback model 4.1 different parameter were chosen for K, which can be selected by the difficulty level within the settings of the interventions. The

verification which parameter works the best exceeds the limit of this master thesis. Furthermore, it might be possible that the parameter is dependent on individual criteria, like on the person who uses the application. As the heart rate was decreased significantly after using "Flying Boxes" for 60 s compared to the heart rate before starting "Flying Boxes", and the subjective stress level was significantly reduced after the usage of "Flying Boxes", the biofeedback model seems to be functional with the used parameters.

Two participants reported in the interviews of the user study that they could not use "Seasons" for a long enough time. To be usable for an even greater population, the biofeedback model of "Seasons" needs to be further improved and adjusted to the heart rate. Since the other three participants did not report such an effect and the subjective stress level decreased significantly, it is a hint that this model is functional in general, and maybe needs a further adoption in the parameters u, v, w only. The parameters u, v, w in the equations 4.5 and 4.4 are not dependent on the resting heart rate HR_{rest}. Maybe choosing them according to HR_{rest} as u(HR_{rest}), v(HR_{rest}), and w(HR_{rest}) could result in an even greater population which is able to use "Seasons" for a longer time.

5.4 User Study

The user study was conducted to gain more information about the effect and the usability of the stress reducing smartwatch applications "Flying Boxes" and "Seasons", to answer the research question which effecs can these intervention have and how can they be used, and to prove the hypothesis - the intervention "Flying Boxes" is more effective in reducing Stress than "Seasons". All in all 28 stressful situations occurred during the user study, where either "Flying Boxes", "Seasons", or both interventions were used. Not all heart rate data files, connected to these situations, were received by "Redbox". This can have different reasons. It is not possible within the Fitbit™ system to send data from the device to another system directly, but it is possible when sending data to the companion first, and then to another system. The process of sending data to "Redbox" contains two steps. Thus, two different process steps have to be considered when looking for the reason of losing data.

The first process step is sending data from the device to the companion application of the smartphone. A possible reason for loosing data could be that the device was not connected to the phone. If data is not saved on the device and cannot be sent to the companion, data loss could occur. To prevent this kind of data loss the data files which were supposed to be sent to the companion application were saved as a JSON file on the device. Fitbit™ provides a method in the SDK which can check if the data was sent by the device. This method was used within "Flying Boxes" and "Seasons". If a data file was recognized as transferred to the companion application this data file was deleted on the device to prevent using up the storage space. It could be possible that the detection of transferred files is not to 100% accurate and therefore data was lost.

In the second process step of sending data, data is sent from the companion application to "Redbox". Therefore, an internet connection of the smartphone is needed. When starting the user study the participants were advised to make sure to connect their smartphone to the internet either via WLAN or via mobile internet access of their phone. Still, it could be possible that it was forgotten to connect the phone to the internet or that the internet connection was not stable and thus data was lost.

The data analysis was conducted with data sets where the heart rate data was available when participants started either "Flying Boxes" or "Seasons".

5.4.1 Evaluation of the Results of the User Study Regarding the Hypothesis

To prove the hypothesis that "Flying Boxes" is more effective in reducing stress than "Seasons" the results of the participant's subjective stress level and of the participant's heart rate were considered.

First of all, when looking at the results of the subjective stress level data, the subjective stress level decreased significantly after using either "Flying Boxes" or "Seasons". On average the stress level decreases by 14% after using "Flying Boxes" and by 12% after using "Seasons". Therefore, it seems that both interventions are able to decrease stress. As the difference in the decrease is 2%, it indicates that there is no difference in the effect of using "Flying Boxes" or "Seasons" regarding the subjective stress level.

According to the results of the measured heart rate data, it can be proposed that the heart rate decreased significantly after using "Flying Boxes" for 60 s compared to the heart rate when starting the intervention. It needs to be identified if this decrease is correlated to "Flying Boxes" or are caused by other factors. Due to the fact, that the data sets of the differences D_{30}, D_{90}, D_{120} of "Flying Boxes" could not be assumed to be normally distributed the parametric t-test could not be applied for these data sets and the non parametric sign test was used. As the H_0 hypothesis of the sign test could not be rejected, no suggestions can be made about an increase or a decrease of the heart rate after using "Flying Boxes" for 30 s, 90 s, or 120 s compared to the initial heart rate. It might be that the sample sizes of these samples was not sufficient enough for the power of the sign test with a significance level of 0.05 and therefore, a rejection of H_0 was not possible. Furthermore, it is possible that the heart rate did not decrease after using the intervention and therefore the H_0 hypothesis could not be rejected. No suggestions can be made if the heart rate decreased or increased after 30 s, 60 s 90 s, or 120 s of using "Seasons" compared with the heart rate when starting the intervention at 0 s. It can be that the sample sizes were too small for the power of the tests to reject the H_0 hypotheses with a significance level of 0.05. Another possibility that the H_0 hypothesis could not be rejected is that the heart rate did not decrease significantly after using "Seasons".

The hypothesis that "Flying Boxes" is more effective in reducing stress than "Seasons", cannot be assumed as being valid as the subjective stress level decreased in both interventions and no assumptions can be made regarding a decrease of the heart rate. It can be assumed that the interventions "Flying Boxes" and "Seasons" are both able to reduce stress equally as there are only neglectable differences in the subjective stress level.

5.4.2 Evaluation of the Results of the User Study Regarding the Primary Study Questions

Following, the results to answer the primary study questions will be discussed.

How is the usability of "Flying Boxes" and "Seasons"?

According to the SUS questionnaire, the participants rated the usability of "Flying Boxes" on average with 95% and the usability of "Seasons" on average with 93%. According to Bangor et al. a score of 90% and more can be translated into an A on a grading scale between the letters A and F, where A is the best grade [117]. Both interventions reached the best possible usability score of an A. This indicates that the applications fulfill the requirements of usability of the users.

These findings are inline with the findings of the qualitative interviews. Both interventions were described as easy to use with an appealing design. Only two things were not described as optimal when using the intervention "Flying Boxes". One of them was the circle function which could be used optionally. It was described that the circles could not be distinguished from the boxes very well. The second thing rated not as optimal were the buttons on the right side of the watch for changing the color of the boxes and the shape of the circles. The watch has another button on the left side but this button is reserved for exiting Fitbit^{TM} applications. Trying to implement another function as to exit the intervention for this button did not seem to work well. Thus, using the touch screen could be a possibility to increase the usability even more and prevent the usage of the buttons on the right side. In "Seasons" nothing was experienced as negative regarding the usability.

Does "Flying Boxes" and "Seasons" reduce the heart rate?

As it has already been discussed in section 5.4.1 no suggestions can be made about an increasing or decreasing effect of the heart rate after using "Flying Boxes" for 30 s, 90 s, or 120 s compared with the heart rate at 0 s or after using "Seasons" for 30 s, 60 s, 90 s, or 120 s compared with the heart rate at 0 s. A significant heart rate decreased after using "Flying Boxes" for 60 s compared to the heart rate before using "Flying Boxes" could be shown. Thus, it indicates that using "Flying Boxes" for 60 s can reduce the heart rate if the heart rate is at least 10 bpm above the resting heart rate when starting "Flying Boxes". To identify if the heart rate decrease is correlated to "Flying Boxes", and not due to other influences, a controlled user study should be conducted.

5.4.3 Evaluation of the Results of the User Study Regarding the Secondary Study Questions

In this section the results of the user study are discussed to answer the secondary questions.

Does one of the prototype applications "Flying Boxes" or "Seasons" reduce the heart rate in favor of the other one?

As the statistical tests could not reject the H_0 hypothesis at any tested time difference of the heart rate, no assumption can be made if the heart rate is decreasing, increasing, or remains steady during the usage of "Seasons". Thus, no comparison regarding the reduction of the heart rate over time can be made between "Flying Boxes" and "Seasons". Probably, more data sets would be needed to answer this research question.

When is which prototype application be used?

Due to the results of the qualitative interviews which can be seen in section 4.4.7, it can be assumed that both applications are used in stressful and overwhelming situations, whereby "Flying Boxes" was preferred when distraction was wanted and the participant had enough energy to do an active intervention. "Seasons" was used when the desire of calming was present and when there was not enough energy left for doing an active interaction. That "Flying Boxes" was used for distraction, whereas "Seasons" was used for calming was expected as "Flying Boxes" was developed to fulfill a distraction function, whereas "Seasons" was developed aiming to stay focused. Thus, "Flying Boxes" seems to be an intervention for situations where one needs to be distracted, and "Seasons" might be the intervention to use when one would like to calm down.

How can the prototype applications effect stress?

As discussed above in section 5.4.1, both intervention seem to decrease the level of stress. The results of the qualitative interviews (see section 4.4.7 and section 4.4.7) let one assume that "Flying Boxes" without the circle function and "Seasons" can have a calming and distraction effect in stressful situations, depending on the person who uses the intervention and the situations. This is supported as one person mentioned stress during the use of "Flying Boxes", whereas other participants experienced eustress during its usage. Furthermore, the effect of "Seasons" seems to be contrary as a change of an image towards the summer landscape can result in happiness, whereas a change of an image towards the winter landscape can course disappointment in stressful situations. Two people experienced a more stress reducing effect when using "Flying Boxes" and two people when using "Seasons". Thus, it indicates that both intervention can be calming, distractive, and stress reducing in stressful situations depending on the person and situation. These are expected results as the interventions were developed for calming, distraction, and stress reduction. To identify if the stress reducing effect is correlated to the interventions, it would be necessary to examine these interventions in a controlled

user study.

Moreover, the findings of section 4.4.7 lead to the assumption that it might be more helpful to use the interventions in combination with the standard method for calming and not when facing time-related stress.

Is it supportive to display the heart rate in the prototype application?

As the feelings about seeing the heart rate diverged in "Flying Boxes" as well as in "Seasons" as it can be seen in section 4.4.7, a general statement if the heart rate is supportive or not, cannot be made. It seems to depend on the person if seeing the heart rate is supportive when using "Flying Boxes" or "Seasons". To gain more detailed insight if the interventions would be experienced differently when not seeing the heart rate in "Flying Boxes" or seeing the heart rate in "Seasons", "Flying Boxes" should be tested without seeing the heart rate, and "Seasons" should be tested with seeing the heart rate.

5.4.4 Further Findings

The gamified intervention "Flying Boxes" seems to increase the motivation and engagement of using "Flying Boxes" as the majority of the participants experienced fun when using it. One person also mentioned that he/she did not only use "Flying Boxes" in stressful situation but also for fun. Another person experienced ambition to lower the heart rate faster and "survive" for a longer time in "Flying Boxes". Also, it seems that the relaxing display as a reward system is effective as seeing this display could lead to happiness.

CHAPTER 6

Conclusion

This master thesis was conducted to provide a further understanding of the functionality, usage, and effect of wearable applications for anxiety and therefore for stress as anxiety being a form of stress [3]. First, a literature review was conducted, which has shown the existence of different interventions with various approaches, aiming to support different mental health disorders. One of these approaches is the biofeedback approach. As there are studies which lead to the assumption that biofeedback might be an opportunity for stress reduction [10], it was an aim of this project to investigate the impact of biofeedback on stress, and as the heart rate as a biomarker for stress can be accessible with a smartwatch, it was decided to focus on the biofeedback approach for smartwatch interventions.

To gain further insights on possibilities and limitations of stress reducing smartwatch interventions, different prototype intervention ideas were developed, whereby the prototype applications "Flying Boxes", "Visual Cue", "Walk with Me", "Seasons", and "Vibes" were developed further. These interventions were chosen for further development as the other ones did not seem as realizable due to the limited display size, no access to the HRV, or no possibility to provide an audio signal. Within the development process insights were gained how stress reducing smartwatch application can be realized and how the needs of potential users can be fulfilled. Additionally, within the development process of "Flying Boxes", "Visual Cue", "Walk with Me", "Seasons", and "Vibes" it was identified that it does not seem to be possible to display animated images ("gif") on the smartwatch. Furthermore, detecting the length of a touch event is limited to 0.5 s, and Fitbit^{TM} provides limited vibration patterns which can be applied when accessing the vibration motor. Moreover, the implementation process indicated that it might not be possible to display a feedback message, detect touch events of a tipped pattern, and compare this pattern with the original pattern at the same time on the Fitbit Versa^{TM}.

Nevertheless, due to the implementation process also possibilities were identified. Thus,

by implementing "Flying Boxes" and "Seasons", it could be shown that animating SVG elements and showing different images after each other is possible. Furthermore, by developing one biofeedback model for "Flying Boxes" and one for "Seasons", and thereby, connecting the functionality of these interventions with the user's heart rate, it could be shown that it is possible to implement biofeedback application for a smartwatch.

By implementing "Visual Cue" it could be identified that transferring photos from the smartphone to the smartwatch is possible. Furthermore, the developing process of "Walk with Me" indicates that detecting positive and challenging locations while seeing the time, the heart rate, and walked steps is possible. Moreover, it showed that it seems to be possible to let the phone ring by pressing a button on the smartwatch.

After the development process of the prototype applications was finished, a one-armed user study of "Flying Boxes" and "Seasons" with 5 participants was set up to investigate the effects of these interventions and how they can be used. The participants tested the interventions in stressful situation in everyday life, whereby they took notes about the circumstances of using the intervention and their stress rate before and after the usage. While they used the intervention, their heart rate data was saved. After the testing phase of the intervention was finished, the participants answered the SUS questionnaire and were interviewed about the usability and the effects of the interventions.

The analysis of the heart rate data could show that the heart rate was significantly decreased with a significance level of 0.05 after using "Flying Boxes" for 60 s compared to the initial heart rate. Furthermore, the subjective stress level was significantly decreased after the usage of either "Flying Boxes" or "Seasons" compared with the stress level before the intervention was applied.

The interviews as well as the SUS questionnaire indicate that both interventions "Flying Boxes" and "Seasons" fulfill the requirements regarding the usability of the users.

The hypothesis - "Flying Boxes" is more effective in reducing stress than "Seasons" - does not seem to valid, as the difference in the mean decrease of the subjective stress level of both intervention was 2% and two participants experienced "Flying Boxes" as more stress reducing, whereby two participants thought that "Seasons" can reduce stress better, one participant thought both intervention are stress reducing, depending on the situation which one is better. It was described that in general "Flying Boxes" is calming, distracts one from stressful situations, and can cause eustress. One person mentioned that he/she did not like "Flying Boxes" as he/she gets stressed by it. He/She also said that she does not like computer games in general for the same reason. But he/she also admitted that it can be helpful if a situation is overwhelming as "Flying Boxes" can help to distract one from this situation. Another person said that he/she developed ambition to reduce the heart rate faster and to play for a longer time, which indicates that gamification might increase engagement. "Flying Boxes" was used in stressful and overwhelming situations

were the participants wanted to be distracted by an active situation. In "Seasons" the experienced effects were also calming and distraction from stressful situation. It was mentioned that "Seasons" caused happiness when a summer landscape or the relaxing image was displayed, whereby it could cause disappointment when the winter landscape was displayed. One participant stated that he/she did not notice an effect of "Seasons". "Seasons" was applied in stressful and overwhelming situations when the user wanted to calm down. Seeing the heart rate in "Flying Boxes" caused different reactions: Some participants experienced it as a pressure, whereas on the other side it was experienced as good to see and resulted in ambition to lower ones heart rate faster. The same effect could be noticed in "Seasons", some participants thought that it is good that the heart rate is not displayed, whereas other participants expressed the wish to see the heart rate.

All in all, it can be summed up, that it seems to depend on the person and the situation which intervention - "Flying Boxes" or "Seasons" - might be more effective.

CHAPTER 7

Outlook

Even though this master thesis already provides insight and findings on limitations and possibilities of smartwatch applications to reduce stress and, therefore, providing the first steps into assisting people facing anxiety or stress when using public transportation, more research and development needs to be done to complete the goal of the European Commission of improving the accessibility of transportation. Following an outlook is given how the results of this thesis can be used and developed further in the future.

7.1 Biomarker

It might be possible that Fitbit^{TM} provides access to other physiological parameters like the HRV which can indicate the level of stress in the future. Therefore, one should keep an eye on the progress of the accessible physiological parameter and of the overall technology when doing research on stress reducing smartwatch applications.

7.2 Limitation and Possibilities

With the technological advancement ongoing on wearables, it is possible that the limitation detected now might turn into possibilities in the future. Thus, it might be possible to implement an intervention idea in a way, which is not possible by now, in the future. Furthermore, the display size was assumed to be a limiting factor for "Pack your Suitcase", "Find Me", "Connect by Numbers", and "Swipe the Pattern". If this is really a factor which limits these prototype ideas, this could be identified by developing these prototypes.

7.3 "Walk with Me"

By implementing the user interface and the functionality for the smartwatch and companion application, the basis of providing an intervention to review positive and stressful

situations in everyday life is given. To provide a complete application an interface needs to be created to enable the user to review his/her marked situations during the day.

7.4 "Visual Cue"

In "Visual Cue" it is already possible to view images transferred from the smartphone to the device and to delete these images again. For an increased usability of this intervention, information of the transferring process or the deletion process could be integrated in the application.

7.5 "Vibes"

In "Vibes" 4 different vibration patterns are already integrated which can be repeated by the user. To provide more variety, more vibration patterns could be integrated in the future. Furthermore, a "Zen-Mode" was developed in "Vibes", whereby the feedback messages are not functional in combination with detecting touch events and comparing those with the original pattern. As comparing touch events with the original one seem to be functional, another way needs to be identified in the future to implement this app to be functional as a whole.

7.6 "Flying Boxes" and "Seasons"

Even though the user study seems to show stress reducing results for the biofeedback smartwatch applications "Flying Boxes" and "Seasons" further improvements can be made to gain an even better functionality. Therefore, in "Flying Boxes" the circle function could be improved further to make it possible to distinguish the circles from the boxes better. Moreover, a touch screen function could be implemented to change the color of the boxes and replace the button on the right side to increase the usability even more.

As a too short intervention time of "Seasons" was mentioned after the user study by two participants the parameters of the biofeedback model could be further adopted to provide an even better functionality and provide a longer intervention time for a larger population. The resting heart rate could be considered when adopting the parameters u, v, w as described in section 5.3.3.

Moreover, a setting function could be integrated in "Flying Boxes" as well as in "Seasons" which allows to enable and disable displaying the heart rate. This can solve the discrepancy of users seeing the heart rate as being supportive or obstructive as everybody can choose what he/she thinks works best for him/her.

7.7 User Study

Although the user study of "Flying Boxes" and "Seasons" showed promising results regarding the stress reducing effect and the decrease of the heart rate after using "Flying Boxes" for 60 s, another user study with a larger sample size could be conducted in the future. Thus, an answer could be found whether the heart rate is decreasing after 30 s, 90 s, and 120 s of using "Flying Boxes" and if it is decreased when using "Seasons" as well. Furthermore, it needs to be examined if the decrease of the heart rate after using "Flying Boxes" for 60 s is the effect of "Flying Boxes" or due to other circumstances. Another user study is already planed within the project "PHOBILITY active" [9] to gain more insights into the stress reducing interventions.

Furthermore, another user study could include the applications "Visual Cue", "Walk with Me", and "Vibes" to identify their usability and the effect of these applications on stress.

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Acronyms

ABMT	Attention Bias Modification Training
ACT	Acceptance and Commitment Therapy
ACTH	Adrenocorticotrophic Hormone
AIT	Austrian Institute of Technology
ANS	Autonomic Nervous System
API	Application Programming Interface
AVP	Arginine Vasopressin
BATD	Behavioral Activation Treatment for Depression
CA	Catecholamines
CBP	Cognitive Behavioral Psychoeducation Program
CBT	Cognitive Behavioral Therapy
CNS	Central Nervous System
CRH	Corticotropin-Releasing Hormone
CSE	Coping Self-Efficacy
CSS	Cascading Style Sheets
ERP	Event-Related Potential
ESA	Emotional Self Awareness
GC	Glucocorticoid
GR	Glucocorticoid Receptor
HPA	Hippothalamus-Pituitary-Adrenal
HR	Heart Rate
HRV	Heart Rate Variability
HTTP	Hypertext Transfer Protocol
JSON	JavaScript Object Notation
JSX	Javascript XML
LWH	Living With Heart
MBP	Mindfulness-Based Program
mHealth	Mobile Health
MHL	Mental Health Literacy
MR	Mineralocorticoid Receptor
PST	Problem Solving Therapy
PTSD	Post-Traumatic Stress Disorder
PVN	Paraventricular Nucleus

RCT	Randomized Control Trial
RFT	Relational Frame Theory
SCP	Self-Compassion Program
SDK	Software Development Kit
SNS	Sympathic Nervous System
SUS	System Usability Scale
SVG	Scalable Vector Graphic
VHB	Virtual Hope Box

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Appendix

Further Material of the Method Section

Study Protocol

Phobility

Study Protocol to Evaluate the Prototypes "Flying Boxes" and "Seasons"

Vienna, 14.04.2019

Contents

1 SCIENTIFIC BACKGROUND AND OBJECTIVES

The European Commission established the aim to improve the accessibility of public transportation for people with limits regarding mobility. Many factors can lead to a limitation and reduction in mobility. One causing reason belongs to the field of mental disabilities [1].

The WHO estimated that 100,000,000 people suffer from anxiety or depression in Europe at any time [2], and in Austria 10% of the population suffers of at least one mental health issue. The number of people affected by a mental disability is increasing [1]: It is estimated that depressive disorders become the main reason for disabilities in high- incoming countries by 2030 [3]. Therefore, it is very important to treat and reduce mental disabilities.

Typically, mental disorders are treated with psychotherapy and psychopharmacotherapy, which has shown effectiveness [4]. However, treating the anxiety disorder is not possible for everyone: a lack of services, stigma, or delayed access of therapy causes a gap of treatment [5]. Even if a treatment care exists, the patient has to reach the

psychotherapist or self-regulating community which can be challenging.
There is no typical anxiety of mobility, but it is possible that people affected by an anxiety or depression project their anxiety into actions occurring in the context of mobility. Thus, for those a barrier of mobility exists. On the one hand, it can influence the treatment care and on the other hand, it is essential to participate in transportation to maintain social contacts and support the recovery process [1]. One approach to support patients in their disorders are mental health applications. Since 2007 when mindfulness applications began to become popular, the number of people applying the training with their smartphone has increased over millions [6].
In case of stress or anxiety in connection with transportation the intervention needs to be portable, applicable during transportation, and accepted. Those requirements can be met by mobile mental health applications. In the last years, wearables have become popular and available for the general public. By measuring physiological data they attempt to improve the quality of life of the users [7].
Considering that anxiety is stress about an uncertain situation or an undefined danger [8] the prototype Applications "Flying Boxes" and "Seasons" for the Smartwatch Fitbit Versa^{TM} [9] have been investigated, aiming to reduce stress to assist people and patients with anxiety disorders to reduce their stress and thereby, benefit in patients mobility.
Both, "Flying Boxes" and "Seasons" are gamified interventions (game elements applied in non game based environments [10]) working with biofeedback (physiological parameters, which are usually not observable directly are measured with electronic or elektromechanical devices and reported to the user [11]) and distraction coping. Distraction coping is a strategy where the patient focuses on other things but not on the stressor with the aim to reduce the emotional distress [12].
Since there is no evidence if these applications have an effect on stress and thus, are able to reduce stress related increased heart rate, this prospective, randomized study aims to investigate the relation of the prototype applications and heart rate.

2 RESEARCH QUESTIONS

The primary objective of the study is to examine the effectiveness and the usability of the smartwatch prototype applications "Flying Boxes" and "Seasons" on reducing the heart rate in stressful situations.
The **primary study questions** are:

- How is the usability of "Flying Boxes" and "Seasons"?
- Does the use of "Flying Boxes" and "Seasons" reduce the heart rate?

The **secondary questions** are:

- Does one of the prototype application "Flying Boxes" or "Seasons" reduce the heart rate significant in favor of the other one?
- When is which prototype application be used?

- How can the prototype applications effect stress?
- Is it supportive to display the heart rate in the prototype applications?

3 HYPOTHESIS

Janson et al. investigated that a higher degree of distraction coping predicted a steeper and straighter cortisol decrease after high values of salivary cortisol up to 60 min after stress. The salivary cortisol is a measure of the hypothalamic-pituitary-adrenal axis stress responses [13]. As "Flying Boxes" provides higher distraction opportunities while facing a stressor, it is hypothesized that the intervention "Flying Boxes" is able to be more effective in reducing stress than "Seasons". Another reason which leads to this hypothesis is that "Flying Boxes" is more like an entertainment game than "Seasons". Entertainment games seem to be promising on mood and mental health issues [14].

4 STUDY METHODS

4.1 Study design

Prospective and parallel study on 5 healthy people

4.2 Study sites

- When and wherever stressful situations occur in Vienna and surroundings

4.3 Inclusion criteria

- Age: older than 18 years
- Stress in everyday life measured with a questionnaire based on the perceived stress scale (PSS) (minimum 10 points) (see 6.1) [15]
- Written informed consent to participate in the study
- Owner of an Android or an iOS smartphone

4.4 Exclusion criteria

- Mental health issues
- Mental health disease
- Existing diseases affecting the heart
- Less than 60% in the questionnaire based on the computer user self-efficacy score (CUSE) (see 6.1) [16]

- Frequent use of a smart watch

4.5 Study intervention

People with an academic background are asked to participate in the study. In case of willingness to participate, possible participants are reviewed on inclusion and exclusion criteria. If they meet the criteria and after receiving written informed agreement (see appendix 6.4), participants will receive an explanation leaflet (see appendix 6.4) and the Fitbit Versa™ on which the prototype applications "Flying Boxes" and "Seasons" are installed for one week. The Fitbit Versa™, "Flying Boxes", "Seasons", and the circumstances under which "Flying Boxes" and "Seasons" shall be used will be explained in detail and tried out. The explanation will be done following the leaflet which can be seen in appendix 6.4. During the usage of "Flying Boxes" and "Seasons" the starting and end time of a session, the heart rate, the resting heart rate, the number of flying boxes or circles, the number of different "Season" stages, the score, the difficulty, and the time when the application is closed will be documented. This data will be saved within the "Redbox" system provided by the Austrian Institute of Technology and used for data analysis to examine the primary and secondary questions. Furthermore, the participant will receive questionnaires regarding the reasons he/she used the application, which have to be completed after every usage of the application. When the testing phase is finished (after one week) the participant will receive another questionnaire - based on the system usability scale (SUS) [17] (see appendix 6.1), and will be interviewed regarding the usability and the effect on stress of the application (see appendix 6.1). These questionnaires will be analyzed to investigate the research questions.

4.6 Data collection

The Fitbit Versa™ will be applied to use the biofeedback applications: "Flying Boxes" and "Seasons" for a week. The Fitbit Versa™ will be used to collect data, as following:

"Flying Boxes"

- Starting time of an application session
- End time of an application session
- Start time of the heart rate measurement
- Heart rate time series
- Resting heart rate
- Number of objects falling down in the session
- Number of boxes falling down in the session
- Number of circles falling down in the session

- The score of one session
- The difficulty
- The time when the application is closed

”Seasons”

- Starting time of the session
- End time of the session
- Starting time of the calibration of the session
- Time the relaxed state is reached
- Resting heart rate
- Number of different frames
- Number of total assessed frames
- Heart rate time series
- Pairs of time and reached frame

The companion application for the smartwatch is used on the owner's smartphone to adjust the difficulty level of the application. Also, it will take part in transferring the data to ”Redbox”.

4.7 Data storage, privacy, and Data protection

The data collected by Fitbit Versa™ is stored in the ”Redbox” platform and stored on the Fitbit®, Inc. servers, whereby data is transferred into the United Stated of America and other countries. Fitbit® follows the EU-US-Privacy Shield Guidelines [9]. In this study anonymous accounts are created to use this service without passing personal information as first name, last name, or address.

4.8 Study investigations

- Quantitative questions: questionnaires based on the SUS as it can be seen in appendix 6.1.
- Interviews: Qualitative questions as it can be seen in appendix 6.3.

4.9 Statistical analysis

To obtain the statistical analysis of the heart rate data, data sets which are collected and saved in "Redbox" will be considered only. The data sets are grouped depending on the prototype application used. The Shapiro-Wilk test is used as pre-test for normal distribution. As analysis, the paired sample t-test is applied to test for differences before and after the application of the smartwatch. α =0.05 will be regarded as significant

4.10 Quantitative and qualitative analysis of questionnaires and interviews

The scores of the questionnaires based on SUS will be summarized and multiplied by 2.5 to gain the overall score [17]. The interviews (interview questions see appendix 6.3) will be analyzed with the principle of analytical induction regarding the hypothesis - "Flying Boxes" is able to be more effective in reducing stress than "Seasons" - and the research questions: how is the usability of the applications?, how can the applications effect the heart rate?, is one application more effective in reducing the heart rate?, and when and where is which prototype application be used?. First, the answers will be written in paraphrases, then codes will be identified. The codes will be examined for similarities and differences thus, themes will be formed. These themes will be investigated for similarities and differences.

5 OBJECTIVES AND FUTURE ASPECTS

The goal of this prospective and parallel study is to investigate the usability of the prototype applications "Flying Boxes" and "Seasons". Its purpose is to identify if these applications have an impact on heart rate during stressful situations. The study aims to analyze under which circumstances, when, and where which applications can be applied effectively. Thus, the aim of this study is to provide information how mHealth application can be used in stress causing situations, meaning how the usability of mHealth application can be further improved to satisfy the needs of stressed users. Analyzing the circumstances under which one type of application is more effective then the other one will have an impact on supporting users to choose the most suitable application without the need of trying different interventions until a suitable one is found.

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6 APPENDIX

The questionnaires and interviews will be in German since the study is conducted in Vienna and surroundings. Thus, the questionnaires and interviews shown in the appendix are also in German.

6.1 Questionnaires

Following one can see the questionnaires given to the participants during the study.

Fragebogen 1 – Studie Phobility

ID:

Alter:

Geschlecht: weiblich ☐ männlich ☐

Leiden Sie an Krankheiten, die die Leistung des Herzens betreffen: ja ☐ nein ☐

Nutzen Sie regelmäßig eine Smartwatch? ja ☐ nein ☐

Haben Sie psychische Probleme oder Krankheiten? ja ☐ nein ☐

Im Folgenden (basierend auf Computer User Self-Efficacy Score) sind Situationen geschildert, die entsprechend ihrer Häufigkeit im letzten Monat zu bewerten sind.

	Nie	Fast nie	Manchmal	Oft	Immer
1. Wie oft waren Sie auf Grund eines unerwarteten Ereignisses verärgert?	☐	☐	☐	☐	☐
2. Wie oft fühlten Sie, dass Sie die wichtigen Dinge in Ihrem Leben nicht kontrollieren konnten?	☐	☐	☐	☐	☐
3. Wie oft waren Sie nervös oder gestresst?	☐	☐	☐	☐	☐
4. Wie oft haben Sie sich sicher gefühlt, mit Ihren persönlichen Problemen umgehen zu können?	☐	☐	☐	☐	☐
5. Wie oft haben Sie sich gefühlt, dass die Dinge so laufen, wie sie sollen?	☐	☐	☐	☐	☐
6. Wie oft hatten Sie das Gefühl, dass Sie nicht alle Aufgaben erledigen können?	☐	☐	☐	☐	☐
7. Wie oft waren Sie in der Lage, aus dem Ruder gelaufene Dinge unter Kontrolle zu bekommen?	☐	☐	☐	☐	☐
8. Wie oft hatten Sie das Gefühl	☐	☐	☐	☐	☐

Ihren Aufgaben nachgekommen zu sein?					
9. Wie oft waren Sie auf Grund von Dingen, die außerhalb Ihrer Kontrolle lagen, verunsichert oder wütend?	☐	☐	☐	☐	☐
10. Wie oft hatten Sie das Gefühl, dass sich schwierige Aufgaben angehäuft haben, ohne diese bewältigen zu können?	☐	☐	☐	☐	☐

Vielen Dank für die Teilnahme!

Fragebogen 2 – Studie Phobility

Im Folgenden finden Sie 30 Aussagen (basierend auf Perceived Stress Scale) zu Gefühlen im Umgang mit Computern. Bitte bewerten Sie inwiefern die Aussage auf Sie zutrifft – wobei 1 bedeutet: ich stimme überhaupt nicht und 6: ich stimme voll überein.

ID:

	1	2	3	4	5	6
1. Mit den Schwierigkeiten, die beim Benutzen eines Computers auftreten, komme ich meistens klar.	☐	☐	☐	☐	☐	☐
2. Mir fällt das Arbeiten mit Computern sehr leicht.	☐	☐	☐	☐	☐	☐
3. Ich bin sehr unsicher hinsichtlich meiner Fähigkeit mit Computern umgehen zu können.	☐	☐	☐	☐	☐	☐
4. Ich habe Schwierigkeiten mit der meisten Software, die ich benutze.	☐	☐	☐	☐	☐	☐
5. Computer machen mir Angst.	☐	☐	☐	☐	☐	☐
6. Ich arbeite gerne mit Computern.	☐	☐	☐	☐	☐	☐
7. Computer machen mich produktiver.	☐	☐	☐	☐	☐	☐

10. Ich habe oft Schwierigkeiten, wenn ich ein neues Computer Programm nutze.	☐	☐	☐	☐	☐	☐
12. Ich fühle mich im Umgang mit Computern sicher.	☐	☐	☐	☐	☐	☐
13. Der Computer macht oft nicht das, was ich möchte.	☐	☐	☐	☐	☐	☐
14. Manchmal finde ich das Arbeiten mit Computern verwirrend.	☐	☐	☐	☐	☐	☐
15. Ich würde bevorzugen, dass wir den Umgang mit Computern nicht lernen müssten.	☐	☐	☐	☐	☐	☐
16. Es ist leicht, ein neues Computer Programm zu lernen.	☐	☐	☐	☐	☐	☐
17. Ich verschwende viel Zeit mit Computerproblemen.	☐	☐	☐	☐	☐	☐
19. Ich habe immer Probleme, wenn ich einen Computer benutze.	☐	☐	☐	☐	☐	☐
21. Computer Fachsprache verwirrt mich.	☐	☐	☐	☐	☐	☐
22. Computer sind zu kompliziert für mich.	☐	☐	☐	☐	☐	☐
23. Das Benutzen von Computern macht mir selten Spaß.	☐	☐	☐	☐	☐	☐
24.Computer sind eine gute Unterstützung.	☐	☐	☐	☐	☐	☐

25. Manchmal passieren Dinge bei der Benutzung des Computers und ich weiß nicht warum.	☐	☐	☐	☐	☐	☐
26. Im Bezug auf Computer würde ich mich nicht als kompetent bezeichnen.	☐	☐	☐	☐	☐	☐
27. Durch Computer spare ich Zeit.	☐	☐	☐	☐	☐	☐
28. Die Arbeit mit Computern frustriert mich.	☐	☐	☐	☐	☐	☐
29 Ich bin ein begabter Computernutzer.	☐	☐	☐	☐	☐	☐
30. Bei der Computernutzung habe ich Angst, den falschen Knopf zu drücken und den Computer zu beschädigen.	☐	☐	☐	☐	☐	☐

Vielen Dank für die Teilnahme!

Fragebogen 3 – Studie Phobility

Im Folgenden (basierend auf System Usability Scale) finden Sie 10 Aussagen. Bitte bewerten Sie inwiefern die Aussage nach der Nutzung der Anwendungen „Flying Boxes“ / „Seasons“ auf Sie zutrifft. 0 bedeutet: trifft gar nicht zu und 4 bedeutet: ich stimme stark mit der Aussage überein.

ID:

Name der Anwendung:

	0	1	2	3	4
1. Ich kann mir sehr gut vorstellen, die Anwendung regelmäßig zu nutzen.	☐	☐	☐	☐	☐
2. Ich empfinde die Anwendung als zu komplex.	☐	☐	☐	☐	☐
3. Ich empfinde die Anwendung als einfach zu nutzen.	☐	☐	☐	☐	☐
4. Ich denke, dass ich technische Unterstützung brauchen würde, um die Anwendung zu nutzen.	☐	☐	☐	☐	☐
5. Ich finde, dass die verschiedenen Funktionen der Anwendung gut integriert sind.	☐	☐	☐	☐	☐
6. Ich finde, dass es in der Anwendung zu viele Inkonsistenzen gibt.	☐	☐	☐	☐	☐
7. Ich kann mir vorstellen, dass die meisten Leute schnell lernen die Anwendung zu nutzen.	☐	☐	☐	☐	☐
8. Ich empfinde die Bedienung als sehr umständlich.	☐	☐	☐	☐	☐
9. Ich habe mich bei der Nutzung der Anwendung sehr sicher gefühlt.	☐	☐	☐	☐	☐
10. Ich musste eine Menge Dinge lernen, bevor ich mit der Anwendung arbeiten konnte.	☐	☐	☐	☐	☐

Vielen Dank für die Teilnahme!

6.2 Question to answer each time the application was used

- Datum und Zeit
- Welche Anwendung haben Sie genutzt?
- Welche Situation hat ausgelöst, dass Sie die Anwendung verwendet haben?
- Wie haben Sie sich gefühlt als Sie die Anwendung gestartet haben?

6.3 Interview questions to answer after the test phase is finished

Following one can see the interview questions asked at post-test.

- Datum
- Wie hoch war Ihr Stresslevel auf einer Skala von 1-10 vor der Woche? Wie hoch ist es jetzt?
- Wie haben Sie das Design von „Flying Boxes“ empfunden? Wie das von „Seasons“? Wie war für Sie die Darstellung der Farben und Bilder?
- Wie war die Bedienbarkeit von „Flying Boxes“? Wie von „Seasons“?
- Was machen Sie normalerweise unter Stress? Vergleichen Sie ihre standard Methode mit den Anwendungen aus der Studie!
- Was war an „Flying Boxes“ positiv? Was an „Seasons“?
- Was war an „Flying Boxes“ negativ? Was an „Seasons“?
- Haben Sie ”Flying Boxes” mit den Kreisen gespielt? Wie war das für Sie?
- Hatte „Flying Boxes“ eine Wirkung auf Sie? Wenn ja, welche? Hatte „Seasons“ eine Wirkung auf Sie? Wenn ja, welche?
- Haben Sie einen Unterschied in der Wirkung zwischen den Anwendungen gemerkt? Wenn ja, beschreiben Sie! Gab es weitere Unterschiede in den Apps?
- Welche Gefühle und Emotionen hatten Sie bei der Nutzung von „Flying Boxes“? Welche bei „Seasons“?
- In welchen Situationen haben Sie „Flying Boxes“ genutzt? In welchen Situationen „Seasons“ ?
- Wie waren Ihre Gefühle und Emotionen die Herzrate in ”Flying Boxes” zu sehen? Hätten Sie gerne ein anderes Symbol gesehen? Hätten Sie gerne ein Symbol in ”Seasons” gehabt?

- Haben Sie in bestimmten Situationen eine der beiden Anwendungen bevorzugt? Wenn ja, in welchen Situationen und welche Anwendung? Was war der Grund dafür, dass Sie die Anwendung in diesen Situationen bevorzugt haben?
- Stellen Sie sich vor, Sie stehst kurz vor einer Prüfung, die Sie sehr stresst. Sie haben weiterhin die Smartwatch mit den Applikationen „Flying Boxes“ und „Seasons“ zu Verfügung. Würden Sie eine dieser Applikationen verwenden oder Ihre bewährte Technik zur Stressreduktion? Wenn eine der Applikationen, welche und warum? Wenn Ihre gewohnte Stressreduktionstechnik, warum ziehen Sie diese den Applikationen vor?

6.4 Leaflet for participants, leaflet for explanation, consent form

First, one can see the leaflet handed out the the participants as a reminder how to use the applications. Second, a leaflet for the explanation of the study can be seen. Third, the content form which needs to be signed for participation is shown.

MERKBLATT

- Bitte in stressigen Situationen eine Interaktion mit der Anwendung auf der Smartwatch durchführen und den Anweisungen folgen.
- Beim Nutzen der Anwendung bitte darauf achten, dass eine Verbindung zum Smartphone aufgebaut ist.
- Bitte nicht vergessen die Fragen zur Situationsbeschreibung auszufüllen, unter der die Anwendung durchgeführt wurde. Eine Korrekte Interaktion liegt vor, wenn die Smartwatch mit dem Smartphone über Bluetooth verbunden ist, wenn die Anwendung genutzt wird.
- Der Verbindungsaufbau kann einige Sekunden in Anspruch nehmen.
- Während der Anwendung kann der Versuch eines erneuten Verbindungsaufbau einige Sekunden in Anspruch nehmen

1

ABLAUF PHOBILITY - PROBANDENAUFKLÄRUNG

1) Datenschutzvereinbarung und Merkblatt den Teilnehmern geben.
2) Einverständniserklärung vorlegen – vor allem Punkt (14) – (16) erklären.
3) Projektidee von Phobility erkläre.
4) Ablauf erklären: 1 Woche, in stressigen Situationen Anwendungen nutzen und Situation beschreiben, danach einen Abschlussfragebogen ausfüllen und ein Interview:
   Teil 1 (Usability): basierend auf SUS
   Teil 2 (Usability/Verwendung/Stress): Interview
5) Datenschutzerklärung unterschreiben lassen. Proband bekommt eine Kopie (Scan, via E-Mail).
6) Installation und Einrichten der Anwendung auf dem privaten Smartphone und Smart Watch.
7) Einloggen in „Redbox“.
8) Uhr und Verbindungsaufbau zu Companion App kurz erklären.
9) Anwendungen erklären:
   a) „Flying Boxes“
      - Herunterfallende Boxen und Kreise in blau und rot: mit oberen seitlichen Knopf Farbe des Balkens unten anpassen.
        → Boxen müssen gleiche Farbe, wie Balken haben, wenn sie auf den Balken treffen.
      - Es dürfen nur Boxen auf den Balken treffen: mit unteren, seitlichen Knopf wird Kreis zu Box.
      - Settings in Companion App: Einstellung der Schwierigkeit.
      - Verlassen der Anwendung: linker seitlicher Knopf.
   b) „Seasons“
      - Es gibt verschiedene Bilder, die eingeblendet werden: von Sommer bis Winter. Ziel ist das Sommerbild zu erreichen, in dem man entspannt.
      - Verlassen der Anwendung: linker seitlicher Knopf.
10) Test, ob Daten an „Redbox“ übertragen werden.

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11) Geräte und Ladekabel aushändigen - Uhr kann aber muss nicht ständig getragen werden.
12) Bestätigung über den Erhalt der Uhr und des Ladekabels unterschreiben lassen.
13) Situationsbeschreibung aushändigen.
14) Merkblatt aushändigen.
15) Termin für 7 Tage später ausmachen.

EINVERSTÄNDNISERKLÄRUNG

PHOBILITY

Information für Teilnehmer und Teilnehmerinnen an der Evaluierungsstudie “Flying Boxes“ und „Seasons“

1

„Flying Boxes“ und „Seasons“ Evaluierungsstudie

1 HINTERGRUND

Das Projekt untersucht im Rahmen einer Masterarbeit den Einsatz von Smart Watch Anwendung in stressigen Situationen im Alltag. Im Zeitraum von einer Woche interagieren die Teilnehmer und Teilnehmerinnen der Studie mit der Anwendung und ihre Herz Rate, Anwendungszeiten, Ruhepuls, Fortschritt während einer Anwendung, Schwierigkeit, Name der Anwendung werden erfasst. Ziel der Evaluierung ist die Nutzerfreundlichkeit der Anwendung, wann und unter welchen Umständen die Anwendungen genutzt werden und die Prüfung der Relation von Herzfrequenz und Anwendung.

2 ABLAUF

1. Teilnehmerinformation
2. Ausgabe der Fitbit Versa™ Smart Watch und Erklärung dieser
3. Laufende Erfassung von Daten (Dauer eine Woche, während die Anwendung genutzt wird), regelmäßiges Tragen der Smart Watch im Zeitraum einer Woche, Fragebogen zum Nutzungsgrund
4. Abschlussfragebogen

3 NUTZEN

Die Teilnehmer und Teilnehmerinnen erhalten die Möglichkeit, neue Anwendungen zur Senkung der Herzfrequenz zu testen und selbst an der Gestaltung dieser Anwendung mitzuarbeiten.

4 EINSCHLUSSKRITERIEN

- Teilnehmer oder Teilnehmerin ist älter als 18 Jahre
- Eigentümer eines Smartphones
- Alltagsstress

5 AUSSCHLUSSKRITERIEN

- Psychische Probleme
- Psychische Krankheiten
- Krankheiten, welche die Herzfrequenz beeinflussen
- Keine Vertrautheit mit Computern

6 TEST-SET

Folgende Geräte (als „Test-Set“ bezeichnet) werden an die Teilnehmer und Teilnehmerinnen ausgeliefert:

1. Fitbit Versa™ – Smart Watch
2. Ladekabel für Fitbit Versa™

7 KOSTEN

Die Teilnahme an der Evaluierungsstudie ist kostenlos. Die Geräte werden leihweise gratis zur Verfügung gestellt.

8 RISIKEN

Für die Teilnehmer und Teilnehmerinnen entstehen durch die Teilnahme an der Evaluierungsstudie keine Risiken. Es wird darüber hinaus empfohlen, sich an die 10 Regeln zum Umgang mit Mobiltelefonen der Allgemeinen Unfallversicherung (AUVA)[1] zu halten. Sollte eine Hautunverträglichkeit am Handgelenk auftreten, sind die Studienbetreuer in Kenntnis zu setzen.

9 WEITERGABE

Die Weitergabe der Geräte im Test-Set ist nicht möglich.

10 RECHTE DER TEILNEHMER UND TEILNEHMERINNEN

Teilnehmer und Teilnehmerinnen haben das Recht, Auskunft über die von Ihnen gespeicherten personenbezogenen Daten zu verlangen. Darüber hinaus haben sie das Recht, Daten berichtigen oder löschen zu lassen.

[1] https://www.auva.at/cdscontent/load?contentid=10008.544454&version=1391167497

die Einschränkung der Verarbeitung Ihrer Daten oder deren Übertragung zu verlangen. Darüber hinaus haben sie das Recht, Widerspruch gegen die Verarbeitung Ihrer Daten zu erheben.
Wenn Daten aufgrund der Einwilligung verarbeitet werden, kann diese jederzeit widerrufen werden. Durch den Widerruf wird die Rechtmäßigkeit der Verarbeitung bis zum Widerrufszeitpunkt nicht berührt.
Wenn Teilnehmer oder Teilnehmerinnen der Ansicht sind, die Verarbeitung Ihrer Daten verstößt gegen datenschutzrechtliche Bestimmungen, können sie sich mit einer Beschwerde an die Datenschutzbehörde (www.dsb.gv.at) wenden.

11 PFLICHTEN DER TEILNEHMER UND TEILNEHMERINNEN

Die Teilnehmer und Teilnehmerinnen der Studie verpflichten sich, das Ihnen zur Verfügung gestellten Test-Set am Ende der Evaluierungsstudie zu retournieren. Schäden am Test-Set sind umgehend zu melden. Darüber hinaus entstehen ihnen keine weiteren Pflichten.

12 ENDE DER TEILNAHME

Die Teilnahme an der Evaluierungsstudie ist über einen Zeitraum von einer Woche vorgesehen. Teilnehmer und Teilnehmerinnen können jederzeit ohne Angabe von Gründen die Teilnahme an der Evaluierungsstudie beenden und eine Löschung personenbezogener Daten anfordern.

13 HAFTUNGSAUSSCHLUSS

Das System dient lediglich der Erhebung von Daten im Rahmen der Evaluierungsstudie und **dient nicht der Kontrolle von medizinischen Daten oder als Notfallsystem**. Alle Teilnehmer und Teilnehmerinnen handeln in Eigenverantwortung.

14 VERARBEITETE KATEGORIEN VON DATEN

Im Laufe der Studie werden folgende Daten aufgezeichnet:

1. Herz Rate
2. Anwendungszeiten
3. Ruhepuls

4. Fortschritt während einer Anwendung
5. Eingestellte Schwierigkeit
6. Name der Anwendung

Im Projekt finden ausschließlich anonyme Benutzerkonten Anwendung. Auf den Servern des Fitness-Armband-Herstellers werden keine persönlichen Angaben der Teilnehmer und Teilnehmerinnen gespeichert.

15 ORT DER DATENVERARBEITUNG

Die wissenschaftliche Auswertung der verarbeiteten Kategorien von Daten erfolgt in Österreich durch das AIT.
Bitte beachten Sie, dass es aus technischen Gründen notwendig ist, die unter Punkt 14 aufgelisteten Kategorien von Daten mit Servern des Herstellers der Smart Watch in den vereinigten Staaten von Amerika und anderen Ländern zu synchronisieren. Zur Synchronisation, wird ein nicht personenbezogenes Benutzerkonto verwendet, sodass der Hersteller der Smart Watch die Daten nicht bestimmten Teilnehmern oder Teilnehmerinnen zuordnen kann.

16 SPEICHERDAUER

Personenbezogene Daten werden nach Projektende gelöscht.

17 ANSPRECHPERSON

Anna Lea Kutsch

5

„Flying Boxes“ und „Seasons“ Evaluierungsstudie

EINVERSTÄNDNISERKLÄRUNG ZU TEILNAHME AN DER EVALUIERUNGSSTUDIE PHOBILITY

Ich bestätige, dass ich ausführlich und verständlich über die Bedeutung und die Anforderungen der Evaluierungsstudie „Phobility“ aufgeklärt wurde. Ich habe darüber hinaus den Text der **Information für Teilnehmer und Teilnehmerinnen der Evaluierungsstudie „Phobility“** (6 Seiten) gelesen und verstanden. Aufgetretene Fragen wurden mir vom Evaluierungsstudienleiter verständlich und genügend beantwortet. Ich habe zurzeit keine weiteren Fragen. Ich bin damit einverstanden, dass meine im Rahmen dieser Evaluierungsstudie ermittelten Daten (siehe Punkt 14 der Information) verarbeitet werden. Um die Richtigkeit der Datenaufzeichnung zu überprüfen, darf die Evaluierungsstudienleitung Einblick in meine erhobenen Daten nehmen. Eine Kopie dieser Einverständniserklärung habe ich erhalten. Das Original verbleibt beim Studienmanagement.
Ich weiß, dass ich meine Einwilligung jederzeit – auch während der Durchführung der Studie - ohne Konsequenzen widerrufen kann. Durch den Widerruf wird die Rechtmäßigkeit der Verarbeitung bis zum Widerrufszeitpunkt nicht berührt.

Name der Teilnehmerin / des Teilnehmers: ……..……

Ort und Datum: ……..

Unterschrift Teilnehmer(in): ……..……..

Kontaktdaten Studienmanagement:

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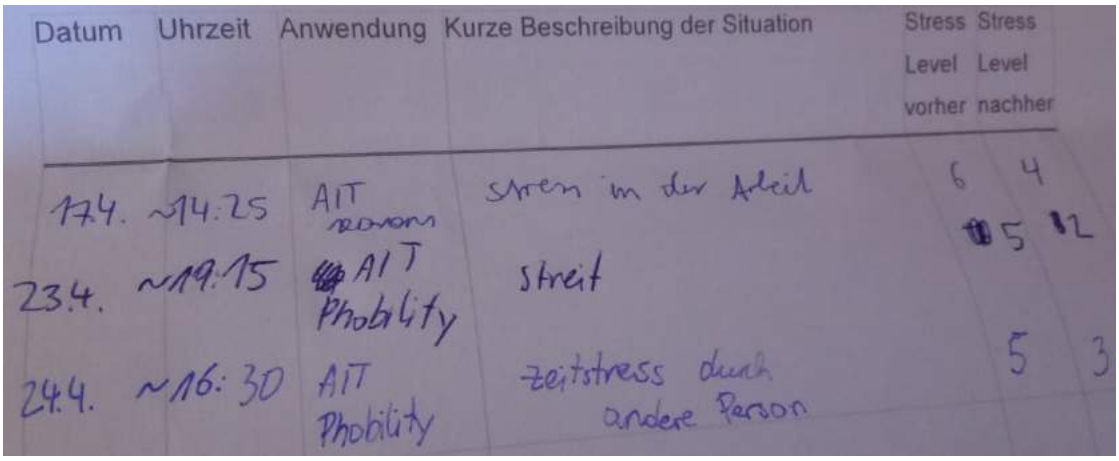
anna-lea.kutsch@ait.ac.at

Further Material of the Result Section

Notes of the Participants made during the Study when Using the Interventions

Notes of the participants (person 1-5) taking every time an intervention was used when facing stress. In grey it was checked if the data was received by "Redbox".

Person 1



Datum	Uhrzeit	Anwendung	Kurze Beschreibung der Situation	Stress Level vorher	Stress Level nachher
17.4.	~14:25	AIT	Stress in der Arbeit	6	4
23.4.	~19:15	AIT Phobility	Streit	5	2
24.4.	~16:30	AIT Phobility	Zeitstress durch andere Person	5	3

Person 2

Datum	Uhrzeit	Anwendung	Kurze Beschreibung der Situation	Stress Level vorher	Stress Level nachher
18.4.19	18:24	phasility	Unordnung in Wohnung → mit dadurch verbundenen Aufgaben, Angst, nicht alle Aufgaben für den Tag erledigt zu bekommen	5	3
20.4.19	20:22	Seasons	Lernstress, Bewusstwerden von Zeitknappheit + Umfang des Stoffes	5	5
		Puls nach beendet phasility	< 30 sek auf Ruhepulsniveau → Spiel automatisch	5	4

Daten vom Anfang vorhanden

alle Daten vollständig

alle Daten von Phasility vorhanden vollständig

22.4	15:53	phobility	kommt bei einer Aufgabe am PC nicht voran Anfangsdaten fehlen	3	3
23.4	14.24	Seasons wieder sehr schnell im Rebenbereich Anfangsdaten vorhanden	zusätzliche Aufgaben → Zeitdruck bzw. nicht wissen, welche Aufgabe zuerst bewältigen soll	5	4
	14.26	phobility	Anfangsdaten vorhanden	4	2
24.4.	17:35	phobility	Lerndruck, Zeitknappheit Daten von Anfang vorhanden	6	6

Person 3

Datum	Uhrzeit	Anwendung	Kurze Beschreibung der Situation	Stress Level vorher	Stress Level nachher
24.04.19 ~00:15 →		Flying Boxes	alle Aufgaben, die für den 23.04 vorgesehen waren konnten in der knappen Zeit nicht erledigt werden Anfangsdaten vorhanden, weitere Daten fehlen	7	5
24.04.19	10:07	Flying Boxes	Erstellung der to-do Liste mit Punkten, die alle heute erledigt werden müssen Anfangsdaten fehlen	~~8~~ 7	~~7~~ 6
24.04.19	22:16	Seasons	Mit der Erledigung der to-do Liste für heute überfordert, sodass es sich womöglich nicht ausgeht keine Anfangswerte vorhanden	8	8

Person 4

Datum	Uhrzeit	Anwendung	Kurze Beschreibung der Situation	Stress Level vorher	Stress Level nachher
17.4	12^{50}	AIT Probability	Vergessen einen Termin auszumachen. Daten vollständig vorhanden	3	2
20.4	15^{05}	AIT Seasons	Alle Arbeiten zusammengefasst die ich in nächsten Wochen zu erledigen habe → Zeit-probleme ; geht sich alles aus ? Daten vollständig	5	3

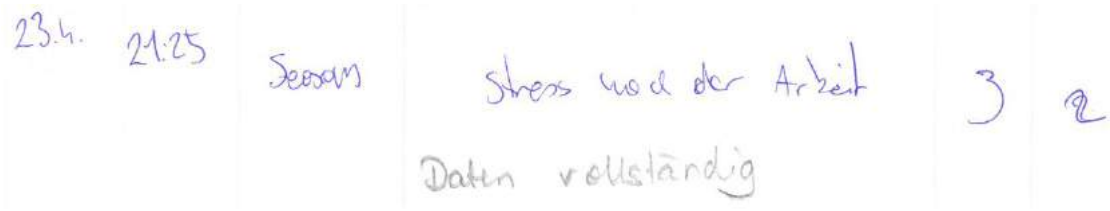
21.4	11^{10}	AIT Phob.	Fehler in der Arbeit entdeckt.	6	4
			Daten vollständig		
24.4	10^{50}	AIT Sensors	Konnte ein Problem nicht lösen, was größere Auswirkung auf Arbeit hat.	6	4
			Daten vollständig		

Person 5

Datum	Uhrzeit	Anwendung	Kurze Beschreibung der Situation	Stress Level vorher	Stress Level nachher
~~17.4.~~	~~10:35~~	~~AIT-Season~~	~~Polizeibesuch i. d. Arbeit~~		
17.4. 19.	10:35	AIT Season	Polizeibesuch i. d. Arbeit Daten vollständig	3	~~4~~ 2
17.4. 19	12:05	ait Mobility	Testfahrt ins Aich ↳ sehr spät dran zu einem Termin Daten als Anhang vorhanden	4	2

Datum	Uhrzeit	Anwendung	kurze Beschreibung d. Situation	Stress vorher	Stress nachher
18.04.19	09:40	Ait Session	Telefonat mit Psychiatrie => wegen einer Klientin. Anfangsdaten vorhanden	~~3~~ 4	~~4~~ 3
18.4.19	Circa 11:40	Ait Session	~~Telefonate~~ Mehrere Telefonate zeitgleich während und mehrere Klient*innen im Büro waren. Anfangsdaten nicht vorhanden	5	3
18.4.19	circa 14:10	Ait Flexibility	Terminkoordination + Verschiebungen von mehreren Klient*innen. Daten von Anfang vorhanden	5	4
~~16:55~~ 18.4.19	16:55	ait Session	Klient schreit mich an + beschimpft mich. Daten vollständig	3	2
19.4.19	ca. 13:45	ait Session	Innerliche Anspannung rechtzeitig mit allem fertig zu werden. Daten voll vorhanden	4	2

20.4. 14	10:30	Phopility	Stress alle Erledigungen Lerig zu bekommen bevor ich in die Arbeit muss Daten von Anfang vorhanden	3	2
20.4.	11:24	Phobility	Im copy Shop - 5 Stress dass es lange dauert und ich zu spät zur Arbeit komme Daten von Anfang vorh	4	3
20.4.	11:57	phobility	In d. Ubahn auf dem Weg zur Arbeit Daten vollständig vorhanden	3	2
21.4. 14	14:57	Seasons	Gespräch mit Klienten Anfangsdaten nicht vorhanden	3	2
22.4.14	vor 8:00 Uhr	Phobility	~~Ener~~ Anspannung vor dem Termin Daten von Anfang vorhanden	2	1



Transcription of the Interviews of the User Study

Person 1

I: Wie hoch war dein Stresslevel auf einer Skala von 1-10 vor der Woche?
A: Naja, nicht so hoch, mh. Sagen wir mal: 3.
I: Und wie hoch ist es jetzt?
A: Mh, 2.

I: Wie hast du das Design von „Flying Boxes“ empfunden?
A: Das Design? Also so wie das Spiel aussieht?
I: Ja, genau.
A: Ok, ja, eh gut, zufrieden!

I: Und wie war das Design von „Seasons“?
A: Das Design war auch gut. Also das Design find ich von beiden gut.

I: Wie war für dich die Darstellung der Farben und Bilder?
A: Vielleicht könnte man bei den „Boxes“ verschiedene Farben - also andere Farben, vielleicht auch noch zum Einstellen machen. Grün oder so - vielleicht - oder, dass es sich immer ändert. Sonst waren die Farben gut.

I: Wie waren die Farben und Bilder bei „Seasons“?
A: Bei „Seasons“ waren sie auch gut.

I: Wie war die Bedienbarkeit von „Flying Boxes“?
A: Sehr leicht verständlich und einfach.

I: Wie war die Bedienbarkeit von „Seasons“?
A: Ja, genauso.

I: Was machst du normalerweise unter Stress?
A: Mh, puh, naja, ich versuche durchzuatmen und mich zu beruhigen. Ähm, vielleicht auch andere Sachen. Es kommt immer drauf an. Wenn es jetzt Zeitstress ist, dann kann man das ja nicht so machen, wenn‘s anderer Stress ist, dann vielleicht mal was

anderes machen. Oder wenn es jetzt Stress ist mit, ähm, irgendwelchen Abgaben auf der Uni, dann kurz Pause machen – was anderes machen. Ja.
I: Vergleiche deine Standardmethode mit den Anwendungen aus der Studie!
A: Ähm, naja ich find‘s, diese Spiele waren vielleicht, die kann man halt dazu verwenden. Ich bezweifele, dass alleine die Spiele da helfen. Aber sie sind so, wenn man im Prozess des Beruhigens ist, vielleicht ein Teil eben.

I: Was war an „Flying Boxes“ positiv?
A: Ähm, positiv war an “Flying Boxes”, dass man eben was machen muss, also, dass man eben etwas drücken muss und sich eben auf das Ganze konzentrieren muss. Dass man dadurch auch abgelenkt wird von seinem Stress. Und dadurch, dass man aber nicht so viel tun muss, beruhigt man sich und das - es erzeugt weniger Stress. Man kann halt was tun, das ist gut, dass man ein wenig aktiv ist. Aber es ist nicht zu viel, was man tun muss, dass man wieder von dem gestresst ist.

I: Was war an „Seasons“ positiv?
A: Positiv war, dass es einen eben beruhigt.

I: Was war negativ an „Flying Boxes“?
A: Eigentlich nichts. Ich finde das Spiel war cool.

I: Und was war negativ an „Seasons“?
A: Naja, da finde ich, dass einfach zu wenig zu tun war. Also nur hinschauen ist irgendwie so – kommt immer drauf an, vielleicht wenn Leute, die sich wenig mit Computer auskennen überfordert sind von diesem einfachen Drücken, dann ist vielleicht „Seasons“ besser. Aber sonst find ich‘s besser, wenn man selbst aktiv werden muss.

I: Hast du "Flying Boxes" mit den Kreisen gespielt?
A: Mhmh. Nein, habe ich nicht gemacht.

I: Hatte „Flying Boxes“ eine Wirkung auf dich?
A: Ja, ich also ich find, dass durch das Drücken, das Spiel beruhigend wirkt und, dass es halt Stress reduziert.

I: Hatte „Seasons“ eine Wirkung auf dich?
A: Nicht so wirklich viel. Also, vielleicht auch ein bisschen beruhigend. Aber ich finde es ein bisschen langweilig.

I Hast du einen Unterschied in der Wirkung zwischen den Anwendungen gemerkt?
A: Ähm, naja für mich – bei mir hat das „Flying Boxes“ mehr gewirkt, als das „Seasons“?
I: Inwiefern hat das mehr gewirkt als das „Seasons“?
A: Naja, mh, es war beruhigender. Man konzentriert sich mehr drauf und dann ist es beruhigender.
I: Gab es weitere Unterschiede in den Apps?
A: Wie meinst du das jetzt?
I: Ob dir noch irgendwas aufgefallen ist? Irgendein Unterschied noch?
A: Ähm, nein, weiß ich jetzt nicht –glaub nicht.

I: Welche Gefühle und Emotionen hattest du bei der Nutzung von „Flying Boxes“?
A: Gefühle und Emotionen [Lachen] puh, äh, [Pause], ja, naja Spaß vielleicht ein bisschen und [Pause] ich weiß nicht. Gar keine Emotionen. Es hat mich beruhigt ein bisschen. Na, Spaß.

I: Und welche Gefühle und Emotionen bei „Seasons“?
A: Ja, bei „Seasons“ das war ein bisschen langweilig, also langweilig. Mir war dann nach kurzer Zeit fad.

I: In welchen Situationen hast du „Flying Boxes“ genutzt?
A: Ähm, benutzt, einmal habe ich einen Stress gehabt und einmal habe ich einen Stress gehabt wegen einer anderen Person. Also Zeitstress. Und dann noch zum Spaß

I: In welchen Situationen hast du „Seasons“ benutzt?
A: Da habe ich in der Arbeit einmal Stress gehabt.

I: Waren die Stresssituationen anders?
A: Ja, schon.

I: Inwiefern?
A: Naja, es ist halt ein Unterschied, in der Art von Stress, ob man jetzt in der Arbeit noch schnell noch was machen muss, Arbeitsstress hat oder ob man mit einer Person einen Stress hat. Und dadurch Stress hat. Ja.

I: Wie waren deine Gefühle und Emotionen die Hertzrate in "Flying Boxes" zu sehen?
A: [Lachen] Joa, cool war es. Ich habe es interessant gefunden, dass man es mal so über den Tag sieht.
I: Ich meine im Spiel „Flying Boxes“.
A: Achso, naja, vielleicht ein bisschen Druck, dass der Puls jetzt runter geht. Vielleicht nicht besonders gut. Wenn man dann so das Gefühl hat, jetzt muss mein Puls herunter gehen, wenn ich das spiel.

I: Hättest du gerne ein anderes Symbol gehabt?
A: Joa, schon.
I: Hast du eine Vorstellung was?
A: Ja, vielleicht so mh, einfach nur Farben. So eine Box mit grün und rot. Also wenn der Puls erhöht ist, dann rot und wenn der schon unten ist dann grün.

I: Hättest du gerne ein Symbol in „Seasons“ gehabt?
A: War da die Hertzrate abgebildet?
I: Nein
A: Nein, ich finde es eigentlich sogar besser ohne Hertzrate, weil dann hat man kein Druck oder so.

I: Hast du in bestimmten Situationen eine der beiden Anwendungen bevorzugt?
A: Ja, immer weil ich das – also ich finde das eine Spiel cooler, deswegen habe ich das immer bevorzugt. Aber jetzt nicht auf irgendeine Situation bezogen. Allgemein!

I: Stelle dir vor, du stehst kurz vor einer Prüfung, die dich sehr stresst. Du hast weiterhin die Smartwatch mit den Applikationen "Flying Boxes“ und „Seasons“ zu Verfügung. Würdest du eine dieser Applikationen verwenden oder deine bewährte Technik zur Stressreduktion?

A: Also ich tät meine bewehrte Technik nehmen und ich tät das Spiel „Flying Boxes“ verwenden.
I: Und warum?
A: Naja, weil ich fand, dass eine Kombination aus meiner bewährten Technik und von dem „Flying Boxes“ am besten meinen Stress reduziert und ja, das „Flying Boxes“ finde ich, wirkt bei mir besser als das „Seasons“.

A: Hast du sonst noch irgendwelche Anmerkungen?
I: Ähm, naja, in manchen Stresssituationen kann man das ja nicht so richtig verwenden, weil wenn man jetzt zum Beispiel Zeitstress hat wegen irgendwas, dann ist das halt – dann kann man das ja nicht verwenden. Weil dann muss man ja eigentlich schnell irgendwas machen und dann kann man ja nicht das Spiel spielen, weil man ja Zeitstress hat. Aber ansonsten, wenn man anderen Stress hat, anderen Druck oder so hat und jetzt nicht unmittelbar etwas tun muss und einen anderen Druck hat ohne Zeitstress, dann kann man das – dann ist das Spiel gut.

Person 2

I: Wie hoch war dein Stresslevel auf einer Skala von 1-10 vor der Woche?
A: So generell gesehen?
I: Ja.
A: So um 5 herum.

I: Wie hoch ist es jetzt?
A: Eigentlich recht ähnlich, auch circa wahrscheinlich.

I: Wie hast du das Design von „Flying Boxes“ empfunden?
A: [Pause] Das fand ich eigentlich recht gut, weil es eigentlich recht simple war und es auch mit der Bedienung, ehr weniger nur das Design oder?
I: Ja, gibt es noch weitere Anmerkungen zum Design?
A: Nein.

I: Wie war das Design von „Seasons“?
A: Das war auch recht hübsch gemacht, nur weniger simple und man musste halt genauer schauen, aber es war trotzdem sehr eingängig.
I: Inwiefern musste man genauer schauen?
A: Was sich verändert und das Bild an sich war etwas aufwändiger im Vergleich zu „Flying Boxes“.

I: Wie haben dir die Farben und Bilder in „Flying Boxes“ gefallen?
A: Sehr gut. Es war, ja sehr ansprechend.

I: Und in „Seasons“ die Farben und Bilder?
A: Vielleicht vergleichsweise ein bisschen geringer als in „Flying Boxes“?
I: Warum?
A: [Lachen] ähm, [Pause], kann ich irgendwie schwer begründen, aber vielleicht weil die Bilder sehr abstrakt waren und das gesamt Bild habe ich vielleicht nicht als ganz so harmonisch empfunden.

I: Wie war die Bedienbarkeit von „Flying Boxes“?

A: Das war eigentlich ziemlich einfach, weil man eh nur einen Knopf drücken musste. Je nachdem welche Einstellung man gewählt hat.

I: Welche Einstellung hast du gewählt?
A: eigentlich immer nur mit einem Knopf zum Drücken das gespielt.

I: Und wie war die Bedienbarkeit von „Seasons“?
A: [Lachen] sehr, sehr einfach, weil man da gar nichts machen musste, außer das Spiel zu starten.

I: Was machst du normalerweise unter Stress?
A: Normal versuche ich eigentlich ehr äh, an einen ruhigen Ort zu setzten und bewusster zu atmen und so ein bisschen runter zu kommen.

I: Vergleiche deine Standardmethode mit den Anwendungen aus der Studie!
A: Ähm, also bei „Flying Boxes“ war es für mich eigentlich eher die Ablenkung vom Stress, was für mich kurzfristig gesehen, also es hat finde ich schon immer was gebracht, wenn ich in stressigen Situationen war, dass ich dann immer runter gekommen bin. Aber ich glaube, dass es halt auch damit zu tun hatte, dass ich mich dann halt zu Seite setzte und das Spiel spielte. Und dann war das halt so ähnlich, wie ich das sonst mache, dass ich halt auch ein bisschen zur Ruhe komme. Ich weiß nicht, ich kann zu „Seasons“ nicht unbedingt was sagen, weil ich das Gefühl hatte, dass mein Stresslevel nicht unbedingt etwas mit meinem Puls zusammen hängt und deswegen das Spiel immer sofort beendet war.

I: Was war an „Flying Boxes“ positiv?
A: Ich fands teilweise gar nicht so einfach, weil die Blöcke recht schnell kamen, und deshalb musste ich mich manchmal schon sehr drauf konzentrieren, was mich dann umso mehr ablenkte. Das fand ich recht gut, und das es nicht so arg komplex war.

I: Was fandest du positiv an „Seasons“?
A: Also, wenn das bei mir so gewesen wäre, dass der Puls am Anfang recht hoch war, glaube ich, hätte es halt, so eine Art meditative Wirkung, wenn man einfach nur drauf

schaut. Ich glaube man könnte sich dadurch schon etwas beruhigen. Was bei mir leider nicht so der Fall war.

I: Was war an „Flying Boxes“ negativ?
A: Mh, [Pause] Ähm, ich hatte manchmal das Gefühl, dass wenn ich nach dem Spiel aufgehört habe, dass es während des Spiels zwar kurzfristig besser wurde, aber dass hinterher nach Beendigung, wenn ich quasi wieder in meinem Alltag war, dass dann der Stresslevel wieder ähnlich hoch war, wie zuvor.

I: Was war an „Seasons“ negativ?
A: Naja, meine persönlichen Erfahrungen halt. Dann, das ich das Spiel nicht wirklich spielen konnte durch meinen niedrigen Ausgangspuls.

I: Hast du "Flying Boxes" mit den Kreisen gespielt?
A: Nein, habe ich nicht. Ich fand es so schon komplex, also schwer genug.

I: Hatte „Flying Boxes“ eine Wirkung auf dich?
A: Ja, eine vorübergehende Wirkung.
I: Welche Wirkung?
A: Eine entspannende Wirkung.

I: Hatte „Seasons“ eine Wirkung auf dich?
A: Nein, eigentlich nicht wirklich.

I: Gab es weitere Unterschiede in den Apps?
A: Ja, das „Flying Boxes“ hatte für mich eine größere stressreduzierende Wirkung als „Seasons“.

I: Welche Gefühle und Emotionen hattest du bei der Nutzung von „Flying Boxes“?
A: Äh, ich konnte meinen aktuellen Stress halt hinten anstellen. Mh, welche Gefühle, dass ist schwer zu sagen. Welche Gefühle und Emotionen? Was hattest du nochmal gesagt?
I: Welche Gefühle und Emotionen hattest du bei der Nutzung von „Flying Boxes“?

A: Ich war vielleicht durch das Spiel an sich, ja gestresst könnte ich auch nicht sagen, aber es war eben ein anderer positiver Stress durch die Ablenkung. Aber ein konkretes Gefühl könnte ich jetzt eigentlich nicht beschreiben.
I: Wie waren die Gefühle bevor du die Anwendung genutzt hast?
A: Frustration, vielleicht Traurigkeit oder Angst.
I: Haben sich die Gefühle während der Anwendung verändert?
A: Es hat mich halt dazu gebracht, dass ich [Pause] nochmal darüber reflektiert habe und es mit noch mehr Leichtigkeit genommen habe und gedacht habe, jetzt mache ich halt meine Aufgaben und nochmal so, wie ich es machen muss und mit weniger Stress und ich muss halt trotzdem irgendwie vorankommen.

I: Welche Gefühle und Emotionen hattest du bei der Nutzung von „Seasons“?
A: Vielleicht ein bisschen Langeweile. Ich konnte auch immer nur kurz spielen. Bei mir war es halt leider nie Winter.

I: In welchen Situationen hast du „Flying Boxes“ genutzt?
A: Mh, wenn ich das Gefühl hatte, dass mich irgendwie die Situation im Alltage ein bisschen überwältigt und wenn ich mich gerade auf etwas anderes konzentrieren möchte und den Stress nicht im Kopf haben möchte.

I: In welchen Situationen hast du „Seasons“ genutzt?
A: Eigentlich bei ähnlichen Situationen.
I: Was heißt ähnlich?
A: Genau gleich.

I: Wie waren deine Gefühle und Emotionen die Hertzrate in „Flying Boxes“ zu sehen?
A: [Pause] Ich glaube, wenn ich gesehen hätte, dass sich mein Puls nur verlangsamt, dann hatte das schon nochmal eine beruhigende Wirkung auf mich, weil es mir dann halt bewusst wird und ich glaube es hätte vielleicht auch geholfen eine „fake“ Puls Rate zu nehmen und die Senken zu lassen, dass das eine positive Wirkung hat. Keine Ahnung.

I: Hättest du gerne ein anderes Symbol gesehen?

A: Anstatt meiner Hertzrate?
I: Ja, oder eine andere Darstellung?
A: Fand ich schon ganz gut so, weil als Grafik wär das ja auch schlechter darstellbar gewesen.

I: Hättest du gerne ein Symbol in „Seasons“ gehabt?
A: [Pause] Ist sie da nicht dargestellt?
I: Nein.
A: Durch die Veränderung der Bilder wird einem die Hertzrate ja auch bewusster. Ja, vielleicht wäre es ganz nett.

I: Hast du in bestimmten Situationen eine der beiden Anwendungen bevorzugt?
A: [Pause] Äh, [lange Pause] Ich glaube wenn ich gerade unterwegs war, dann war „Seasons“ das, was ich bevorzugt hab. Aber durch das, was ich eben beschrieben hab, hab ich es dann eigentlich gar nicht mehr genutzt.

I: Was ist der Grund, dass du es in diesen Situationen bevorzugt hättest?
A: [Pause] [Lachen] da muss ich mich nochmal reindenken [Pause] ja, vielleicht war es auch gar nicht so. So viel Unterschied hat es auch gar nicht gemacht. Eigentlich war es recht gleichwertig für mich.
I: Also gab es keinen Unterschied für dich?
A: Doch vielleicht schon. Ich glaub „Seasons“ habe ich eher verwendet, wenn ich eigentlich keine Ablenkung wollte und mich schon eher auf das Problem bewusst konzentrieren wollte und halt nochmal versuchen wollte, alles so‘n bisschen nachzudenken und halt dabei ruhiger zu werden.
I: Und in welchen Situationen hast du dann „Flying Boxes“ verwendet?
A: Wenn ich die Ablenkung wollte, bewusst.

I: Stelle dir vor, du stehst kurz vor einer Prüfung, die dich sehr stresst. Du hast weiterhin die Smartwatch mit den Applikationen „Flying Boxes“ und "Seasons“ zur Verfügung. Würdest du eine dieser Applikationen verwenden oder deine bewährte Technik zur Stressreduktion?

A: Ich könnte mir schon vorstellen, irgendwie „Flying Boxes“ zu verwenden, weil ich tendiere vor ‘ner Prüfung eher dazu mich irgendwie einzusteigen und mir irgendwelche Horrorszenarien auszumalen, dann würde mich das vielleicht etwas ablenken.

I: Hast du sonst noch Anmerkungen?
A: Das einzige was mir aufgefallen ist, ist, dass bei „Flying Boxes“ hin und wieder mal ein kurzes Stocken, oder sowas war. Aber das hat nichts am Spiel geändert. Und was mir gestern aufgefallen ist, da habe ich gestern stehend in der U-Bahn „Flying Boxes“ genutzt. Da habe ich irgendwie den Puls auch nicht senken können und bin dann auch trotzdem nicht ruhiger geworden. Ich glaube, dass das dann trotzdem daran liegt, dass das dann in Kombination besser funktioniert, wenn ich mich irgendwo in Ruhe hinsetzte und dann runter komme.
I: Meinst du es hätte geholfen, wenn du in der U-Bahn gesessen hättest?
A: Dann vielleicht eher. Es kann sein, dass ich vielleicht die Kombination brauche oder hauptsächlich das zur Ruhe kommen für mich entscheidender ist für die Stressreduktion und nicht unbedingt alleine das Spiel.

Person 3

I: Wie hoch war dein Stresslevel auf einer Skala von 1-10 vor der Woche?
A: 10 ist stark?
I: Ja
A: 10.
I: Und jetzt, nach der Woche?
A: 6.

I: Wie hast du das Design von „Flying Boxes“ empfunden?
A: Gut, aber ich fand‘s mit den Circles zu schwierig, weil die Circles und die Boxen in der ersten Sekunde exakt gleich ausschauen – und ich brauch eine gewisse Zeit, bis ich reagieren kann und das war ein bisschen zu schnell. Also, wenn die Kreise nicht ausgefüllt wären, würde ich gleich erkennen, dass es keine Box mehr war. Dann hätte ich es leichter gefunden.

I: Wie hast du das Design von „Seasons“ empfunden?
A: Das war ehr gut.

I: Wie waren die Farben und die Bilder?
A: Die waren besser als erwartet für eine Smartwatch.
I: Bei beiden Spiele?
A: Ja, ich fand‘s eigentlich gut, das Design.

I: Wie war die Bedienbarkeit von „Flying Boxes“?
A: An und für sich war die Bedienbarkeit schon ganz gut, ich fand‘s nur mühsam dann immer da drauf zu drücken, weil dann musste ich mit dem anderen Finger immer ein Gegengewicht halten und wenn, man dann mit zwei spielen wollte, war es noch ein bisschen mühsamer.
I: Was meinst du mit zwei?
A: Weil der untere mit den Circles. Du musstest halt immer dagegen und dann war die Uhr schon so schief, weil man mit Kraft da drauf drücken musste. Das fand ich ein bisschen, also wenn es mit Touch gewesen wäre, hätte ich es besser gefunden.

I: Wie war die Bedienbarkeit von „Seasons“?
A: Die war einwandfrei, die war gut

I: Was machst du normalerweise unter Stress?
A: Weinen [Lachen], duschen gehen und versuchen, dass ich irgendwie runter komme, oder spazieren gehen, oder dass ich mal von der Situation wegkomme und dann ruhig wieder starten kann.

I: Vergleiche deine Standardmethode mit den Anwendungen aus der Studie!
A: Es war eigentlich genauso wie das „Seasons“. Das einzige was mich ein bisschen, wenn ich Stress habe, versuche ich halt einen Plan zu machen, wie sich das ausgeht, dass ich das Ganze berechnen kann. Und ich hatte halt oft den Eindruck, dass wenn ich jetzt das Spiel spiele, dann komme ich nicht dazu meinen Plan zu machen, dann komme ich nicht dazu meine Sachen zu machen, und dann war ich irgendwie ähhh, dann war ich auch irgendwie etwas gestresst. Oft war ich auch etwas gestresst, weil ich spät dran war und dann hatte ich nicht die Zeit, dieses Spiel zu spielen. Ich finde das „Seasons“ Spiel an und für sich besser. Ich mein ich habe das „Flying Boxes“ gespielt, weil ja mein Puls für das „Seasons“ zu niedrig war. Aber bei „Flying Boxes“ geht mein Puls runter und dann geht er wieder rauf, weil ich mich kurz konzentrieren musste und ur angespannt war: Oh mein Gott, die nächste Box kommt, ich muss wieder drücken. Deswegen mag ich auch Computerspiele und sowas gar nicht gerne, weil ich da ur angespannt bin und für ur viele Leute ist das halt ein Ausgleich, aber für mich ist das eher –da kann ich nicht runter kommen.

I: Was war an „Flying Boxes“ positiv?
A: Das lenkt schon ab. Wie ich schon gesagt habe, es bringt einen schon von der Situation weg und es lenkt einen – also, wenn ich in einer Situation bin, wo ich mich nicht wohl fühle, dann kann ich mir schon vorstellen, dass es beruhigender ist, weil das „Seasons” Spiel – man kann nicht das oder das nehmen: es ist situationsabhängig. Im Restaurant gab es eine Situation da habe ich mich unwohl gefühlt. Da hätte mir das „Seasons“ Spiel überhaupt nichts gebracht, weil ich dann immer noch mit den ganzen Einflüssen von außen konfrontiert gewesen wäre, die mich unruhig fühlen lassen, diese ganzen Geräusche und so. Und durch das „Flying Boxes“ war ich dann so abgelenkt, dass ich die Geräusche, also das du die einfach nicht mehr wahrnimmst.

I: Was war an „Seasons“ positiv?
A: Ich find die Idee gut sich mal zu beruhigen, aber ich kann mir vorstellen, dass viele das nicht können, dass sie versuchen, sich aktiv zu beruhigen. Dass sie etwas zur Ablenkung brauchen.

I: Was war an „Flying Boxes“ negativ?
A: Das mit den Circles, dass man das nicht so schnell erkannt hat. Und das die Uhr nach einer Zeit schon etwas schief war. Ich meine durch das Silikon Band tut das eh nicht weh. Aber ist mir nur so aufgefallen, dass wenn man da so drauf drückt, dass man mit dem anderen Finger dann dagegen gleicht. Also wie gesagt, Touch hätte ich irgendwie cooler gefunden.

I: Was war an „Seasons“ negativ?
A: Das ich‘s nicht spielen konnte, weil meine Herzrate zu niedrig war. Und das es nach fünf Sekunden war so herzlichen Glückwunsch, du hast deinen Puls gesenkt – mein Stress hat sich gar nicht reduziert dadurch. Dann dachte ich, jetzt kann ich es ja nicht nochmal spielen und wechseln wollte ich dann auch nicht. [Pause] Man sollte vielleicht unterstützen, dass man selber entscheiden kann, also nicht nur die Hertzrate, sondern, dass die Smartwatch mich fragt, ob ich mich jetzt weniger gestresst fühle und dass man dann sagt: ja oder nein, und wenn nein das Spiel ohne die Hertzrate.

I: Hast du "Flying Boxes" mit den Kreisen gespielt?
A: Ja, anfangs schon.
I: Und wie war das für dich?
A Scheiße, das war wirklich scheiße!

I Hatte „Flying Boxes“ eine Wirkung auf dich?
A: ja, schon.
I: Welche?
A: Das ich angespannt war.
I: Durch das Spiel?
A: Ja, weil immer, wenn ich mich dann so konzentrieren musste, dass ich das Gefühl hatte ich verkack. Deswegen spiele ich nicht gerne Computerspiele.

I: Hatte „Seasons“ eine Wirkung auf dich?
A: 10 Sekunden vielleicht schon.

I: Hast du einen Unterschied in der Wirkung zwischen den Anwendungen gemerkt?
A: Mh, ja, ich finde das von „Seasons“ ein bisschen besser. Von der Grundidee schon mal. Das man aktiv versucht, sich zu beruhigen. Weil du musst ja eine Taktik finden, wie du dich beruhigst, dass du kurz hingehst. Dass du spazieren gehst, Tief ein- und ausatmest, an was anderes denkst. Und ich finde es in dem Hintergrund gut, dass ich in Zukunft weiß, was für mich am beruhigendsten ist, weil das kann ich ja mit der Uhr verfolgen, ob ich jetzt ruhiger bin oder nicht. Und bei „Flying Boxes“ ist es halt so, wie wenn ich ein Handyspiel oder sowas spielen würd.

I: Gab es noch weitere Untschiede?
A: Äh, [Pause]. Fällt mir jetzt auf die Schnelle nicht ein. Weiß nicht.

I: Welche Gefühle und Emotionen hattest du bei der Nutzung von „Flying Boxes“?
A: Angespannt und konzentriert.

I: Und welche bei „Seasons“?
A: Da war ich ruhiger als bei „Flying Boxes“?
I: Schon vor dem Spiel?
A: Nein, durch das Spiel, also während des Spiels, weil ich halt versucht habe, tief ein und auszuatmen, weil es war ja mein Ziel, dass dieses Ding sich ändert.

I: In welchen Situationen hast du „Flying Boxes“ genutzt?
A: Ich wollte es in der Restaurant Situation nutzen, dann habe ich es genutzt gestern, als ich meine TO DO Liste zusammengestellt habe und irgendwann anders habe ich es auch noch genutzt.
I: Kannst du das verallgemeinern?
A: Als ich das Gefühl hatte, dass mir alles zu viel wird.

I: In welchen Situationen hast du „Seasosn“ genutzt?
A: Als ich wusste, dass es sich nicht ausgehen wird.

I: Das sich was nicht ausgehen wird?
A: Meine ganzen Sachen. Ich wusste das muss ich alles heute noch machen und ich war müde und wollte nur schlafen gehen. Und ich wollte nicht hektisch die Dinge erledigen. Weil ich den Eindruck hatte, wenn ich es in Ruhe mache, dann ist es besser, als wenn ich jetzt komplett panisch alles mach. Und ich wollte mich beruhigen und kontrolliert das Ganze angehen.

I: Wie waren deine Gefühle und Emotionen die Hertzrate in "Flying Boxes" zu sehen?
A: Beunruhigend, weil es wirklich tief runter gegangen ist beim einen Mal. Ich glaube ich war bei 46 beim einen Mal. Da war ich so mh, Ich habe bei 55 aber angefangen oder sowas. Da war ich so ok ich bin bald tot. [Lachen]
I: Hat es dich gestresst die Rate zu sehen?
A: Nein, ich fand‘s gut. Also ich finde das hilft. Wenn ich sehe, ich habe mich schon etwas beruhigt, dann finde ich es besser, als wenn ich nicht wüsste wie schauts jetzt aus. Ich glaube das würd mich unruhig machen.

I: Hättest du gerne ein anderes Symbol oder ein anderes Zeichen?
A: Für die Circles schon
I Und für die Hertzrate?
A: Achso, mh, mich hat nichts gestört.

I: Hättest du gerne ein Symbol in „Seasons“ gehabt für die Hertzrate?
A: Ja, ich denke schon.
I: Was für eine Art von Symbol?
A: Ich schätze auch ein Hertz und dann die Zahl oder sowas.

I: Hast du in bestimmten Situationen eine der beiden Anwendungen bevorzugt?
A: Ja, also in der mit der Geräuschkulisse, wo ich mich in der Situation unwohl gefühlt hab, fand ich die Boxes besser, weil ich so quasi der Situation entkommen konnte. Und als ich mich aktiv beruhigen wollte, fand ich das „Seasons“ besser.

I: Stelle dir vor, du stehst kurz vor einer Prüfung, die dich sehr stresst. Du hast weiterhin die Smartwatch mit den Applikationen „Flying Boxes“ und „Seasons“ zur Verfügung.

A: „Seasons“
I: Warum? du hast auch noch deine Standard Taktik zu Stressreduktion zur Verfügung.
A: Ähm, ich würde trotzdem „Seasons“ verwenden, weil mich das „Flying Boxes“ eher angespannt gemacht hat. Weil ich mich dann ja eher beruhigen möchte, dann.

I: Hast du noch weitere Anmerkungen?
A: Ja, eben, dass es nicht nur mit der Hertzrate getrackt werden sollte, weil Hertzrate zumindest in meinem Fall nicht unbedingt ein Indikator für Stress war. Ähm, ich es schon öfter gespielt hätte, wenn es gegangen wäre, und das wars. Sonst habe ich eh schon alles im Laufe des Interviews gesagt. Und es war auch voll schade, weil ich diese Woche durch die Feiertage recht wenig Stress hatte. Wenn es in der Woche davor gewesen wäre, hätte ich halt den ultimativen super Stress gehabt. Und es wäre vielleicht besser und aussagekräftiger gewesen, wenn ich die Uhr in diesem Zeitraum gehabt hätte. Dann hätte ich auch viel öfter spielen können und es viel öfter nutzen können. Da war meine Hertzrate vielleicht das ein oder andere Mal schon höher, aber in dieser Woche war es eigentlich sehr viel weniger stressig.

Person 4

I: Wie hoch war dein Stresslevel auf einer Skala von 1-10 vor der Woche?
A: Durchschnittlich jetzt meinst du?
I: Ja
A: Durchschnittlich 3, nein 2, zwischen 2 und 3
I: Wie hoch ist es jetzt?
A: 2, im Wesentlichen gleich

I: Wie hast du das Design von „Flying Boxes“ empfunden?
A: Mit dem Design meinst du die Grafik vom Spiel?
I: Ja
A: Sehr ansprechend. Wie habe ich das Design empfunden? Naja, übersichtlich, kompakt und klar dargestellt.

I: Und wie das von Seasons?
A: Das war schon fast künstlerisch.

I: Wie war für dich die Darstellung der Farben und Bilder?
A: Ganz angenehm, weil ich mit den Bildern dann irgendwie den Puls assoziiert habe. Wenn es Frühling ist, dass es runter geht, das hat irgendwie gepasst. Also dahingehend war es, glaube ich, gut gewählt.

I: Und wie waren die Farben bei „Flying Boxes“?
A: Wie gesagt, die haben auch gepasst. Da geht es halt nur darum, dass man zwei unterschiedliche Farben nimmt, damit man es sieht

I: Man konnte die Farben gut auseinander halten?
A: Ja, sicher.

I: Hast du auch mal mit den Kreisen gespielt?
A: Nein, das habe ich nicht gemacht, weil das war mir tatsächlich auch ein bisschen zu aufregend, dann. Wie ich es vorher einmal probiert habe, da habe ich schon gemerkt, dass das zu sehr Kapazitäten einnimmt, als dass ich das Gefühl habe mein

Puls geht runter. Ablenkung hätte es mehr gebracht, aber ich glaube nicht, dass es meinen Puls – oder ich habe nicht das Gefühl gehabt, dass ich mich dadurch entspanne. Ablenkung ja, Entspannung ehr nein.

I: Wie war die Bedienbarkeit von „Flying Boxes“?
A: Sehr einfach, einfach gehalten. Ja, ich meine einen Klick, damit ist es getan.

I: Wie von „Seasons“?
A: Kein Klick und damit ist es getan.

I: Was machst du normalerweise unter Stress?
A: Das ist natürlich situationsbedingt. Die meisten Stresssituationen kommen dann zustande, wenn ich auf irgendeinen Fehler drauf komme, in irgendeiner Art, wenn ich vergessen habe etwas zu Planen oder auf einen Fehler in meiner Arbeit drauf komme. Normalerweise versuche ich, den Fehler zu finden. Und erst dann ist der Stress Level bei mir ganz weg. Normalerweise habe ich da nicht versucht erstmal das Problem wegzuschieben und mich abzulenken.

I: Vergleiche deine Standard Methode mit den Anwendungen aus der Studie!
A: Ein ganz anderer Umgang mit Stresssituationen. Die App zielt drauf ab, in meinem Fall, dass ich mich ehr ablenke von dem Problem, sozusagen kurz irgendwas anderes mache, um das Stresslevel zu reduzieren. Mein Umgang wäre gewesen, dass ich mich in das Problem hineinstürze, um es dann endgültig zu lösen, quasi.

I: Was war an „Flying Boxes“ positiv?
A: Die Bedienbarkeit, dass das alles sehr einfach dargestellt ist und die Handhabung sehr gut war. Und, dass es eine echte Ablenkung von der Stresssituation war.

I: Was war bei Seasons positiv?
A: Bei „Seasons“ habe ich es gut gefunden, dass das quasi eine Ablenkung von der Stresssituation dahingehend war, dass man sich mit sich selbst quasi beschäftigt, weil da habe ich immer drauf geachtet, dass ich eine Atemübung noch dazu mache und schaue, wie sich das Bild verändert. Das heißt, da habe ich mich auf mich konzentriert. So zusagen, oder wie auch immer.

Was ich gut gefunden habe, war, dass es sozusagen zwei unterschiedliche Herangehensweisen waren, einmal tue ich mich mit dem Boxes Spiel ablenken, indem ich etwas anderes mache und bei „Seasons“ ist die Ablenkung durch diese Atemübung für mich gekommen und zu schauen, wie sich das Bild verändert. Das habe ich gut gefunden, dass es zwei unterschiedliche Sachen quasi waren für mich. Ich glaube es ist dann personen- und situationsbezogen, was dann besser und was schlechter ist.

I: Was war an „Flying Boxes“ negativ?
A: Bei „Flying Boxes” negativ war, also für mich war diese Einstellung mit dem Kreis zusätzlich – hat mich dahingehend ein bisschen überfordert, dass ich immer drauf geschaut habe, was macht der Puls gerade – geht der eh runter? Das heißt ich habe immer mit einem Auge auf den Puls geschaut und ich habe schon gemerkt, dass wenn der mal nicht kontinuierlich runter gegangen ist, dann bin ich etwas unrund geworden und diese zusätzliche Anwendung mit Kreis wäre, glaube ich, zu viel gewesen – für mich. Also, deshalb habe ich es auch auf der mittleren Einstellung gelassen. Das hat für mich gut funktioniert.

I: Und was war an „Seasons“ negativ?
A: Ähm, ähm für mich nichts, weil ich glaube für mich haben diese statischen Sachen besser funktioniert, als diese dynamischen Sachen. Für mich hat „Seasons“ besser funktioniert glaube ich.

I: Hatte „Flying Boxes“ eine Wirkung auf dich?
A: Ja, [Pause] ja
I: Welche?
A: Das es eine extrem gute Ablenkung von der Stresssituation gegeben hat.

I: Und bei „Seasons“?
A: Bei „Seasons“ war definitiv die Wirkung, dass ich mich da auf meine Atemübungen konzentriert habe und sozusagen, äh, dadurch bin ich definitiv ruhiger geworden. Es hatte eine beruhigende Wirkung.

I: Hast du einen Unterschied in der Wirkung zwischen den Anwendungen gemerkt?
A: Ja, definitiv: Einmal die Ablenkung und einmal die Beruhigung für mich.

I: Gab es weitere Unterschiede in den Apps.
A: In Ihrer Wirkung?
I: Allgemein?
A: Würde mir jetzt nichts einfallen.

I: Welche Gefühle und Emotionen hattest du bei der Nutzung von „Flying Boxes“?
A: Bohr, [Pause] ich glaube dadurch, dass „Flying Boxes“ ein sehr dynamisches, interaktives Spiel ist, war da immer eine gewisse leichte positive Aufregung vorhanden, wenn ich das Spiel gespielt habe. Ich wusste, dass ein kleines Spiel auf mich wartet, wo ich dann irgendetwas mache, wo dann auch irgendwas passiert - hat dann eine gewisse ähm kleine Vorfreude in mir ausgelöst, wie jetzt ein Kind auf ein Computerspiel hätte.

I: Gab es noch weitere Gefühle oder Emotionen?
A: Bis auf Stress dann nicht.

I: Welche Gefühle und Emotionen hattest du bei „Seasons“?
A : Da war es dann wieder so, wo ich dann gemerkt habe, dass es ja ein statisches Spiel ist, wo man ja nicht aktiv irgendwelche Knöpfe drücken muss, ähm, hat das im Gegensatz zu dem Boxen Spiel dann eine automatisch, eine leicht beruhigende Wirkung schon gehabt. Wo ich dann gewusst habe jetzt kann ich mich auf meine Atmung konzentrieren oder jetzt kann ich in mich selbst hineinhören. Und es hat dadurch schon sehr beruhigend gewirkt.

I: In welchen Situationen hast du „Flying Boxes“ genutzt?
A: Ähm, [Pause] Grundsätzlich habe ich das dahingehend entschieden, welche App ich verwende, ähm, nach Bauchgefühl, welche Art von Ablenkung ich jetzt brauche. Brauche ich jetzt etwas, wo ich selber etwas drücken muss. Brauche ich etwas dynamisches oder etwas statisches. Und, wenn ich gerade noch viel Energie verspürt habe, dann habe ich das „Flying Boxes“ genommen, weil das – eine dynamische Ablenkung - dann gut gepasst hat. Wenn ich schon ein bisschen kaputt war oder sowas, dann habe ich ehr die Ablenkung [Pause] durch das „Seasons“ Spiel verwendet. Was sich nicht unbedingt in meinem Stresslevel wiederspiegeln muss.

I: „Seasons“ hast du jetzt auch schon erzählt, in welchen Situationen du das benutzt hast. Wie waren deine Gefühle und Emotionen die Hertzrate in „Flying Boxes“ zu sehen?
A: Ja, das war tatsächlich ähm [Pause] das hat tatsächlich was ausgemacht. Wenn Trend so war, dass es runter ging, dann war es extrem positiv- dann habe ich mich gefreut, weil dann komme ich runter. Wenn ich aber gesehen habe, dass es gleich bleibt, oder sogar etwas steigt, dann hat mich das schon etwas nervös gemacht, weil ich dann dachte ich funktioniere nicht, wie es sein sollte.

I: Hättest du gerne ein anderes Symbol anstatt der Hertzrate gesehen?
A: Nein.

I: Hättest du gerne ein Symbol für die Hertzrate in "Seasons" gehabt?
A: Nein, ich glaube [Pause] mich würde das ehr etwas nervös machen, hätte ich gesagt

I: Hast du in bestimmten Situationen eine der beiden Anwendungen bevorzugt?
A: Nein, achso, nein, was heißt [Pause]. Das war situationsunabhängig, nur was ich sozusagen die, die, die – ausschlaggebend war von mir die Reaktion auf die Situation. Es war zum Beispiel: ich habe bei beiden Fällen einen Fehler in meiner Arbeit entdeckt und einmal war ich aber auch schon so fertig auch, also ausgelaugter und müder, dass ich einfach etwas gebraucht habe, was mich beruhigt und da habe ich „Seasons“ genommen und einmal habe ich einfach viel Energie gehabt und deshalb habe ich mich abgelenkt und das andere Spiel genommen. Das heißt die Situation war dieselbe, aber meine Reaktion auf die Situation war anders.

I: Stelle dir vor, du stehst kurz vor einer Prüfung, die dich sehr stresst. Du hast weiterhin die Smartwatch mit den Applikationen
"Flying Boxes“ und "Seasons“ zur Verfügung. Würdest du eine dieser Applikationen verwenden oder deine bewährte Technik zur Stressreduktion?
A: Wenn ich vor einer Prüfung stehe, würde ich intuitiv die „Seasons“ App nehmen, weil ich glaube, dass das für mich die bessere Ablenkung ist. Ähm, wenn das etwas, ich sage jetzt einmal statisch, obwohl sich das Bild eh verändert, aber wenn das so eine Ablenkung ist wie Seasons.

I: Was genau meinst du mit statisch?

A: Naja, dass ich keine Knöpfe auf der Uhr drücken muss, damit sich da etwas tut, sondern, dass das allein durch die Veränderung vom Puls geht.

Person 5

I: Wie hoch war dein Stresslevel auf einer Skala von 1-10 vor der Woche?
A: Vor der Woche mit der Smartwatch? Mh, teilweise schon 8 in der Arbeit.
I: Und außerhalb der Arbeit?
A: Nicht so hoch. Vielleicht, manchmal 5.
I: Wie hoch ist dein Stresslevel zur Zeit?
A: 3

I: Wie hast du das Design von „Flying Boxes“ empfunden?
A: Mh, gut, also sehr selbsterklärend, hat sich gut ausgekannt. Simple, schlicht, gut in der Anwendung.

I: Wie war das Design von „Seasons“?
A: Voll gut, ja

I: Wie war für dich die Darstellung der Farben und Bilder?
A: Auch gut.

I: In „Seasons“ oder in „Flying Boxes“?
A In beiden. Ich habe beides gut erkennen können. Ja.

I: Wie war die Bedienbarkeit von „Flying Boxes“?
A: Generell ganz gut, ich glaube, ich fand‘s, also das einzige was so‘n bisschen im Alltag ähm, schwierig war, dass die zwei Knöpfe, wo du auf der einen Seite die Farbe wechselst und beim anderen die Form, also eine Circle zu einem Cube machst – blöd, weil die halt nebeneinander liegen – an der Uhr. Da musste ich erst reinkommen, wie ich die Uhr am besten halte, um die Uhr gut bedienen zu können.
I: Ist dir sonst noch etwas zur Bedienbarkeit aufgefallen?
A: Nö, das war eigentlich das einzige, was so‘n bisschen. Ja.

I: Wie war die Bedienbarkeit von „Seasons“?

A: Da war ja nicht so viel zu bedienen [Lachen]. Man konnte sich halt ein schönes Bild anschauen und schauen, wie sich‘s halt verändert hat. Da konnte man ja jetzt nicht so aktiv jetzt was machen.

I: Was machst du normalerweise unter Stress?
A: Mal tief durchatmen, irgendwie versuchen mal tief durchzuatmen und so runter zu kommen. Ein Glas Wasser zu trinken oder fünf Kaffee. [Lachen] Aber eher ein Glas Wasser.

I: Vergleiche deine Standardmethode mit den Anwendungen aus der Studie!
A: [Lachen] Ähm, hat alles so seine guten und schlechten Seiten. Ich hab gemerkt, dass manchmal in der Arbeit, wenn grad viel zu tun war, gleichzeitig, mich dann die Anwendung oder dass ich dann halt gespielt hab nochmal ein bisschen mehr gestresst hat, weil ich mich dann darauf konzentrieren musste. Weil, man musste das ja dann noch in die Liste eintragen und irgendwann habe ich das dann einfach ins Handy eingetragen und am Abend auf die Liste, dann war das irgendwie auch weg. Ähm, ja also ich find so meine Standardmethoden, oder wie war die Frage, das schließt sich ja gegenseitig nicht aus.
I: Und wie würdest du es vergleichen?
A: Mh, ja ich fands irgendwie cool bei „Seasons“ sich auf was konzentrieren zu können und da auch irgendwie zu sehen, wie man wieder mehr in die Ruhe kommt und bei „Flying Boxes“ fand ich‘s irgendwie war das mehr Ablenkung.
I: Und wie steht das im Vergleich zu deiner Standardmethode?
A: Naja, Unterschiede ja. Also durchatmen kannst du auch irgendwie aktiver machen. Du kannst es aber auch während dem Spiel. [Lachen] ich weiß nicht. Das beantwortet deine Frage nicht so. Also, ich fand bei „Flying Boxes“ es sehr angenehm, dass man diesen Ablenkungsfaktor hat. Dass man sich jetzt aktiv auf etwas anderes konzentrieren muss. Das habe ich bei meiner normalen Methode nicht so.
I: Sonst ist es dann eher unterschiedlich?
A: Ja.

I: Was war an „Flying Boxes“ positiv?
A: Mh, dass es halt aus Situationen abgelenkt hat und man aktiv ähm was gemacht hat.

I: Und was war an „Seasons“ positiv?
A: Ähm, in manchen Situationen war es recht angenehm, dann nicht aktiv was machen zu müssen. Ähm, und einfach zuschauen zu können, wie du halt wieder ruhiger wirst.

I: Gab es noch weitere positive Dinge zu den beiden Spielen?
A: Ich mochte bei „Flying Boxes“ auch, dass man oben den Puls gesehen hat. Ähm, ja und bei „Seasons“ fand ich halt in gewissen Situationen angenehm, nicht aktiv was tun zu müssen.

I: Was war an „Flying Boxes“ negativ?
A: Manchmal, dass man aktiv was tun musste. Also es kommt halt immer auf die Situation an, aber manchmal fand ich‘s dann halt als eher noch zusätzliche Belastung. Aber ich habe dann auch je nachdem in den Situationen dann so gewählt, also nach dem ersten Tag.

I: Was war an „Seasons“ negativ?
A: [Pause] Ich fand halt irgendwie so, ich fand die Idee voll nett und ich glaube halt irgendwie auch, wenn Personen, weiß ich nicht. Du konntest halt irgendwie keinen Einfluss drauf nehmen. Du hast es halt anschauen können und es war halt irgendwie, wie eine andere Art von Pulsanzeige. Aber du hast es halt nicht irgendwie wirklich beeinflussen können, dass sich das Bild halt irgendwie aktiv verändert. Ja.

I: Hast du "Flying Boxes" mit den Kreisen gespielt?
A: Ja, [Lachen]
I: Wie war das für dich?
A: Ich habe am Anfang nicht gleich gecheckt, dass sich die - quasi die Form des Kreises verändert. Dass ich den Kreis zu einem Viereck mach und nicht den Balken unten verändere, dass der jetzt Kreise aufnimmt. Ich habe ein bisschen gebraucht bis ich das rausgefunden hab und bin zu Anfang oft gestorben. Und dann hat‘s voll Spaß gemacht. Ja.
I: Und nachdem du es rausgefunden hast, hat es gut funktioniert?
A: Ja, dann hat es gut funktioniert.

I: Hatte „Flying Boxes“ eine Wirkung auf dich?
A: Ja.
I: Welche?
A: Es hat Spaß gemacht. Irgendwie aktiv da ein Spiel zu spielen und es hat mich tatsächlich wirklich beruhigt. Oft.

I: Hatte „Seasons“ eine Wirkung auf dich?
A: Ja. Ich habe mich halt einfach gefreut. [Lachen]
I: Inwiefern?
A: Ich habe mich gefreut, wenn die Landschaft sommerlicher wurde und wenn dann die Meldung kam: Herzlichen Glückwunsch! Du bist jetzt relaxter.
I: Hast du einen Unterschied in der Wirkung zwischen den Anwendungen gemerkt?
A: [Lachen] Ja, das eine hat mich eher etwas runter geholt und auch mit meinen Gedanken von der Situation abgelenkt und mich dann auch etwas zur Ruhe gebracht. Das andere hat eher Freude ausgelöst und auch ein bisschen so: Das ist der Stand der Dinge. Und manchmal hat es mich dann gestresst, wenn der Schnee kam oder Schneegestöber.

I: Gab es weitere Unterschiede?
A: Also bis auf, dass das eine passiv zu beobachten ist und bei dem anderen aktiv zu tun, oder?
I: Ob noch irgendwelche anderen Unterschiede aufgefallen sind.
A: Naja, also so eben das man bei dem einen passiv mal zusieht und bei dem anderen aktiv was tut. Ja, das sind halt die großen Unterschiede. Sonst eigentlich nicht.

I: Welche Gefühle und Emotionen hattest du bei der Nutzung von „Flying Boxes“?
A: Mh, am Anfang hat es mich eher etwas gestresst.
I: Am Anfang heißt immer, wenn du das Spiel gestartet hast oder am Anfang der Woche?
A: Nein, am Anfang, also in den ersten Tagen.
I: Was genau hat dich gestresst?
A: Was aktiv tun zu müssen in der Situation, wo ich schon gestresst war. Wie war die Frage nochmal? Achso, Gefühle und Emotionen. Mh, [Pause] Ja, und dann habe ich

auch so‘n bisschen, also ich will jetzt nicht übertreiben, aber fast so ein bisschen ein Ehrgeiz entwickelt. [Lachen]
I: Dass du es länger schaffst zu spielen?
A: Ja, und auch, dass ich den Puls schneller senken zu können. Genau. Und bei „Seasons“, ja war es manchmal etwas enttäuschend, wenn du versuchst dich zu relaxen und dann tief einatmest und dann auf die Uhr schaust und dann geht der Schnee weg und dann kommt er plötzlich wieder [Lachen]. Also es hat irgendwie beides ausgelöst. Also Freude und Nein: Enttäuschung. Also Enttäuschung ist vielleicht übertrieben.

I: Gab es weitere Gefühle?
A: Nein.

I In welchen Situationen hast du „Flying Boxes“ genutzt?
A: Ähm, gute Frage. [Pause] Ich glaube vor allem viel in der Arbeit. In Arbeitssituationen. Ähm. Wenn die Zeit dazu war. Es war irgendwie so, welche App ich genutzt habe, war eine Zeitfrage, was gerade besser passt. Aber auch so in der U-Bahn, wenn mich irgendwie eine U-Bahn Situation gestresst hat oder ich von einem Termin zum anderen gefahren bin und so eine innere Anspannung hatte, weil ich schnell wo ankommen will. Dann war das sehr angenehm, um sich halt abzulenken von dieser U-Bahn Fahrt. Und, ja genau. Ich finde das war immer so eine Zeitfrage, um das zu spielen, dann habe ich eigentlich lieber „Flying Boxes“ gespielt.
I: und wo du dann keine Zeit hattest „Seasons“?
A: Ja, genau. Oder wo ich dann keine Zeit hatte, mich aktiv damit zu beschäftigen. Ja, ok die Stresssituation ist zu Ende. Jetzt habe ich Zeit, wieder zu Ruhe zu kommen, dann habe ich eher „Seasons“ gestartet. Und dann fand ich‘s eh schöner da irgendwie hinzuschauen.

I: Wie waren deine Gefühle und Emotionen die Hertzrate in "Flying Boxes" zu sehen?
A: Sehr gut, das fand ich sehr positiv.

I: Hättest du gerne ein anderes Symbol gesehen?
A: Als die Hertzrate?
I: Ja, zum Beispiel nicht unbedingt die Zahl an sich, sondern etwas anderes?

A: Nein, ich fand das eigentlich sehr, sehr gut. Das ist mir auch während der Anwendung aufgefallen, dass also, weil mir ist das manchmal gar nicht so aufgefallen. Ich glaube die Kugeln sind ja unterschiedlich schnell geflogen. Ich weiß gar nicht, ob mir das so aufgefallen wär. Aber mit der Hertzrate konnte ich das dann besser in Verbindung bringen. Dann ist mir aufgefallen: jetzt ist die Hertzrate schon so weit unten: deshalb ist es so langsam. Ja.

I: Hättest du gerne ein Symbol in „Seasons“ gehabt?
A: mh, [Pause] Ja vielleicht schon. Ja.
I: Was für eins?
A: Vielleicht auch die Zahl.

I: Hast du in bestimmten Situationen eine der beiden Anwendungen bevorzugt?
A: Ja, also wenn gerade irgendwie Zeit knapp war, habe ich „Seasons“ bevorzugt und wenn ich mich von was ablenken wollte, dann habe ich „Flying Boxes“ bevorzugt.

I: Stelle dir vor, du stehst kurz vor einer Prüfung, die dich sehr stresst. Du hast weiterhin die Smartwatch mit den Applikationen „Flying Boxes“ und „Seasons“ zur Verfügung. Würdest du eine dieser Applikationen verwenden oder deine bewährte Technik zur Stressreduktion?
A: Mh, ich glaube ich würde „Flying Boxes“ spielen und tief durchatmen. [Lachen]
I: Und warum?
A: Weil ich mich ablenken würde von den Gedanken an die Prüfung und tief durchatmen, weil das immer angenehm ist wenn man Stress hat.

I: Hast du sonst noch Anmerkungen?
A: Ich würde beides weiter nutzen. Ja.

Summarized Interviews

Theme	Person 1	Person 2	Person 3	Person 4	Person 5
Design "Flying Boxes"	• good • suggestion: more colors, choose colors in settings	• good, because simple • colors and images very appealing	• good • boxes and circles not easy to keep apart • suggestion: don‘t fill circles • better then expected for a smartwatch	• very appealing • clearly arranged • clear • appropriate colors	• self-explaining • simple • plain • colors and images well visible
Design "Seasons"	• good • colors well illustrated	• pretty • look closely to see how image changes • catchy	• good • better then expected for a smartwatch	• almost artistic • pleasant colors and images • spring in combination with low pulse is good choice	• very good • color and images good recognizable
Usability "Flying Boxes"	• easy • simple • understandable	• easy • only one button, depending on settings	• good • pressing button is hard, → skew watch, counterbalance with finger necessary • with circle harder • touch better	• very easy • one click • handling very good	• good in usage • button for color and circle next to each other stupid → got used to it

Usability "Seasons"	• easy • simple • understandable	• very, very easy → only start game	• impeccable	• very easy → no click	• not a lot to operate
Default Method at Stressful Situations	• dependend on the kind of stress • breathe deeply • calm down • make a break • do something else • time related stress: make a break or do something else not possible	• go to a quiet place • breath deeply • calm down	• take a shower • try to calm down • go for a walk • distance from the situation to start calm • make a schedule	• depends on situation, most stress situation due to mistake (forgot to plan something, mistake in work) • if mistake is found, stress disappears • normally looking into the problem	• breath deeply • drink glass of water • calm down
Tactics in Seasons			• breathing deeply	• breathing exercise • concentration on breathing	

Circle Feature	• use without circle only	• play without circle, was difficult enough	• did not recognize circle well • shit	• did not use circle, too thrilling → did not notice that pulse or stress decreases • more distraction then "Flying Boxes" • overstraining	• beginning: did not check that circle changed to box when pressing button → later fun

Effect of "Flying Boxes"	• calming • stress reduction • not stress causing due to dimension of activity • pusshing the button results in stress reduction • fun	• distraction from stress • calming • fast boxes, concentration, more distraction • short term: during game → stress reducing • short term: relaxing • positive stress due to distraction • distance from stress • reflecting: more easiness, thoughts: do work as it is supposed to but with less stress	• stress: no time to make schedule • concentration • tension • alternating pulse • feeling to fail	• if pulse not continuously decreasing uncomfortable • very good distraction from stressful situation • positive, small excitement	• distraction • concentration • fun • most times relaxing • calming • beginning of the study stress to do something actively, later on not anymore • ambition to reduce pulse more quickly and play longer

Effect of "Seasons"	• calming	• no effect	• only 10 s usable	• distraction due to breathing exercise • looking how image changes • trend decreasing: positive, joy • trend staying the same or increasing: nervous → do not function as I am supposed to	• concentration • calming • joy: summer image, relaxed • information state of affairs • sometimes stress at winter image • sometimes disappointingly if snow disappears and appears again
Effect Watch on Stress			• assisting to find tactics to relax as → checking with watch		

Compare Effect of "Flying Boxes" and "Seasons"	• "Flying Boxes" more effective then "Seasons" • concentration needed in "Fling Boxes" → "Flying Boxes" more relaxing then "Seasons"	• calming down through "Seasons" because sitting at quiet place → similar to standard method • "Flying Boxes" was more stress reducing then "Seasons"	• standard method like "Seasons" • difference to standard method: no schedule in intervention • "Seasons" more calming then "Flying Boxes" • "Flying Boxes" better to be distracted from situation	• intervention different handling with stressful situation then standard method (actively look into problem) • effect of situation depends on person • "Seasons" worked better, more calming then "Flying Boxes" • "Flying Boxes" more distraction	• "Seasons" concentration and calming whereas "Flying Boxes" distracting • standard method: no concentration, but in "Flying Boxes" • "Flying Boxes" calming and distracting whereas "Seasons" joy and information about state of the art • winter: stress

Situation/ Circumstances before using "Flying Boxes"	• one time: time related stress • fun	• frustration • sadness • distraction • overwhelming situations • wish to concentrate on other things • wish for stress reduction	• loud noise • situations of feeling uncomfortable • overstraining situations	• anticipation like child of computer game • having a lot of energy • not dependent on stress level	• having time • a lot in work • metro: internal stress → want to reach destination faster

Situation/ Circumstances before using "Seasons"	• stress at work	• overwelming situations • wish to concentrate on other things • wish to distance from stress • no distraction wanted • wish to calm down • concentrate on problem consciously	• to much to do • want to calm down • aim: do things calm and controlled	• tired • situation not dependent on stress level	• no time for activity • activity seen as burden

Feeling about Seeing the Heart Rate in "Flying Boxes"	• causing pressure	• showing decreasing pulse only could have a calming effect • good • other symbol like graphic would be difficult to implement	• causing concerns because heart rate decreased so much (55 → 46) • good to see • not knowing heart rate could lead to restlessness • did not interfere	• can check if pulse decreases • if did not decrease feel uncomfortable	• positive • without HR would not recognize that velocity decreases depending on pulse
Ideas of Different Heart Rate Symbol	• box with colors: green at low pulse, red at high pulse	• fake pulse which is decreasing all the time		• no other symbol	
Feeling of "Seasons" without HR	• better: no pressure	• change of image heart rate aware • symbol would be nice	• like to see heart rate	• symbol would make me nervous	• like to see heart rate as number

Correlation Stress and Pulse		• does not think pulse and stress correlated: could play "Seaons" for short period only	• pulse did not increase upon stress • could not really play "Seasons" • idea: do not connect heart rate to "Seasons"		
Evaluation of "Flying Boxes"	• cool game • nothing negative • was fun	• note too complex	• dislike computer games → no calming effect for me	• positive: distraction in stressful situations • anticipation like a child for a computer game	• distraction is pleasant • sometimes activity is burden • fun

Evaluation of "Seasons"	• too less to do • like it to be active • maybe "Seasons" for inexperienced computer users better • boring (fast)	• could be meditative • possibility for calming • a little bit boring • never winter image • short game period	• "Seasons" is better • not playable because pulse to low • like idea to relax but probably not possible for many people	• distraction of stressful situation and focusing on oneself positive • nothing negative	• cool to concentrate and to see how oneself calms down • sometimes pleasant not to be active • dislike no influence • another kind of pulse reading

Stress Reduction	• interventions as supplement during the process of calming down • not at time related stress possible	• interventions in combination with sitting down at calm better effect (metro example: using intervention standing did not release stress or pulse) • use "Flying Boxes" in exam related stress → like to work oneself into something, horror scenarios → distraction good	• interventions not possible at time related stress • method depends on situation • exam related stress use "Seasons"	• which intervention depends on reaction to situation: much energy left: "Flying Boxes", at rest: "Seasons" • exam related stress: "Seasons", better distraction	• intervention and standard method do not exclude each other • breath deeply can be realized within the game or more active • which intervention matter of time • exam related stress: "Flying Boxes" + breath deeply → breath deeply always good in stressful situations → "Flying Boxes": distraction

Comments		• sometimes "Flying Boxes" stutter → does not change anything	• do not connect "Seasons" to heart rate only • this week not as much stress as usual		• writing situation in table was stressful at beginning of study, later write in cell phone → better • would use both intervention in future

Table 2: Summarized code-paraphrase combinations gained by the interviews of the user study after using the interventions "Flying Boxes" or "Seasons" for one week.