Acceptability, feasibility, and usability of a mobile health intervention (IVY) to enhance implicit vitality among breast cancer patients: a mixed-methods study

Shelley Groote Schaarsberg

Master thesis Health Psychology & Technology
Faculty of Behavioural Management & Social Sciences

Supervisors: Marcel Pieterse & Christina Bode

UNIVERSITY OF TWENTE.

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Abstract

Purpose - Cancer-related fatigue (CRF) is the most common side effect of cancer and treatment with detrimental effects on quality of life. Until now, CRF is intangible; causes and their interrelationships are not well understood by researchers, patients and health professionals. These factors impede successful treatment. Growing evidence indicates that CRF is partly driven by distortions in perception. These cognitive biases develop outside awareness and should also be treated implicitly. Therefore the University of Twente and the ZGT have joined their forces and created the mobile health application IVY. IVY tries to modify biases among breast cancer patients from fatigue to vitality by means of Cognitive Bias Modification. This study aims to evaluate the user's perspective on acceptability, feasibility and usability of IVY and understanding their level of engagement with the intervention.

Methods - A user experience study with a mixed-methods approach was conducted. Breast cancer patients(n=15) were interviewed after they used the IVY intervention for 14 days and answers were coded thematically. Results of the semi-structured interviews were compared with input from quantitative measures on subjective vitality and fatigue (Checklist Individual Strength, Vita-16 & Visual Analogue Scales on Vitality and Fatigue) to triangulate the qualitative findings. Log data were also taken into account to verify and understand users' perspectives.

Results - The perceptions of the users revealed a mixed but mainly positive evaluation of engagement and experience with the intervention. Usability and feasibility of the intervention complied with demands. Patients were satisfied with the attractive design and approachability of the app; log data confirmed that users were easily able to use the app regularly. Evaluation of acceptability showed ambiguity: perceptions were biased by a lack of understanding of the purpose of the app and the combination of a lack of subjective fatigue before use and the absence of a positive change in vitality after use of the intervention.

*Conclusion -*Affections towards the intervention varied and revealed that persuasive design needs more attention to engage also users who prefer challenge and variation instead of monotony and simplicity. Our results indicate that these factors might contribute to sustained user engagement that is needed to keep IVY interesting in the long term. The current study suggests that IVY is feasible and usable from a user's perspective. To raise acceptability and engagement, personalization in both design and implementation is recommended. For

implementation, broader research into the effects of IVY on various target groups deserves priority.

Table of content

1 Introduction

This study aimed to investigate acceptability, usability and feasibility of a mobile health intervention from a user perspective. Before the most important theories and concepts are explained, the targeted problem is outlined firstly.

1.1 Cancer-related fatigue

Are you sometimes engulfed in a total wave of exhaustion? Unfortunately, for the majority of the 18 million people diagnosed with cancer each year, this is a daily struggle (Sung et al., 2021). Cancer-related fatigue (CRF) is the most common and distressing symptom reported by patients and survivors and can be defined as a subjective sense of tiredness that is disproportionate to activity level. CRF can manifest itself physically, emotionally and/or cognitively (National Comprehensive Cancer Network, 2019) for example by generalized weakness, a decrease in motivation and interest to engage in activities, and diminished concentration (Cella et al., 2001). Compared to normal fatigue, CRF has more severe consequences and rest or sleep are usually not sufficient to feel refreshed. As a result, CRF interferes with daily functioning, has a huge impact on overall quality of life (National Comprehensive Cancer Network, 2014) and is often associated by a wide interplay of psychological conditions such as depression, fears, sleep disorders and pain (Ma et al., 2020; Bower, 2014; Ryan et al, 2005; Schmidt et al, 2015). Moreover, a meta-study by Syrowatka, Motulsky, Kurteva, & Hanley (2017) has underlined CRF as a predictor of distress.

The prevalence rates of CRF vary from 60% to 90% with a strong persistent pattern during the course of treatment (Berger et al., 2018). For breast cancer patients in particular, prevalence of CRF is much higher among patients who receive chemotherapy in comparison with those who undergo radiotherapy (Donovan et al., 2004) and often symptoms do not disappear when treatments are finished. In fact, about 30% of former patients reported to struggle with fatigue for even months or years after treatment (Goedendorp et al., 2013). As described by breast cancer patients, CRF is overwhelming, and gives them a feeling of helplessness, like they are imprisoned by the body of an 80-year-old woman (Levkovich, Cohen & Karkabi, 2017). Recent findings (Ehlers, Dubois & Salerno, 2020) underscore the importance of adequate management of CRF in (breast) cancer patients. But first, many ambiguities have to be clarified.

Despite the high impact and prevalence rates, a clear understanding of the phenomenon CRF is currently lacking. CRF is considered as a multifactional phenomenon,

influenced by an interplay of demographic, psychosocial, biological, medical and behavioural factors, such as inflammation, comorbidity of depression and anxiety, lack of physical activity and poor nutrition (Ryan et al., 2007). So far, it remains unclear whether fatigue should be considered as one symptom that is expressed in multiple dimensions (e.g. mental and physical) or as two separate symptoms, that need different treatments (De Raaf, 2013). A lot is still unclear about the underlying mechanisms and as a result CRF is often under-diagnosed and under-treated (James et al, 2015). Patients are often told that they have to learn to deal with it, but have actually no clue how to do this. This problem is reciprocal: both patients (74%) and oncologists (80%) view CRF as unmanageable (Vogelzang et al., 1997). Additionally, fatigue is often withheld by patients from physicians (Ripamonti et al., 2018) and also proper knowledge and education are lacking for patients (Schmidt, Bergbold, Hermann & Steindorf, 2021). Taken together, these problems increase the barrier for successful treatment of CRF.

Currently, treatment of CRF is primarily focused on addressing medical causes. When these are excluded, a multimodal approach with a focus on the combination of mental processes, physical activity and sleep is often offered (Berger et al., 2017). In the Netherlands, treatments are wide-ranging and focused at building endurance, setting boundaries and finding the right balance between effort and relaxation (Helen Dowling instituut, 2022; Kanker.nl, n.d.).

Currently a golden standard to manage CRF effectively is lacking. (Thong, Van Noorden, Steindorf & Arndt, 2020). Research shows promising results for physical activity, psychosocial, pharmacological (Fabi et al., 2020) and mind-and-body (yoga and meditation) forms of treatment (Liu et al., 2021). According to a meta-analysis by Mustian et al. (2017), exercise and psychological interventions are effective and significantly superior to the available pharmaceutical options.. In addition, pharmaceutical treatments are often associated with more side-effects than non-pharmaceutical interventions (Goedendorp, Gielissen, Verhagen, & Bleijenberg, 2013). However, most of these interventions are time-consuming and face-to-face contact is often necessary, so there is a strong need for new and accessible treatments that are less burdensome and therefore better suited to the needs of the patient (Bennett, Friedlander, Goldstein, Hickie & Lloyd, 2007). Moreover, the current interventions focus predominantly on explicit cognitions and behaviour. However, there is growing evidence that human behaviour, thoughts and feelings are partly caused and continued by automatic, implicit processes that occur outside of awareness. These implicit processes are

linked to unhelpful psychological and behavioural responses that perpetuate several illness related symptoms such as fatigue (Hughes, Hirsch, Chalder and Mosch-Morris, 2016), pain (Sharpe, 2012), anxiety (Beard, 2011) and depression (Koster & Hoorelbeke, 2015).

Offering low threshold treatments is priority in the treatment of cancer and contributes to self-management among patients. With this knowledge, the eHealth app IVY (Implicit VitalitY) is co-created by researchers of the University of Twente and oncologists of Ziekenhuisgroep Twente (ZGT). The goal of IVY is to modify implicit processes contributing to a distortion between vitality and fatigue. This distortion causes maladaptive perceptions in regard to fatigue and an excessive vigilance towards fatigue related cues. IVY tries to modify this distortion by means of Cognitive Bias Modification (CBM). CBM is an innovative approach that has not been evaluated yet widely among users in the domain of eHealth. Moreover, both effectivity and satisfaction have to be evaluated among the target group before the intervention can be implemented on a larger scale. Therefore, this research tries to find out to what extent IVY is accepted among breast cancer patients and whether they noticed a positive change in their vitality due to the intervention. In the following section, the main important theoretical concepts with regard to this research will be described and explained more in detail.

1.2 Cognitive bias

There is evidence suggesting that illness-related symptoms such as fatigue are developed and maintained by cognitive biases (Hertel & Mathews, 2011; Hughes et al., 2016; Lenaert et al., 2018). Cognitive biases are implicit thought processes that can be formed by repetitional experience with certain cues through associative learning (Stacy & Wiers, 2010). These psychological distortions guide cognition and behaviour unconsciously and drive attention and interpretation in several maladaptive ways. According to a study by Lenaert et al. (2018), four cognitive processes can be distinguished that incite the brain to associative learning in chronic fatigue: perceptual-cognitive (*attentional) biases*, sensitization and sustained arousal, fatigue catastrophizing and generalization. In other words, the severity and frequency of symptoms may increase due to distorted attention (hypervigilance) to and interpretation (catastrophizing) of signs of fatigue. In this case, the brain becomes sensitized more easily and more frequently (Hertel & Mathews, 2011). As a result, patients experience fatigue more often and more severely. In the case of CRF, this can be the start of a negative spiral of cognitions and emotions such as all-or-nothing/avoidance behaviours and fear of progression

that contribute to the increase of fatigue, depression and anxiety, as found in a study by Hughes (2020) among breast cancer patients.

Next to the *attentional bias*, patients can also be at risk of developing a biased self-concept (*self-identity bias),* causing identification of the symptoms of fatigue with their self-image. This integration of illness to the self has been identified by Morea, Friend and Bennett (2008) as an illness self-concept and exists on both an explicit and implicit level. Support for this hypothesis has been previously found in the context of somatoform disorders (Riebel, Egloff & Witthöft, 2001) and pain (Grumm et al., 2008). Patients, both consciously and unconsciously, associated themselves more with illness-related words than healthy people. One model to understand this process is the Schema Enmeshment Model (Pincus & Morley, 2001). Their model states that biases in the processing of information are depending on the interaction between three psychological schemas, related to the self, the illness and the symptom. When two or more schemas are activated simultaneously and repeatedly, the information of one schema spreads to another one. In case of CRF, frequent exposure to fatigue can easily lead to the development of a schema of oneself as 'a tired person'. Thereby, symptoms of fatigue that are in congruence with the self-concept are more quickly processed and the memory for these cues will be expanded (Hertel & Mathews, 2011). The formed schemas are supposed to be entrenched in the implicit system and should also be treated at this level. Thus, to modify these biases, a reversed implicit association has to be evoked in the brain that reinforces the me-vital link and diminuates the me-fatigue link.

One training aimed at modifying cognitive biases implicitly in a relatively simple way is Cognitive Bias Modification (CBM). With help of CBM, automatic, unconscious processes that underlie the distortion are re-trained (Koster, Fox & Macleod, 2009). It is assumed that a modification of biases will result in a change in cognition. In this way, CBM tries to contribute to behaviour change indirectly. The underlying mechanism can be understood by the Reflective Impulsive Model (RIM) which explains human behaviour, thoughts and feelings as the interaction between reflective (slow and conscious) and impulsive (fast and unconscious) processes. These processes function parallel and mutually, impulsive systems tend to drive cognitions and behaviour especially in case of low motivation and self-regulation (Krishna & Strack, 2017).

Research showed that CBM can effectively be used to counter for example pain (Sharpe et al., 2012), depression (Bowler et al., 2012), addictions (Laurens et al., 2020) and eating disorders (Matheson, Wade & Yiend, 2019). However, results are mixed, and the

duration of the effects varies strongly. The most effective conditions have yet to be discovered. A systematic review of meta-analyses on CBM by Jones and Sharpe (2017) revealed that CBM is only effective in the short term for most symptoms. In the long term, positive results for CBM were only found for addiction outcomes. Based on the abovementioned literature, it is assumed that CBM could also be effective to modify biases in the target group of breast cancer patients. However, to fully understand how and why, the designed intervention targeted at this problem will be firstly introduced and explained more thoroughly.
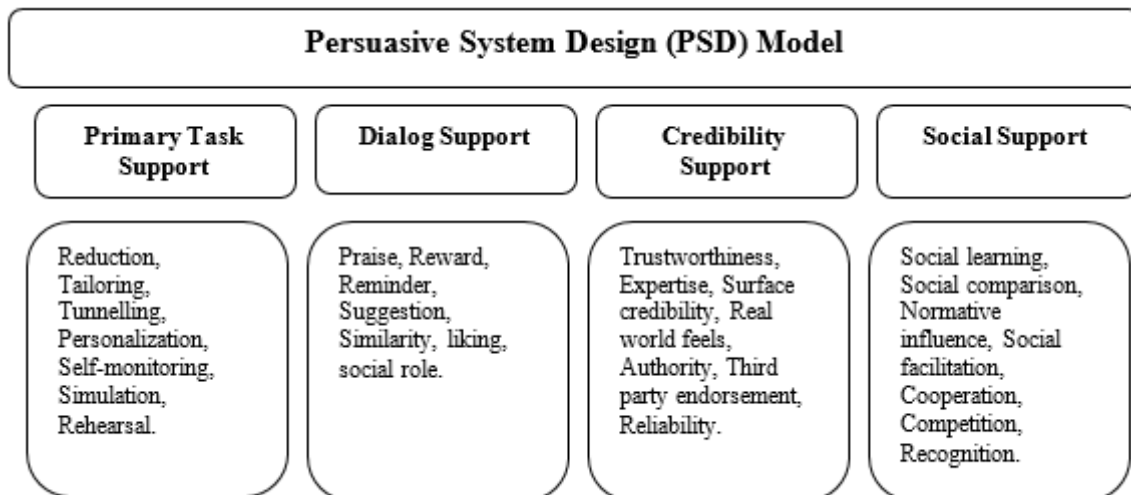
1.3 The intervention: IVY

A newly developed intervention called ImplicitVitality (IVY), aims to modify the cognitive bias among breast cancer patients through CBM. The goal of IVY is twofold: reducing the fatigue bias and improving the vitality bias. In the daily IVY training, users have to categorize words on the idea that positive (eg, energetic) words have to be connected to the category self/vital and negative (eg, exhausted) words to the category others/fatigue. Connecting words in this way is based on the implicit association paradigm, by doing this repeatedly this evaluative association is stored in memory. The movement of swiping words either towards or away from the body is based on the approach-avoidance paradigm and creates the effect that words that are close to you are more important. This feeling is enhanced by a zooming function: words increase in size when they are approached and decrease in size when they are avoided (Neumann & Strack, 2000). By combining these two CBM paradigms, the potential effects of the intervention are enlarged. An example of the training can be found in figure 1. In this case, optimism should be swiped towards the body. By connecting words in this way repeatedly, the association with vitality is expected to be strengthened and the self-identity bias is retrained from fatigue into vital. The underlying idea is that vitality and fatigue are the ends of one dimension and that a vitality-rich self-image creates a buffer that makes the patient resilient against the occurrence of fatigue later on in the treatment and more empowered to endure this process. In this way, IVY is very innovative because it not only addresses current symptoms but also prevents the development of possible biases and corresponding symptoms in the future.

Figure 1
Screenshot of IVY training
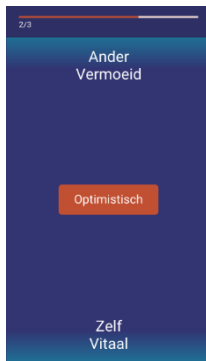
IVY has been created from the users' perspective by means of a user-centred design (UCD). UCD refers to an iterative approach in which the needs, motivations, expectations and interests of the end-users are taken into account in order to improve the impact and uptake of health technologies (van Gemert-Pijnen et al., 2011). Research shows that a user-centred design that aligns with the preferences and needs of the user affects adoption and success of products positively (van Gemert-Pijnen et al., 2018; Abras, Maloney-Krichmar, & Preece, 2004). Through co-creation in collaboration with patients, health professionals and patient advocates, user requirements for IVY were gathered in an usability study by Wolbers, Bode, Siemerink, Siesling & Pieterse (2021). A smartphone application was found to be the most preferred platform for the intervention. Further requirements derived from these interviews aligned with the Persuasive System Model (PSD) (Oinas-Kukkonen & Harjumaa, 2009). Therefore, this model was chosen as a guideline in the design process of IVY. The PSD framework (figure 2) aims to guide designers in selecting appropriate features that fit the target groups and their goals, to make them usable and attractive. When features are well-designed, this will result in positive emotions and better adherence (Ludden, van Rompay, Kelders & van Gemert-Pijnen, 2015). However, overload of similar features should be avoided and can be counterproductive (Räisanen, Lehto, Oinas-Kukkonen, 2010).

Figure 2
Persuasive System Design (PSD) Model (Oinas-Kukkonen & Harjumaa, 2009)

Persuasive System Design (PSD) Model

Primary Task Support	Dialog Support	Credibility Support	Social Support
Reduction, Tailoring, Tunnelling, Personalization, Self-monitoring, Simulation, Rehearsal.	Praise, Reward, Reminder, Suggestion, Similarity, liking, social role.	Trustworthiness, Expertise, Surface credibility, Real world feels, Authority, Third party endorsement, Reliability.	Social learning, Social comparison, Normative influence, Social facilitation, Cooperation, Competition, Recognition.

Within the PSD framework, four categories of features are distinguished: primary task support, dialogue support, system credibility support and social support. A simple, but visually appealing layout with a progress-bar, a reminder and positive messages was preferred by the participants (Wolbers et al., 2021). These needs correspond with reduction and self-monitoring from the category primary task support and liking, praise and reminder from the category dialogue support. Dialogue support provides the users with feedback. This guidance has also been integrated in the app by a differentiation in sound when a word is swiped in the right or wrong direction and by means of the appearance of a green or red light depending on the given answer. In line with users' preferences, a low-threshold smartphone app was created including a daily training of 100 words that takes no longer than 5 minutes each day. To find out whether the intervention is feasible and effective in practice, a pilot study was launched in 2019 among breast cancer patients who are treated at the ZGT (ZiekenhuisgroepTwente) in Hengelo. Within this pilot study, an important step is evaluating the actual experience of the user with the app. Therefore, the main focus of this study is on the user experience.

1.4 User experience

User experience (UX) can be considered a multidisciplinary concept, which can be viewed from many different perspectives. Several definitions of UX are formulated, however, a widely accepted definition does not yet exist. In line with other definitions (ISO 9241, 1999; Roto, Law, Vermeeren & Hoonhout, 2011)), UX will be considered in this study as an extension of a general experience encompassing every perception, feeling and reaction of the user when interacting with a system. This evaluation is individual, dynamic and influenced by several user, system and context related factors, such as motivation and content (Ahsanullah,

Kamil & Muzafar, 2006) . UX should be distinguished from usability, as usability refers solely to an interaction between the user and the product, while user experience also takes emotional aspects into account (van Gemert-Pijnen, Kelders, Kip & Sanderman, 2018; McNamara & Kirakowski, 2006). Attention to these factors is growing in the domain of eHealth, as they contribute to understanding the formation of a pleasurable experience (Hassenzahl, Diefenbach & Göritz, 2010).

Assuming that both functional (usability, utility) and emotional (fun) factors are important in UX, two complementary models are used in this study to cover both aspects. These models are used to support the data analysis and understand the findings. Both models can be found in appendix D. The first model, mainly focused on understanding intentions regarding technology acceptance (TA) from a cognitive perspective, is the Unified Theory of Acceptance and Technology (UTAUT) 2 by Ventaketsh, Thong & Xu (2012). UTAUT 2 states that TA is determined by seven core determinants: perceived ease of use (effort expectancy), perceived usefulness (performance expectancy), opinion of others (social influence), external circumstances that make use more convenient (facilitating conditions), fun or pleasure (hedonic motivation), price value and habit. These determinants are moderated by age, gender and experience. Several empirical studies on mHealth adoption support the predictive value of the determinants proposed in UTAUT 2 (Duarte & Pinho, 2019; Beh, Ganesan, Foroughi & Iranmanesh, 2019). The second model, which mainly focuses on different elements of UX and their functional relationship, is the prominent UX model of Hassenzahl (2003). This model proposes that users form an apparent character (cognitive structure) based on the combination of product features, personal standards and expectations. This apparent character is time and context-dependent and leads to various behavioural and emotional consequences. The overall value of a product is judged by a combination of pragmatic and hedonic qualities of a product. Both serve different psychological needs: the pragmatic quality is related to do-goals and covers functionality and usability, while the hedonic quality is related to be-goals that cover personal aspects such as evoking users' memories (evocation), expressing the users' self (identification) and ability to grow personally (stimulation). While the pragmatic qualities merely facilitate the fulfilment of be-goals, the hedonic qualities of a product are the drivers of positive experiences (Hassenzahl, 2008). The extent to which products fulfil both goals will determine the emotional and behavioural consequences, such as pleasure and satisfaction (Vätäjääta, Koponen & Roto, 2009). To our knowledge, Hassenzahl's model has not been used widely (Siemer et al.,

2020), but several others (Thüring and Malke, 2007; Hektner, Schmidt, and Csikszentmihalyi, 2007) argue to view UX from a broader perspective. Taken together, both described models stress that interventions have to comply with several demands to engage users when striving for acceptance and a positive UX.

   To improve UX, intervention design should not only be focused on usability and effectiveness, but also engagement has to be taken into account (Kim, Kim & Wachter, 2013). User engagement is considered a quality of UX. People engaged in technology are motivated to devote time and attention to it, expressed through positive emotions (Lalmas, O'Brien, Yom-Tov, 2014). Furthermore, user engagement is multifactorial, varies over time and within individuals and is considered as both a state and a process (O'Brien & Toms, 2008; Perski et al., 2016). In accordance with previous definitions, user engagement will be viewed in this study as the connection that exists between the user and IVY, expressed in emotions, cognitions and behaviour (Attfield, Kazai, Lalmals & Piwowarski, 2011; Kelders & Kip, 2019). In the domain of Mhealth, success of interventions has been found to be highly dependent on user engagement (Grady et al., 2018). However, focus on user-engagement attributes is lacking in the design process. Despite their great potential, many Mhealth interventions therefore fail to achieve effectiveness. (Ikwunne, Hederman & Wall, 2022). Understanding user engagement and associated factors have received more attention, but appears to be challenging. No consensus has been reached on mHealth user engagement indicators (usability, satisfaction, acceptability and feasibility). Comparing studies and figuring out how to tailor apps to different types of users is therefore complicated (Ng, Firth, Minen & Torous, 2019). Several studies have attempted to identify facilitators and barriers in regard to engagement. End-user involvement, understanding of the users' context (Torous et al., 2018), frequent updates, positive emotion-focused design (Ludden, Rompay, Kelders & van Gemert-Pijnen, 2015), feedback, guidance and reminders (Saleem et al., 2021) were found to facilitate user engagement. Conversely, user engagement can be hindered by technical issues, mental health problems, lack of personalization (Borghouts et al., 2021), and too much irrelevant content (Musselwhite, Freeman, & Marston, 2017). Another main factor that contributes to engagement is motivation (van Gemert-Pijnen et al., 2018). According to the well-researched Self Determination Theory (Ryan & Deci, 2000), motivation can be classified on a continuum from amotivation to intrinsic motivation. SDT distinguishes several types of motivation that regulate behavior. Amotivation arises when people lack the drive to behave, they are stimulated in any way. When people do something out of interest or pleasure,

they are intrinsically motivated. Anything in between is called extrinsic motivation, varying according to the degree to which behavior is regulated from within the person. People can behave in certain ways because they are forced to (*external regulation*), because of social approval or out of guilt or shame (*introjected regulation*), because of appreciation and valuation (*identified regulation*) or because it is integrated with their values and beliefs (*integrated regulation*). The motivation continuum according to SDT can be found in figure 3.

Figure 3
Motivation continuum SDT
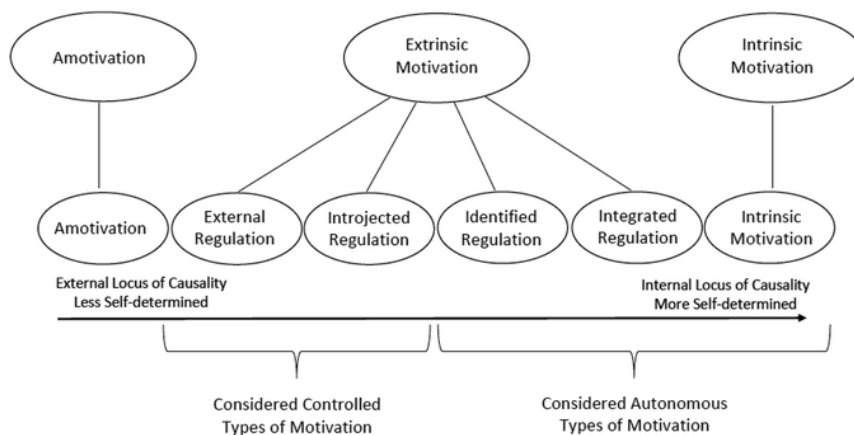
Taken together, engagement is influenced by a wide interplay of interrelated user, system and context factors (Perski et al, 2017). The extent to which these factors are relevant depends also on the targeted behaviour of the intervention.
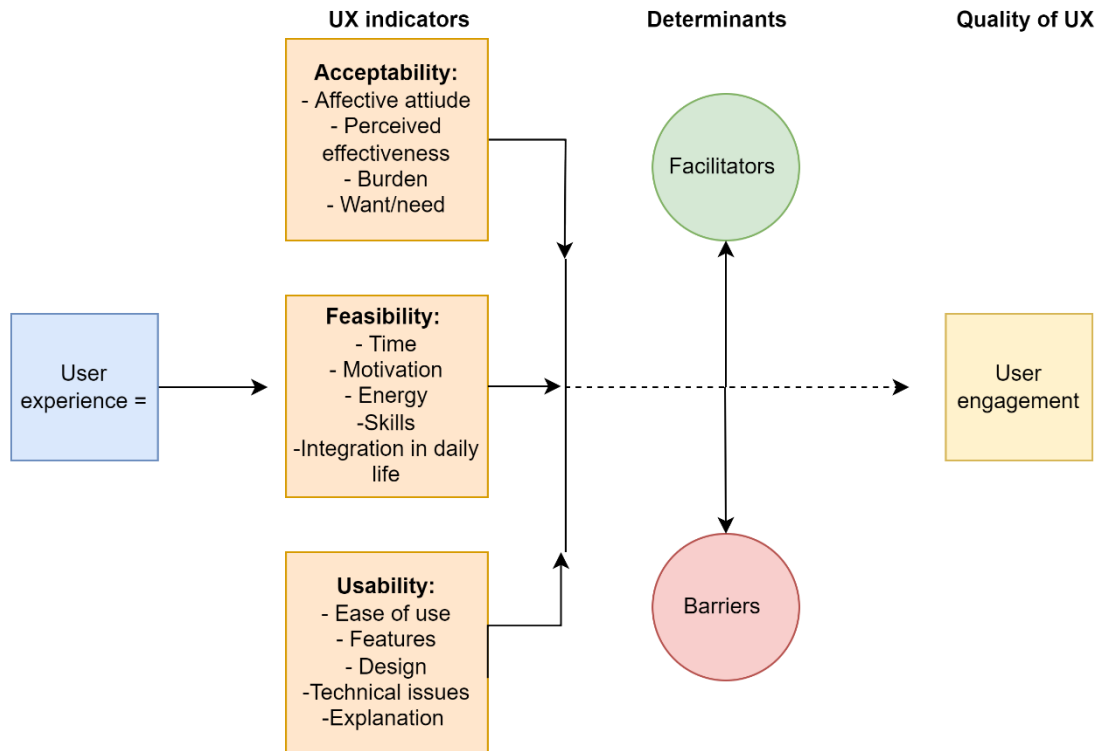
IVY targets implicit behaviour and can not be compared well with other eHealth interventions. However, the IVY study by Wolbers et al. (2021) underlined the need for a persuasive and engaging intervention. These findings align with other CBM evaluations (De Voogd, Wiers, De Jong, Zwitser, and Salemink, 2018; Laurens et al., 2020) who found that this type of intervention is not yet sufficiently engaging. Therefore engagement is chosen to be the main focus of this study. By gaining a better understanding of this concept, this research aims to provide strategies to improve future user engagement. To make this clearer and more concrete, personas are used in this study. Personas are valuable to designing eHealth from a user perspective. These so-called 'actual user archetypes' help designers understand how technology can be designed in a way that suits different types of users (Cooper, 1999).

By increasing usability (Long, 2009), they indirectly contribute to the development of a positive UX.

A clear understanding of their UX is needed to understand why users are engaged. Therefore, user engagement was evaluated in this study by three main indicators: acceptability, feasibility and usability. These three concepts have no uniform definitions and have been used interchangeably by various studies (Hermes, Lyon, Schueller & Glas, 2019; Longo, 2018; Nadal, Doherty & Sas, 2019;). The definitions used in this study are therefore a combination of previous findings and adapted to the research objectives. Acceptability is viewed as the extent to which breast cancer patients consider IVY appropriate, based on cognitive, emotional and behavioural responses to the intervention. This study was focused on several main concepts: perceived effectiveness, burden, affective attitude and want/need (Perski & Short, 2021; Sekhon, Cartwright & Francis, 2017). Feasibility was evaluated by assessing whether patients are able to use IVY successfully, in the way it is purposed to them. Main concepts are derived from research by Bowen et al (2009): time, motivation, energy, skills and integration in daily life. Design factors influencing the UX (=usability) are evaluated through users' perceptions in regard to ease of use, features, design, technical errors and the explanation of the app. Based on the abovementioned concepts, a theoretical framework for the used concepts in this study was created and can be found in figure 4.

Figure 4

Overview of most important concepts used in this study

UX indicators

Acceptability:
- Affective attiude
- Perceived effectiveness
- Burden
- Want/need

Feasibility:
- Time
- Motivation
- Energy
-Skills
-Integration in daily life

Usability:
- Ease of use
- Features
- Design
-Technical issues
-Explanation

User experience =

Determinants

Facilitators

Barriers

Quality of UX

User engagement

1.5 Aims of this study

To assess whether IVY is currently meeting the needs and wishes of the target group, a user experience evaluation was conducted. Engagement with IVY was evaluated by viewing users' perceptions in regard to acceptability, feasibility and usability. Based on these findings, this research tried to map facilitators and barriers in regard to user engagement and to identify whether these determinants could be taken in account in the redesign of the app.
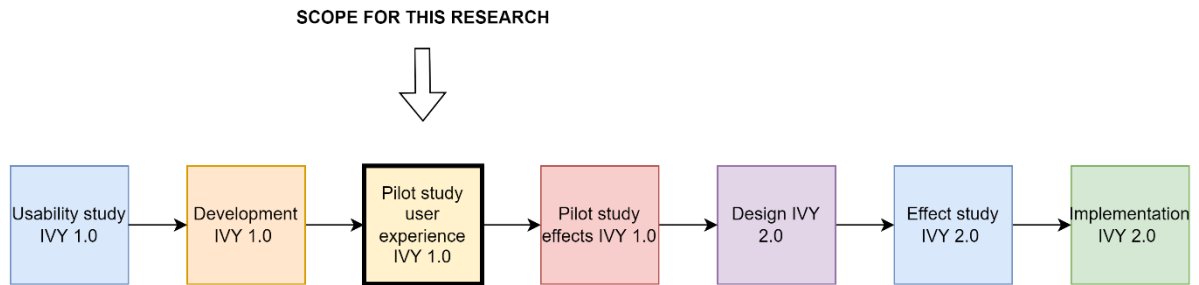
Main goals:
- Evaluation of the acceptability, feasibility and usability of the IVY intervention from a user perspective
- Comprehending the level of user engagement with the IVY intervention

Research questions:
1. What are the perceptions of the users in regard to acceptability, feasibility and usability of the IVY intervention?
2 Which positive (facilitators) and negative (barriers) determinants have influenced the user engagement?
3 In which way can the suggestions of the users be integrated in the redesign of IVY in order to enhance user engagement?

To fully understand this research in the development process of IVY, the scope for this research is displayed schematically in figure 5.

Figure 5

Development stages of IVY and research scope

SCOPE FOR THIS RESEARCH

| Usability study IVY 1.0 | → | Development IVY 1.0 | → | Pilot study user experience IVY 1.0 | → | Pilot study effects IVY 1.0 | → | Design IVY 2.0 | → | Effect study IVY 2.0 | → | Implementation IVY 2.0 |

2 Methods

2.1 Design

A mixed methods design was used in which both quantitative and qualitative data were combined to foster a richer exploration of the data and to increase validity (Bartholomew et al., 2011). The importance of combining several data has gained more understanding in the field of UX evaluation, but is not yet widely applied in a valuable way (Petterson et al., 2018). This research tried to get advance from triangulation aimed at strengthening of theoretical concepts and reduction of the researcher bias (Berg, 2004) Triangulation was chosen as the most appropriate analysis technique and refers in this study specifically to an approach in which multiple data (quantitative and qualitative) are collected simultaneously and weighted equally to understanding findings from different perspectives and support the answering of the research questions (Bishop, 2014)... In this study, the qualitative part consisted of semi-structured interviews with participants about their experience with the app. The quantitative part consisted of 3 elements: questionnaires (Vita-16 & Checklist Individual Strengths), logdata and Visual Analoge Scales on vitality (VAS-V) and fatigue (VAS-F).

2.2 Participants

Thirty patients were included by means of purposive sampling between June 2019 and April 2020 in the ZGT (ZiekenhuisGroep Twente) hospital in The Netherlands. Patients were invited to participate in the IVY study by their internist-oncologist shortly after they were diagnosed with breast cancer. Inclusion criteria were being eligible for neo-adjuvant chemotherapy, having adequate skills in Dutch (written and spoken) and being in possession of a smartphone, of which they know how to use it. Unless patients did not met these requirements, they were invited to participate. Participants were compensated for their participation with a flower voucher. The final sample consisted of eighteen participants. Among them, interviews of fifteen participants were selected randomly for further analysis. All participants were on-treatment and received chemotherapy in a neo-adjuvant treatment setting. The age of the participants ranged from 22 to 62 (M_{age}= 43,6, SD_{age}=10,59). Level of education varied among the participants, most of them completed secondary vocational education (n=7) or higher professional education (n=5). The others completed lower educational school (n=2) or elementary school (n=1).

2.3 Procedure

Patients received information about the pilot study via mail when they agreed to participate. Afterwards, they were called for further instructions by the junior researcher a couple of days after their affirmation. In this phone call, a short introduction was given about the procedure and they were asked for their email to receive a link for the baseline measurement (T0). This meant that they had to fill in some short questionnaires about depression (HADS), subjective fatigue (CIS) and subjective vitality (Vita-16), followed by the Implicit Association Test (IAT) to measure their implicit fatigue related self-concept[1]. Furthermore, they were asked to fill in the baseline measurement before they started with their first chemotherapy. Additionally, it was told that they would receive another email a couple of days before the second chemotherapy, as a reminder that they should start with the IVY training. Each training session consisted of two elements: self-reported fatigue and vitality at the moment of training with a Visual Analogue Scale (VAS) and a computer game in which patients where asked to swipe 100 words either towards them or away from them, depending on the content of the words. Patients were supposed to swipe vitality related words towards them and fatigue related words away from them. After they had trained for 14 days, they received another email for the follow-up measurement (T1) and they were asked if they would share their experiences with the app in a phone interview of circa 30 minutes. Patients were invited to propose a day and time for the interview that would fit them. During the whole process, log data of adherence on both the questionnaires and the training were monitored and patients were contacted by mail or phone when they did not adhere to the protocol. The IVY study was approved by the Medical Research Ethics Committee Twente (NL68528.044.18) and the BMS Ethics Committee (18791).

2.4 Instruments

Quantitative

Visual Analogue Scale (VAS) on vitality & fatigue)
The Visual Analogue scale is a psychometric response scale that can be used to measure subjective experiences that can not be measured directly. In this research, patients were asked to declare their levels of vitality and fatigue before every training in the app by means of this measurement. The VAS-scale consisted of 1 single item in which patients had to indicate their

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[1] The results of the IAT and the HADS are not included in this study

level of fatigue and vitality with a scrollbar on a scale from 1 to 10 (*how vital/fatigued do you feel at this moment*?).

Checklist Individual Strengths (CIS)
The 20-item Checklist Individual Strengths is a self-report measure on fatigue (Vercoulen, Swanink, Fennis, Galama, van der Meer, Bleijenberg, 1994). In this questionnaire fatigue is measured by four dimensions: severity, concentration, motivation and activity. Internal consistency (α=0.84-0.95) and test-rest reliability (r=0.74-0.86) of the subscales were found to be high in other research (Worm-Smeitink et al., 2017).

Dutch Vitality Questionnaire (Vita-16)
The 16-item Dutch Vitality Questionnaire is a self-report measure on vitality. In this questionnaire, vitality is measured by 3 three core dimensions: energy, motivation and resilience. Research showed that the Vita-16 is both reliable (α=0,95) and valid.

Logdata
In this research, logdata are referring to the behavioral logs that contained information about when the users performed the training and to what extent they finished each session of the training. Logdata are known for their additional objective usage patterns as addition to subjective recall of behavior (Sieverink, Kelders, Poel & Van Gemert-Pijnen, 2017). Besides, they are easy to gather, without requiring unnecessary additional effort from the participants.

Qualitative
Interviews
Interviews were conducted by the master student who was involved in the IVY project for her thesis. A semi-structured interview scheme was conducted at the beginning of the pilot study by the junior researcher within the project team. This scheme contained 13 different topics such as content, length, lay-out and utility of the app. Questions were based on experiences of the research team of former projects and general knowledge about eHealth evaluation. Every interview started with a general question: how did you experience the use of the IVY app? Depending on the answers of the patient, the other questions were sometimes asked in a different order. During the interviews, participants were encouraged to explain their answers by mean of probing questions. In case of unclarity, answers were repeated and verified. An overview of the semi-structured interview scheme can be found in appendix A.

2.5 Analysis

Quantitative

All VAS data were transported from SoSci Survey to Excel. For each participant this document contained a separate vitality and a separate fatigue score, corresponding with the days that they used the app and the associated VAS-scales. For each participant the scores of the fourteen days that they trained were selected and gathered in a new file. When participants had multiple scores on one day, the first score was selected only. Afterwards, these results were transported from Excel to SPSS. In this file, data were transformed from long to wide with the restructure function. For each participant, a separate vitality and fatigue variable was created with the VARSTOCASES function, with day as index variable. Graphs of individuals were made by plotting vitality and fatigue for each day by using legacy dialogs. These graphs were analysed visually by looking for patterns and by comparing these patterns with the answers from the interviews. Based on the patterns found, graphs were classified in categories.

Besides, results from the T0 and T1 of the CIS and the Vita-16 questionnaire were used from a existing data file. After checking the data for normality by histograms and the Shapiro Wilk test, the Wilcoxon Signed Rank non-parametric Test was executed.

Logdata

Logdata on adherence were extracted from the CSV file. A clear overview of the amount of sessions for each participant was created in a table

Qualitative

Interviews were transcribed verbatim and themes and subthemes were coded by means of an iterative process of both inductive and deductive coding. In this process, the combination of both theoretical interest and a clear fit with the data (Patton, 1990) was tried to achieve. For the deductive coding, Hassenzahl's model of UX, the UTAUT 2 model and the Mobile App Rating Scale (MARS) questionnaire were used as a first guideline. The MARS questionnaire is widely used as a objective and reliable tool to evaluate health apps (Stoyanov et al., 2015). After transcription, familiarization of the data and the generation of initial codes followed by a thematic analysis of the interviews (Braun & Clarke, 2006), known for interpretation of the research data in various ways (Boyatzis, 1998) . Within the thematic analysis, fragments of the data were labelled and merged into themes. Codes were discussed multiple times with the research team and adapted until agreement was reached. Within this process, initial codes were replaced or combined into new codes and after a couple of iterations, the final coding scheme was developed. To be sure that each code fits the data well, every code was supported by a quote and a clear definition. In this way, other members of the research team

were able to check whether the coding process was done properly. To ensure reliability of the coding process, one interview was coded by two researchers independently . Interrater agreement was calculated by counting the percentage of fragments that were coded in the same way. This comparison of answers resulted in an intercoder agreement of 73%. Although this method does not correct for change agreement (Cohen, 1960), it was sufficient to assess interrater reliability for this study.   After a few adaptions based on the feedback, the final version of the coding scheme was developed. During the whole process, ATLAS.ti 8.4 was used as tool for data analysis. Codes were categorized inductively by means of thematic analysis on acceptability, usability and feasibility.

Mixed methods: triangulation
Triangulation of data was applied on the results of this study. First, the qualitative data in the form of semi-structured interviews with patients were analyzed in a qualitative way to get insight in the subjective experience of the user with the app. Afterwards, input of these interviews was compared with the quantitative measures to verify whether the subjective experiences of the participants were in correspondence with their actual behavior. To answer research question 1, the results from the interviews were leading. However, to fully understand these answers and classify them as determinants, the interview data were combined with results from the VAS, Vita-16, CIS and the log data to answer research question 2. Research question 3 was answered by combing input from the interviews with theoretical knowledge about persuasive system design, user-engagement and CBM interventions, as described above in the introduction.

3 Results

Results of the interviews will now be described more detailed in regard to usability, feasibility and acceptability of the intervention. All results are arranged by research question.

3.1 Research question 1: perceptions

Concerning the first research question '**what are the perceptions in regard to acceptability, feasibility and usability'**, the following results are found:

Perceptions in regard to acceptability

The general *need for the intervention* was perceived as positive by the participants. Personal need, however, was perceived more doubtfully. About a third of participants perceived IVY as redundant. Two main reasons were mentioned: actual subjective feelings and implicit self-concept. As explained in here: "*I am feeling pretty well. I think it's a big difference when someone is feeling not so well […] then you have the idea it can help you perhaps. Then you cope with it differently in your head.*" (P8); "*I don't know if the app has added value to me, because I'm a positive person in general"; ''I have always been a glass-half-full kind of person".* This 'positive' mental attitude is reported by several participants as a precondition and therefore some participants are convinced that IVY would be more useful when patients lack a 'positive way of thinking'.

Besides the need for the intervention, participants also expressed their doubts about the effects. Most of the participants (n=12) did not perceive any change in vitality at all. In contrast, three participants *perceived effects* of the intervention. Changes were described on two levels: approach-avoidance and self-identity. As explained in here: "*It can only make you positive, when you give yourself the positive things, that's how I experienced it. […]* (P4), "*vitality and power, that those words should belong to you*" (P17); "*At a certain moment you know that you have to swipe those words towards you. Those words are more suitable to you in a certain way. […] at a certain moment you think it fits to me and no longer to the other.*" (P11). Besides, several participants (n=6) perceived IVY as a support for their self-regulation and well-being. In this way, IVY influenced both cognitions and behavior: "*sometimes it made me aware of the fact that it is not all negative*" (P17); "*It stimulated me to stay active,*

[…] when I finished the app in the afternoon, I thought well I can also go outside for a walk right now" (P14). Hesitations in regard to effects were expressed by a few others: "*It's hard to indicate if the app has some influence. […] I am very positive by myself and when I got this diagnosis, I thought we will fix this and then something happens and the whole world is falling apart […] so it's also about how your illness is progressing*" (P13); "*The fact that you are in an emotional rollercoaster also plays a role, when you start before the second cycle you don't know what's coming, emotions are all over the place […]*" (P17).

Since both need and effect were perceived as questionable, most participants (n=10) indicated no intention to use IVY again. As explained in here: "*[…], I don't know exactly what it did for me, that is why it is difficult for me to find out if continuing with it will have any effect*" (P9); "*no I don't need it right now*" (P5). However, most of them (n=7) would use IVY again if their needs changed in the future. Others (n=5) already reported willingness to use IVY again. Either by stating the intention to use IVY on a daily basis or to determine whether to use IVY day by day. Most of the participants (n=14) would recommend IVY. In their opinion, usefulness is person-related: "*what might not work for one person, might be useful for somebody else*" (P14). Special recommendations are addressed to people who are forgetful, tired or have a negative way of thinking in general.

Affective attitudes revealed a mixed picture of hesitation, enthusiasm and boredom.
and were influenced by the way in which the rationale behind the app, Cognitive Bias Modification (CBM), was experienced. Although participants are generally satisfied with the way CBM is incorporated, most of them expect that more words would influence their experience negatively: "[…] *It should not last even longer, otherwise it won't be fun at all.*" (P8); *the length is sufficient […], at a certain moment more mistakes are made, since the concentration is lower*" (P14). Hesitations in regard to the mechanism of CBM appeared from the interviews freely and influenced appreciation of the intervention. These hesitations influenced the trustworthiness of the intervention: "*at a certain moment it may be a bit influenceable, then you know which words belong to which category, I don't know if your thoughts go along with that*" (P9), "*In my opinion, you do not complete it truthfully, since you complete it the way the designers want it and not like how you feel at that moment.*" (P14). CBM also caused disappointment (n=2) "*When I was swiping those words towards the right side, it reminded me of playing a game […]*" (P13); *what I disliked was the fact that you*

swipe on autopilot when you are tired, [...] in that way you are not able to let the words sink in " (P17). Besides valuation also understanding appeared to be a problem: "*maybe you can add to the explanation that users should use it slowly, to let the words sink in a bit more [...] I did not see the purpose of the words' they, their, them*"; I think the app should focus more on '*I am strong*' instead of the part about they and them, maybe it will come through better than".

During use of IVY, affective attitudes towards the intervention changed for some participants and revealed why it was hard for them to stay motivated and engaged. The repetitive character (n=6) and lack of challenge (n=4) were pointed out explicitly: "*When you are halfway there and you get fatigue and vitality again, then you think oh I have already had those ones and then I am someone who thinks, well look what's on television*" (P16); *When I was fatigued, the swiping went slower and when I was distracted, I gave a wrong answer, but there was no challenge at all*" (P10). Other reasons for change of attitude were related to expectations: *In the beginning when I was convinced that the app would help me, I was very motivated, but in the end, it was more like oh I still have to do that [...]*" (P17) and low identification on several levels: "*The words don't belong to me, I am vital and I don't know if I will become more vital when I swipe those words to me. The negative words also don't belong to me*" (P8); "*I would prefer other things, mutually, like physical therapy*" (P14).

Perceptions in regard to usability

Ease of use

At the beginning of the interviews, participants were asked to describe their general experience with the intervention. Most of them highlighted that IVY was easy to use (n=9), partly due to the clear and complete explanation. A few participants (n=3) experienced initial difficulties, but were not hindered by them: "*In the beginning I thought, what is the goal, what should I do? But at a certain point if you know it, it's very user-friendly and self-explanatory.*" (P8). During the interviews, it appeared that the explanation was unclear to more participants (n=6): "*In general the explanation was clear to me, but maybe the added value of the app could be explained a bit more clearly*" (P9). Besides, a few questions raised in regard to the optimal way of use (n=4): *"I did not know if the trainings moment should be the same every day [..]"* (P9);, *"is it time-bound, should I do it fast as possible or just let it sink in slowly [...]* (P17).

Technical issues

Besides unclarities in regard to the explanation, the usability of IVY was also hindered by some technical issues. In sum, six technical issues were described. Firstly, two participants reported that they did not receive a reminder consequently. Secondly, three participants reported that the system did not always respond well. They noticed that there was a delay in the system when they swiped too fast in the sessions. These issues are described as 'inconvenient' and 'irritating', but were fixed automatically when participants waited and swiped slowly. Thirdly, one participant reported several technical issues: the app was starting again continuously when she was trying to close it, she was not able to change the time for the reminder and she reported to be confused about the completion of the training: *[..] "Because the app was continuously starting again and did not register anything […] I thought my training days were already finished"* (P2). Fourthly, one participant noticed that the explanation screen was continuing, before she even was able to read it. During the interviews, two other usability issues were mentioned that need to be taken in account when IVY will be redesigned. One participant noticed that the anchoring of the VAS-scales is unclear, as explained in here: "*I thought it was both the same, from low to high, when I set 8 for vitality I did also 8 for fatigue, but actually that's reversed […]*". Besides, two participants reported to be confused about the remaining training days, therefore one of them recommended that the app gives a notification when the 14 days are finished. To increase credibility, adding a praise through a 'thank you for your help' is seen as a valuable addition.

Design

Participants reported to be unanimous positive about the design of the app. Especially the colours were pointed out as positive and well chosen. As explained in here, it evoked a good surface credibility "*Good colours, not too bright or over the top. Because you are in a process in which it should be serious, but it looks really positive.*" (P4). Furthermore, participants valued the reduction in lay-out and described it as simple and clear. In line with that, a couple participants (n=4) appreciated the way in how the PSD feature "liking" was incorporated in the app: "*purple and pink are radiant, you should not keep it all black and white*" (P17).

Features of the app

A couple of app features were praised by participants and enhanced convenience in their use. The reminder was mentioned mostly and facilitated regular use of IVY. Also the praise (closing sentence), the self-monitoring (progression bar) and the feedback function (sound and red cross) were mentioned, but all only once. In regarding to the stimuli, perceptions were not unified. The majority of participants (n=9) valued them as clear, appropriate and sufficient. However, six participants reported to be negative about the lack of variation, as explained in here: "Sometimes *the same words came back 6 or 7 times, then I thought oh there is fatigue again […]"* (P16). Besides, three stimuli (attentive, dull and lively) were considered all once as inappropriate since users did not use them.

Perceptions in regard to feasibility
Adherence
Log data revealed that participants were able to use the app regularly. 53.3% of participants used the app as intended, for at least 14 days. Most of participants trained more than 10 days (n=10), two others only used IVY 3 days and the remaining three showed adherence numbers between 4 and 9 days. During the interviews participants admitted that it was easy for them to use the app regularly. Although sessions were sometimes skipped or forgotten (n=8), the majority reported that they were able to complete the training daily, in a couple of minutes, without interruption. However some participants mentioned barriers in regard to adherence: *You're so busy with the treatment, so every day you're busy with yourself, you have to go to the hospital or chemo or you're not feeling well. And then you forget this very quickly."* (P8); "*Those are things that come again every day and then you think I still have to do that. So that's a bit like an obligation and actually you don't want obligations."* (P1).

Timing of the intervention
Perceptions varied among participants in regard to the timing of the intervention. Half of participants (n=7) reported to be positive about the current timing. They emphasized that the timing was appropriate, because participants know a bit how everything is functioning after the first chemo. In addition, one participant pointed out that the app should also not be introduced at another moment: "[…] *I think it should not be later, fairly in the beginning would be the best. […] then you don't have the app on top of that before you know how everything is functioning in the hospital and how your body is responding to it" (P11).* Two participants suggested to offer IVY before the first chemo, because participants are open-minded in the beginning, as explained in this quote: "*When you already have finished one*

chemo, you know what's coming and it would be nice if you don't know what's coming to you [...]" (P1). In line with that, three participants suggested introducing IVY a bit later, to give participants the opportunity to process information and manage emotions firstly. More specifically, two participants suggested offering IVY around the third or fourth chemo, as explained by participant 9: "I *have the feeling that the fatigue is coming a bit later and, in my opinion, you need it more then.* Interestingly, one participant suggested to offer the training for no longer than two weeks: *"Those two weeks are fine, otherwise you would continue in the week that you actually feel a lot better".*

During the interviews, a few participants explained why they did not like the timing of the intervention. They felt overwhelmed when they were asked to participate in the IVY study and did not like the way in which the research study seemed more important than their treatment for the oncologist at the moment of introduction, as explained in here: *"I was called by the doctor at 9 pm about a result and then she starts talking about this research. This moment was not appropriate to me"* (P13).

Communication

During this study, the social interaction with the health professionals was limited. Participants reported to be satisfied with that, they did not experience this as a shortcoming. According to most participants, more explanation before the start would not have additional value. Most of them reported that the explanation was easy to understand and liked the fact that the explanation was digital. Moreover, a few participants (n=3) emphasized that additional face-to-face explanation could be a burden to patients: "*No, and I don't think you should do that, since patients already have lots of appointments*" (P17). One participant suggested to offer a written explanation in addition, especially for older participants. In line with that, face-to-face explanation for older people could be valuable, according to three participants. More interaction during the training period would not be necessary, since most participants reported to be satisfied with the current way of communication.

3.2 Research question 2: determinants

Concerning research question 2, **'which positive (facilitators) and negative (barriers) have influenced the engagement',** the following results are found**:**

Besides the subjective experience, objective measures also yielded relevant information in regard to research questions 2. Data regarding both perspectives will now be described more in detail.

Comparison of subjective effects from interviews with objective measures
Individual analysis of the VAS-scales showed ambiguous results of effects. Overall, most of the participants showed no clear differences in their general vitality and fatigue patterns between the first and the last training day, a lot of intermediate fluctuations can be observed. However, several graphs (5/18) give indications that could be in favor of effectiveness. One graph showed an increase in vitality (14), two graphs showed a decrease in fatigue (3, 13) and two graphs (4, 18) showed a combination of an increase of vitality with a decrease in fatigue. Compared with the input from their interviews, only participant 4 mentioned explicitly that she noticed a positive difference in vitality. In line with that, participants 14 and 18 reported to be positive about the usefulness even though they did not notice this. Furthermore, also stability in scores, as seen in the other graphs could be an indicator of effect of IVY, since scores are not decreasing nor increasing over time. However, general comparison of VAS-scales with the input from the interviews showed a few remarkable discrepancies . Graphs of participant 1 and 11 showed a decrease in vitality and a increase in fatigue over time. In contrast to these observations , both participants reported in the interviews that they noticed a positive difference in vitality during their training period. Graphs of the VAS-scales can be found in appendix F.

Besides the VAS-scales, results of non-parametric tests of Wilcoxon showed only minor changes in vitality, as measured by the Vita-16 at T0 and T1. In general, levels of vitality decreased over time, with only a significant difference on the subscale Energy. Following this, results of the CIS showed minor changes in fatigue. Mean scores increased between T0 and T1, with only marginal effects on the total score and the subscale severity. These results can be found in table 1.

Table 1
Scale means and test statistic (n = 17/18)

	T0		T1		Willcoxon	
	Mean	SD	Mean	SD	Z	P-value
Vita-16						

Energy	24,4	8,2	21,2	8,4	-2,685	0,007
Motivation	32,4	7,6	31,0	8,4	-0,882	0,378
Resilience	27,4	5,5	27,9	4,8	-1,355	0,175
Total score	84,2	20,2	80,1	19,8	-1,611	0,107
CIS						
Concentration	14,9	8,9	16,5	7,8	-0,544	0,586
Motivation	11,5	6,3	12,8	5,8	-1,305	0,192
Severity	23,6	12,1	28,6	8,7	-1,791	0,073
Activity	8,6	3,5	9,2	3,8	-0,972	0,331
Total score	58,6	27,7	67,1	23,4	-1,422	0,073

In the interviews, users mentioned several facilitators and barriers by themselves in regard to engagement. These can be found in appendix E. Below in table 2, all found determinants are summarized and categorized by indicator.

Table 2
*Identified facilitators and barriers*

Indicator	Facilitator	Barrier
Acceptability	Support in self-regulation and well-being features (reminder, feedback, praise) Feeling of satisfaction Feeling of enjoyment Perceived effectiveness	Uncertain effects Lack of perceived effectiveness Boring and repetitive tasks No fatigue complaints Redundancy Obligation Low identification with stimuli Preference for face-to-face treatment Misunderstandings about Cognitive Bias Modification IVY did not met expectations
Feasibility	Easy to integrate in daily life Low threshold (time, energy, skills)	Quickly forgotten because of other obligations/emotional overload
Usability	Easy to use Appealing design	Technical issues Unclear explanation

Additional finding: user groups on combination of facilitators and barriers

Based on the variety in engagement as explained below in figure 6, participants could be divided into three user groups. These groups are categorized by facilitators and barriers in regard to their engagement. Characteristics of these groups are described below in detail, these characteristics are combined as input for the creation of persona's, which are found in appendix C.

Figure 6

Schematic representation of variety in users' engagement
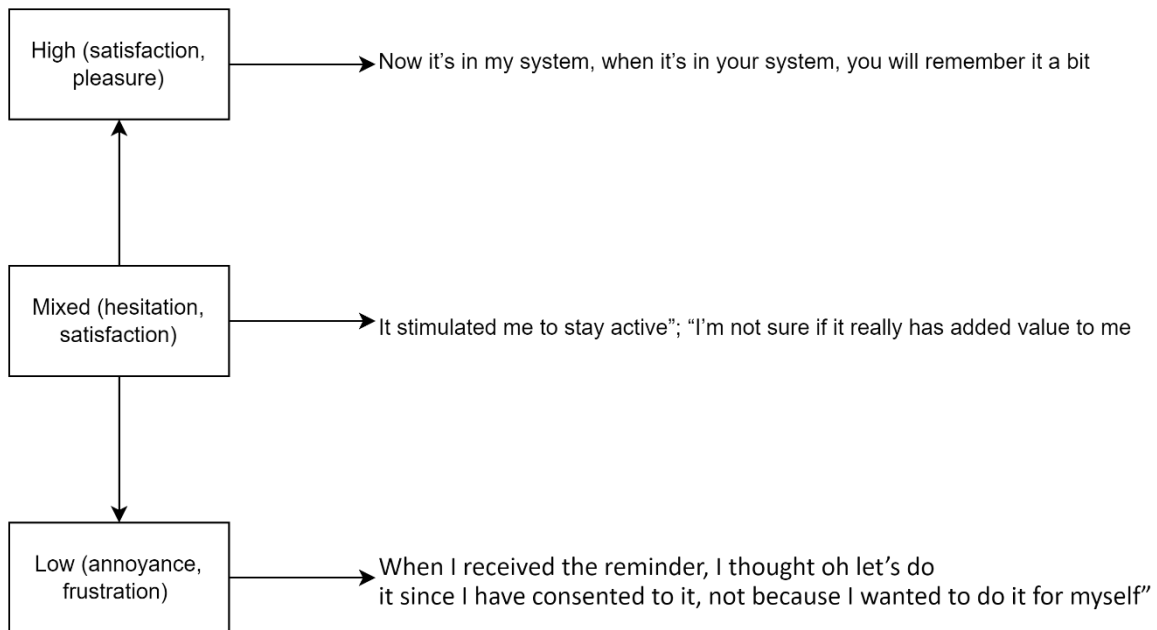
Experience of the persuaded embracers (n=5) participants: 3, 4, 5, 11, 18

Summary: users reported a combination of pragmatic and hedonic reasons why they liked/appreciated IVY, engagement with IVY is apparent from interest in effects and optimal use of IVY, think or just know that IVY helps them, without even experiencing this explicitly, most of them integrated IVY in their daily life like a habit.

Type of motivation according to SDT continuum: intrinsically motivated

Experience of the undecided engagers (n=5) participants: 2, 6, 9, 14

Summary: users are characterized by confusion, they report both positives and negative remarks on utility, engagement and satisfaction. They are willing to share their thoughts towards improvement of IVY and show interest in effects and optimal use of IVY. Although

not yet convinced, they are willing to use IVY again in the future when they are more fatigued.

Type of motivation according to SDT continuum: extrinsically motivated (identified regulation)

Experience of the disappointed skeptics (n=6) participants: 1, 8, 10, 13,16,17
Summary: users reported a combination of pragmatic and hedonic reasons why they disliked IVY, these reasons reinforced each other, disengagement is apparent from lack of motivation, complaints about the length and the monotonous character of the sessions and low levels of stimulation among the participants.

Type of motivation according to SDT continuum: extrinsically motivated (introjected regulation)

3.3 Research question 3: suggestions

Concerning the third research question: **'In which way can the users suggestions be used in the redesign of IVY'***, the following results are found:*

Suggestions design
During the interviews, participants were encouraged to share their thoughts about improvements for the design of IVY. With help of a little prompts, participants run their minds freely. The opportunity of offering personalized words was appreciated by a third of participants: "Maybe *that's a good idea, that you determine the words in a conversation with the participant, how she feels or wants to feel, that your training is based on those words.*" (P8). A possible barrier was also mentioned : "*I think it is important that the selection opinions are limited, […], that you can select 10 for yourself from a list of 15 words*. The idea of selecting your own words that fit you is viewed as both positive (n=1) and negative (n=3). Several barriers were mentioned: "*I think it would be messy if you do that and beside that I think you can also familiarize with the current words in the app*"; "I *think it would be difficult to select your own words when the app is introduced in the beginning, because you don't know what's coming towards you (P10)*".
Participants revealed their desire for more personalization more in detail: "*Is it possible then that the user can select for themselves whether they would like to train with 6, 8 or 15 different words?*"; "*I think the app could be tailored more to age, this version would be sufficient to older people*"; "*Maybe I would like to be able to change the colours […] blue for Tuesday and yellow for Wednesday, just for fun*"; *Maybe you could tailor the app more on age or with and without children […]*"; . Feedback would also be appreciated (n=2): *That*

you can see when your fatigue level is lower or higher and how these results are changing before and after the chemo, a kind of a mid-term result [...]*"* "[...] *Then I will think about what happened, how can I be so fast, did I do it in the morning or in the evening [...]*".

Besides, one participant suggested to add more questionnaires in which participants are able to declare their feelings. Some other possibilities for design were also shared by participants. A couple of them(n=4) expressed preference for challenge and ways to think. Half of the participants believe that more variated words could meet this need. Besides, a facilitator of more challenge was mentioned: "*People who get chemo become more forgetful, so maybe if you can add more challenge, it will also reduce those symptoms*" (P10). In line with that, the option for a kind of crosswords or puzzle game was offered by one participant. Most important user requirements for IVY are summarized below in table 3.

Table 3
User requirement IVY based on suggestions from interviews

User requirements
1. The app contains a feedback function, with an interim score in the shape of a graph
2. Personalization on different levels (sound on/off, colours, amount and type of stimuli, feedback, tailoring to age and general background)
3. The app contains a clear description with the rationale behind the app
4. Explanation about optimal use of the app is added
4. One session contains no more than 100 stimuli
5. Praise after training should be variated
6. Scales of vitality and fatigue are evaluated, and if necessary, anchored in the same direction (1= negative and 10=positive)
7. The technical issues towards reminder and delay in swiping must be fixed
8. The app sends a notification including a praise when the training days are finished

Additional to the research questions, participants also expressed their suggestions in regard to the timing of the intervention. Half of the participants reported suggestions for improvement concerning the timing of the intervention. Two participants suggested to offer IVY before the first chemo, because participants are open-minded in the beginning: "*When you already have finished one chemo, you know what's coming and it would be nice if you don't know what's coming to you [...]*" (P1). In line with that, three participants suggested introducing IVY a bit later, to give participants the opportunity to process information and manage emotions firstly. More specifically, two participants suggested offering IVY around the third or fourth chemo: "I *have the feeling that the fatigue is coming a bit later and, in my opinion, you need it more then" (P9)*. Interestingly, one participant suggested to offer the

training for no longer than two weeks: *"Those two weeks are fine, otherwise you would continue in the week that you actually feel a lot better"*.

4 Discussion

The aim of this study was to evaluate the user experience (UX) of participants with the IVY intervention. Research questions focused on the perceptions of the users in regard to acceptability, feasibility and usability of the IVY intervention, positive (facilitators) and negative (barriers) determinants that have influenced the user engagement and suggestions of the users for the redesign of IVY in order to enhance user engagement. To our knowledge, IVY is the first mHealth app that tries to modify biases from fatigue to vitality among breast cancer patients. Little is known about the UX of CBM interventions among this target group. Results of this study showed a high degree of engagement in general among the participants. This level was raisedby facilitators in regard to usability and feasibility of the app, but diminished by several barriers in regard to acceptability. Taken together, the app was evaluated cautiously positive with clear points for improvement.

4.1 Most important findings
General evaluation of engagement

Level of engagement varied among participants, but was found to be high in general. Initially, engagement was high and guided by the novelty and visually appealing design. However, IVY did not contain the right combination of features that was needed to sustain their engagement on the long term. The findings suggest that engagement was easily interrupted by lack of perceived effect, motivation and the failure to fulfil their expectations. In line with the framework by O'Brien & Toms (2008), findings of this study support the belief that user engagement should be considered as a process. Fortunately, findings revealed that the app has the potential to rebuild this engagement in the future, a clear explanation of the intervention and a more persuasive focused design are potential facilitators to accelerate this process. Still, we have to take in account that engagement is highly unpredictable and difficult to influence. In line with other research (Perski et al., 2017) we found that engagement is not merely about the extent of usage but rather about the interaction of cognitions, emotions and behaviour that are evoked by the experience with the intervention. The findings support the belief that more engagement is not always better. Instead, targeting at sufficient engagement to achieve desired outcomes could yield more potentially and fits better with the needs of the target group and the purpose of the intervention (Yardley et al., 2016). Since the intervention is intended for short term, periods of non-engagement would not be a problem if the intervention has the ability to recapture attention of the users. While

the findings provide an indication of potential facilitators and barriers that influenced the engagement with the IVY intervention, it is still debatable whether these can be truly defined as predictors. This also suggests that the chosen model as a basis for this study is not as straight forward as it was presented. Thus, the findings underline a well known struggle in the literature of engagement and acceptability: lack of knowledge and comprehension about associated factors and their interrelation (Sekhon, Cartwright & Francis, 2017; Kelders, van Zyl & Ludden, 2020).

Usability

With regard to users' perceptions of usability, it is generally linked to positive experiences. In this study, the first major finding confirms the belief that usability plays a dominant role in the overall experience of the user (O'Brien & Thoms, 2008). Usability proved to be a major strength. In line with user requirements derived from Wolbers et al. (2021), participants were unanimously positive about the visually appealing design and straightforward nature of the app.These findings align with other CBM evaluations (Beard, 2012; Prior et al., 2020) and confirm findings by Lee, Moon, Kim & Yi (2015): simplicity is an important determinant of usability that contributes to a positive user experience. This first impression should not be underestimated, since it contributes to both functionality and usability (Tang et al., 2015). However, the results also suggest that a good user experience is not merely built on pragmatic features, also hedonic features have to be satisfying to some extent to enhance user engagement. Aesthetics also serve that function, but their effects are not long lasting. Previous studies (Yuan, Ma, Kanthawala & Peng, 2015; Jarvinen, Ohtonen & Karjaluoto, 2016) have underlined the importance of hedonic motivation in regard to acceptance of technology. The findings of this study both confirm and expands on this literature and suggest that hedonic motivation is especially important when interventions can not easily fulfil users' expectations due to the absence of immediate effects on a symptom level. Thereby, the results also support the idea of pragmatic features as a hygiene factor and hedonic features as a motivator, as proposed by Hassenzahl, Diefenbach & Görtiz (2010). Pragmatic features contribute to a positive user experience by removing barriers that impede the fulfilment of psychological needs. However, hedonic features are critical to actually fulfil the psychological needs of the user. Interestingly, these findings are in contrast with findings from a study by Wolbers, Bode, Siemerink, Siesling & Pieterse (2021) who investigated breast cancer patients' preferences in regard to the design of IVY and concluded that pragmatic features are more important in this context. Our findings complement their study and suggest that

although persuasive elements are not required for improvement of usability they are however necessary to create a positive user experience. By evoking the right emotions, interventions are able to build the intrinsic motivation among the user, making technology acceptance more likely. Still, we have to take in account that their study was conducted in the predesign phase and did not evaluate the actual use of the app . Thereby, the findings support the believe that people are have limited ability to point out prospectively which factors would encourage their engagement with eHealth (Blandford, 2014). Moreover, in contrast to our findings, the participants in their study reported symptoms of fatigue.

Feasibility

A sub research question focused on the users' perceptions of feasibility. The extent to which an intervention can be successfully carried out in a given setting is a key point that needs to be taken in consideration in the process of development and implementation (Proctor et al, 2011). In our study the feasibility of the app was found to be high on average. From this perspective, IVY corresponds well with the needs and preferences of the participants. Results of both experience and adherence showed us that participants were able to use IVY appropriately and regularly, despite their busy and life-changing schedules, which demand interventions that do not hinder their treatment (Firth et al., 2017). The extent to which interventions can be integrated easily into the daily live, a domain of feasibility, is a common facilitator of user engagement (Borghouts et al., 2021). Theresults showed that participants integrated IVY easily due to the simplicity of the task and the low entry-level of skills and time investment that were needed. An interesting finding was the fact that some participants actually liked the fact that IVY returned every day, at set fixed times. This finding is not totally unexpected, since UTAUT 2 (2018) already underlined habitual use in regard to technology acceptance. However from both theory (Ryan & Deci, 2000; Peters, Calvo & Ryan, 2018) and empirical evidence (Wei et al., 2020) we assumed that autonomy is key to human motivation and enhancement of user engagement.

In line with a study by Schuit et al (2021) among cancer patients, participants showed varying preferences towards the timing of IVY. On the one hand, some favoured early introduction at the start of the treatment, while others preferred some time to manage their emotions first. These results suggest that participants differ in how and how easily they cope with their illness (Lashbrook, Valery, Knott, Kirshbaum & Bernardes, 2018). One model that helps us to understand these differences is the patient health engagement model (Graffigna & Barello, 2018). Our results showed that some participants are currently in the first

blackout/arousal phase and are therefore not yet able to succeed in the process of coping and regulating their emotions and the conditions of the illness. Besides, the findings indicate that fatigue has not manifested clearly and therefore is not yet a priority to patients in the initial phase of their treatment, causing lack of engagement with the goal of the intervention. One possible solution to overcome this barrier is to rephrase the explanation of the purpose of the app. Instead of framing IVY as a tool to beat fatigue, IVY should be framed as a preventive intervention to increase vitality, as a buffer against upcoming fatigue. . The Protection Motivation Theory by Rogers (1975) and the Health Belief Model by Hochbaum & Rosenstock (1952) state that people are inclined to improve their health when they experience a combination of a certain amount of both threat and severity. Empirical findings support their beliefs. Dou et al. (2017) showed that the perceived usefulness was influenced by the way users perceived hypertension as a threat. Birkmeyer, Wirtz and Langer (2021) underlined the lack of attention for health related factors such as awareness and threat. Our results support their findings and suggest that breast cancer participants are perhaps not yet fully aware of the severity and vulnerability of becoming fatigued.

Acceptability

Another aim of the study was to get insight in the perceptions users have with regard to acceptability. Acceptability showed a mixed picture, with most concerns about the effectiveness and the need for the intervention. Positive and negative perceptions alternated between users and within users during their training period and showed us that engagement is strongly changeable and not easily grasped. Our results showed ambivalence among the users between both enthusiasm and hesitation. This variation within users is well-known and also found in other CBM evaluations that revealed variability in perceived effects (Laurens et al., 2020), satisfaction (Zhang et al., 2019) and understanding (Leung et al., 2019).

Usefulness in generally linked to facilitating technology acceptance, as proposed by our model. In our study usefulness was biased by a misunderstanding of the rationale behind the intervention. Our findings revealed that users' struggled with the preventive approach of the intervention and that it was hard for them to understand how IVY could be valuable although they did not notice it explicitly. Thereby they linked the usefulness of the app to their current state of vitality and questioned the credibility of the app because they did not perceive complaints nor improvement in vitality/fatigue. These findings are confirmed by the quantitative measures, analysis of VAS-V & VAS-F showed little indications of fatigue at

baseline nor improvements afterwards. The findings in regard to credibility support the study of Beard et al. (2012), in which people required more knowledge in regard to the purpose and the relevance of the intervention. In line with other CBM evaluations (Beard et al., 2012; Yang et al., 2017) our results suggest that misunderstanding about the rationale of the intervention influenced engagement negatively. However, the findings can not easily be compared with other CBM studies since this intervention is one of the first one's who is targeted at prevention of symptoms that are elusive and not yet noticeable.

Both positive and negative affects are generally found to be important in regard to technology acceptance. In line with previous studies (Honary, Bell, Clinch, Wild & Mcnaney, 2019), our results showed that boredom and loss of motivation are two of the main reasons to disengage from technology. Some negative remarks in our study are well-known (Leung et al., 2019), CBM is marked by repetition and monotony. However, other negative remarks found in our study are uncommon and not described previously. Our results showed indication for a switch from intrinsic motivation to use the app, with a real interest in the task, to extrinsic motivation, with a feeling of reluctance. IVY did not fulfil their expectations and was therefore more of a burden than a help to them. Besides being extrinsic, their motivation was also more controlled instead of autonomous: since they had consent to use it, they felt obligated to continue. Research (Peters, Calvo & Ryan, 2018) suggest that this combination is ineffective and hinders motivation and well-being regarding user experience. An interesting question that remains is how users can be encouraged to use IVY from an intrinsic motivation. The findings suggest that some users attach great value to participate in research in general..

Suggestions to improve design IVY

Our findings clearly support the importance of app design from a persuasive perspective as suggested by Oinas-Kukkonen (2009). In line with findings by Wolbers et al. (2021), participants valued the features that helped them in seeing progress and using the app more conveniently, such as the progress bar and the reminder. In fact, users'suggestions showed a preference for more persuasive features. Their wish for more feedback and insight into progress is not remarkable, both are often mentioned in literature as factors that should increase engagement (Carter, Rogith, Franklin & Myneni, 2019; Szinay, Jones, Chadborn, Brown & Naughton, 2020). More interesting is their preference for more stimulation and challenge in an app that is meant to be monotonous to be effective. A possible explanation can be found in a theory by Hassenzahl (2010) which states that people differ in their need for

pleasure/stimulation. This theory seems plausible and may explain also why participants differed in how they valued the playing a game association that IVY evoked, the variance in which they experienced the automaticity of the task and the challenge that was needed for some of them to keep the task interesting. The key of CBM is repetition, so monotony is part of the intervention. However, we have multiple options to adapt the task without diminishing the effects. Firstly, we can add more variation into the task by offering a wider selection of stimuli. When information is considered personally relevant through activation of the self-schema (Petty & Cacioppo, 1986), information is expected to be processed deeper and richer (Rogers et al, 1999). However, our findings do not encourage this theory, participants were mostly satisfied with the current stimuli. Besides, face validity of the stimuli has been confirmed by the usability study of Wolbers et al. (2021)..Secondly, to increase variety, we can offer the task with different lengths. Thirdly, we can help the user in understanding why they have to do the same task continually. Therefore, in line with revisions of Prior et al. (2020), we suggest that the importance of the repetitive character will be explained by means of a metaphor, such as training your muscles in the gym also takes time. Metaphors are one of the main design features that are linked to positive design that influences both adherence and well-being (Ludden, Rompay, Kelders & Van Gemert-Pijnen, 2015). Positive design has gained attention in the field of UX at the expense of design that only resolves usability issues (Hassenzahl & Tractinsky, 2006). To meet this tendency, IVY can be redesigned in several ways, using theory about human motivation as a starting point. According to the Self Determination Theory by Ryan & Deci (2013) three basic human needs are important to foster self-motivation and psychological well-being. IVY can contribute to the fulfilment of these needs and this is key to this target group since their needs are undermined by cancer diagnosis and treatment (Pingree, Hawkins, Baker, DuBenske, Roberts & Gustafson, 2010). The need for autonomy was included in a previous breast cancer intervention (Fitter na Kanker) and resulted in less fatigue and a greater sense of control over one's own health (Bruggeman, Wolvers, van de Schoot, Vollenbroek-Hutten & Van der Lee, 2017).

To support autonomy in the use of IVY, we suggest that users feel the freedom to use the app in their own way, in line with their own values, as much as possible. One design feature that can contribute to this feeling is personalization. In line with our findings, research by Perski, Baretta, Blandford & Michie (2018) showed that users prefer a customized design and personalised reminders when using Mhealth. Our findings support the belief (Mohr et al., 2014) that reminders have to be align with the users' level of motivation and ability.

Reminders are important to keep users engaged and could also be adapted to the users' adherence patterns to be more effective (Fogg, 2009). To support competency, we suggest that users get positive feedback about their performance and that the app also provides them with opportunities to learn.It would be difficult to display results at the implicit level, but it is possible, for example, to display the number of errors, the time spent in one session or the days in a row that the app was used. One important point to consider is the fact that we don't want to encourage people to focus on their fatigue, this could work counterproductive. Another factor that has to be taken into account in this context is the way in which the content is presented has to fit the users' need for cognition. Our findings suggest the belief (Petty, Wheeler & Tormala, 2003) that some people enjoy deep thinking and therefore prefer more in-depth information. To satisfy this need, IVY could perhaps be combined with strategies targeted at explicit fatigue, such as action plans. In line with our findings, feedback should also be available in a combination of graphs and texts. Offering messages via multiple media contributes to learning and remembering information (Mayer, 2014) and is also positively related to engagement (Perski, Baretta, Blandford, West & Michie, 2018). To strengthen the effects of the abovementioned features, incorporation of the user's name would be interesting. Name mentioning has found to influence persuasion of messages by making the content personally relevant and thereby contribute to deep and richer processing of information. However, research by Dijkstra and Ballast (2012) showed varying results on level of persuasion, due to defensive reactions that were evoked. This possible barrier should be taken in account. To support relatedness, we suggest that users get the option to connect with IVY by means of an avatar, of which we know that this feature can contribute to engagement (Solem et al., 2020; Oinas-Kukkonnen & Harjumaa, 2009). However, use of avatars has to be weighted against the fact that this could be too intensive for breast cancer patients. Furthermore, we think that contact with the health professional can be supported by means of an integrated option for a chat or video call. In this way, the health professional can function as a coach in the use of IVY, enabling users to integrate IVY into their health care process (Schubart et al., 2011). As a result, CRF gets more awareness and patients gain more knowledge. Besides, this option could enforce the emotional bonding with IVY, as proposed by Li, Zhang, Li and Zhang (2020). In the end, this will hopefully contribute to improvement of the general well-being of patients.

4.2 Strength and weaknesses

One major strength of this study was its versatility, in which several points fortified each other. Firstly, interviews are known for their versatility (Morris, 2018), and the semi-structured interview schema and the thematic analysis, known for its theoretical freedom (Braun & Clarke, 2006) allowed space for this. Besides, flexibility and a genuine interest of the researcher in the users' experience did also contribute to a certain amount of versatility. Prompts contributed to more in depth answers and revealed for example that participants would use IVY again if they will become fatigued in the future. Guided by the first-person perspective, this research tried to see the 'experience' explicitly from the perspective of the user (Tijmstra & Boeije, 2011). Therefore, participants were interviewed in their natural environment, to get the most honest and real answers. Besides, versatility was also found in the multiple possibilities in analyses of the data. In this process, the combination of qualitative and quantitative analysis worked well and did indeed foster a richer explanation of the data. Qualitative data are known for their ambiguity and the quantitative data provided an extension of the findings from the interviews. For example, participants explained in the interviews that they trained a lot with the app, but the quantitative measures on adherence showed a contradictive picture. This example underlined the fact that qualitative measures are lacking validity and we need objective data to verify answers. Especially for abstract concepts as user-engagement, who are hard to evaluate, objective and subjective measurements are needed to fully understand results (Lalmas et al., 2014).

A second strong point of the research was the mixed-methods approach. As mentioned by Treharne & Riggs (2014), mixed-methods approach supports research in 3 ways: exploring convergences, complementarities and dissonances. The quantitative data contributed to a deeper understanding of users' attitudes and preferences as derived from the interviews. From the quantitative data we learned that users were indeed not tired at all and that fluctuations in regard to vitality and fatigue are common among this target group .Besides, the quantitative data also revealed interesting dissonances in regard to adherence to the intervention. The combination of both methods contributed to a more reliable and well-motivated understanding of the users' experience (Johnson, Onwuegbuzie & Turner, 2007).

The third strength of this study was the combination of theory about both technology acceptance and User Experience. This combination is not often used in research (Hornbaek &

Hertzum, 2017), but combines the different perspectives from pragmatic and experiential (users' emotions and experience). By doing this, this research has gained for example knowledge about how and why perceived ease of use and perceived enjoyment are interrelated. There are a lot of unclarities in the field of human-interaction research in understanding why those concepts are interrelated and under which conditions. This research contributed to the shaping of theory around these mechanisms. By doing this, this study offers a good starting point to future research in the field of technology acceptance and user experience.

The last strength worth mentioning was the combination of both deductive and inductive coding. For example, the codes 'engagement' and 'hedonic attributes' were guided by theory, while the codes 'course of disease' and 'daily life routine' emerged from the data freely. The combination of both approaches worked well because both have their own strengths and weaknesses (Linneberg & Korsgaard, 2019). Structure and theoretical relevance were guided by the deductive approach. However, this study also embraced the surprises in the data that opened new perspectives to a more coherent description and understanding of the experiences with the app from an inductive perspective.

The first major limitation of this research is the scope. This is from two perspectives a limitation of this study. Firstly, from the literature, we know that both user experience and engagement are multi-factorial, depending on a plethora of factors, and hard to measure because of a lack of standardization in definitions. As a result, results are difficult to compare to other studies. Besides, the scope is also limited by the fact that user experience is changeable and not easy to catch at one point in time (O'Brien & Toms, 2008). This research had to deal with a very specific target group, that undergoes a lot of changes that could have influenced their experience in several ways. When the participants would be interviewed later in their diagnosis, perhaps their experiences would be different. A change in perceptions of fatigue complaints due to a change in meaning of fatigue has been found in earlier research among breast cancer patients (Salmon et al., 2017) Therefore, the generalisability of the results can be questioned.

Another weak point was the coding process. This step of the study was not done efficiently, which caused delay and confusion and hindered describing the results in a coherent and structured way. Codes were too detailed, did not cover an overarching theme, and did not fit

well with the research questions. A lot of back and forward steps were needed to tackle this problem. Especially the internal and external heterogeneity of the themes (Patton, 1990) were disadvantaged by this limitation. The next time, it would be better to use two researchers for the analysis of the data and that the coding schema is checked for inter agreement in a more reliable way, such as using Cohen's Kappa (Kappa, 1960).

The last limitation is the selection bias, the results showed that a couple of participants are enthusiastic and always willing to participate in research, although they do not it for themselves. Perhaps we did not yet grasp the patients that are less inclined to search for help when they need it and the ones that are perhaps also less willing to accept new technology. Especially high-educated young women have been known to seek help to manage illness-related psychological issues in the domain of cancer (Garssen, Van der Lee, Van der Pol, Ranchor, Sanderman & Schroevers, 2016).

4.3 Recommendations for future research

Future research should evaluate the user experience at several points in time in the design process, to ensure that the intervention stays aligned with their needs and preferences. One possible addition could be the evaluation of experiences just-in-time, to get more in-depth knowledge about the cognitions, emotions and behaviour that are evoked by the intervention. A Ecological Momentary Assessment (EMA) would be appropriate to gather this information. These evaluations could also be used to investigate whether our ideas of improvement to reinforce engagement with IVY would indeed be of added value according to the target group. In this context, future research could also be focused more on how IVY can be implemented at best in the treatment process, taking into account the knowledge and experience of the health professional and the patient in regard to the flow of the treatment and the integration with interventions that are already available to explicitly address fatigue. Because engagement and effects of eHealth are supposed to be strongly connected, future research should also be focused on examining the effects of IVY on a larger scale. Focussing on patients that are less inclined to search for help and are less willing to accept technology, known as laggards, could be of special interest. Moreover, evaluating IVY among patients who are further along in the treatment process would be valuable, to find out whether these patients indeed show differences in regard to their experience and management of fatigue.

4.4 Conclusion

This study found both in-depth knowledge about the current level of engagement and insights into the assumed determinants of engagement of the users with the IVY intervention. Results of this study imply that IVY is certainly feasible and more or less acceptable to be implemented in the treatment process of breast cancer. Our findings offer clear starting points to lift up the engagement and persuasion level of the app. Factors that for sure need to be taken into account, since they could hamper a successful adoption of the app. However, the effects of the app need to be investigated to find out whether IVY would be indeed worthy to be praised by breast cancer patients. The novel and innovative approach has the potential to boost their vitality but first has to deliver on his promises.

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Appendix A

Interview scheme pilot study

1 Ervaring met de app
- Hoe heeft u het gebruik van de app ervaren?
- Vond u iets bijzonder leuk of interessant? Of iets bijzonder storend?
- In hoeverre heeft u het gevoel dat de app invloed op u heeft gehad? (iets gemerkt/veranderd?)
- Heeft de techniek altijd gewerkt?
- Hoe ging het swipen?

2 Doel van de training
Voordat de echte training in de app begint, wordt er een korte tekst met uitleg getoond.

- Wat vindt u van de uitleg van de training in de app?
  - Is het duidelijk wat u moet doen? (praktische uitvoering)
  - Is het duidelijk wat het nut is van de training? (relevantie)
- Hebt u verbeterpunten met betrekking tot de uitleg van de training?
- De uitleg was nu vooral elektronisch; wat vond u hiervan? Had u liever uitleg face-to-face gehad van verpleegkundige/oncoloog/onderzoeker?

3 Mening over huidige app
- Wat vond u van de trainingssessies in de app? Hoe heeft u dit ervaren?
- Wat vindt u positieve punten van de app?
- Wat vindt u negatieve punten van de app?

4 Lengte van de training
- Hoelang was u bezig met één sessie in de app?
- Heeft u aan 1 stuk door getraind of training onderbroken?
- Wat vindt u van de lengte van de training? *(aantal woorden; momenteel 100 per sessie)*
- In welke mate denkt u dat het aantal woorden dat u moet swipen in één training sessie invloed heeft op uw motivatie?

5 Inhoud van de training
- Wat vindt u van de woorden in de training?

6 Uiterlijk van de app
- Wat vindt u van het uiterlijk van de app? *(kleuren, naam, lay-out etc.)*

7 Motivatie in de app
- Hoe was het voor u om de app voor 14 dagen elke dag te gebruiken?
- In hoeverre was u gemotiveerd om elke dag een training te volgen in de app?
  Kunt u uitleggen waarom? Heeft u de training elke dag voltooid?

8 Aanpassingen app
- Wat zou u willen veranderen of aanpassen in de app?
- Welke elementen moeten er wel in en welke juist niet?

9 Nut van de app

- Heeft u het gevoel dat de app nuttig kan zijn in uw situatie?
  Kunt u uitleggen waarom?

10 Aanbieden app
- Wat vond u van het moment van aanbieden van de app?
- Was u hier tevreden over zoals het nu was over of zou u dit anders willen zien? Licht toe.

11 Professionals
- Wat heeft u terug gekregen van de dokters en verpleegkundigen over de app?
- Wat vond u hiervan? In hoeverre zou u iets anders willen zien?

12 Omgeving
- Heeft u met anderen uit uw omgeving gedeeld dat u bezig was met trainen in de app?
- Wat was de reactie van mensen uit uw omgeving hierop? Wat heeft dit opgeleverd?

13 Vervolg
- Bent u van plan de app langer te gaan gebruiken, na afronding van dit onderzoek?
  Licht toe waarom wel/niet.   (*mag wel als ze dit willen*)
- Zou u de app aan andere patiënten aanraden? Waarom wel/niet?

14 Afsluiting
- Heeft u nog overige opmerkingen over de app?
- Zijn er dingen die u nog wilt bespreken die nog niet genoemd zijn?
- Hartelijk bedankt voor uw deelname aan ons onderzoek
- Presentje als dank

Appendix B

Coding scheme

Code	Second level code	Third level code	Corresponding quote
1. Attitudes towards use of IVY	Ease of use		De app was wel heel gebruiksvriendelijk vond ik. Ik denk dat je het goed kan snappen, want het is maar swipen he.
	Usefulness	Precondition	Ik denk wel dat je zelf ook een initiatief moet hebben, dat je zelf denkt van het is voor mij eigen welzijn, ik moet wat doen.
		Perceived	Ik snapte het doel ook niet helemaal, hoe ik daar minder moe van zou moeten worden.
	Perceived effect	Vitality/fatigue	Nee er is weinig veranderd.

Ja, ik denk het wel maar dat vind ik lastig om te zeggen. |
| | | Other effects | Af en toe sta je er wel bij stil inderdaad dat je denkt van oh het is niet alleen maar negatief.

Het stimuleert wel om inderdaad bezig te blijven. |
| | | Intention | Maar ik heb niet zoiets van ik zou het nu doorgebruiken bijvoorbeeld |
| | | Recommendation | Ja, onder het mom van mij heeft het niet zoveel {…} maar probeer het gewoon eens, |

			misschien brengt het jou wel wat.
	Satisfaction		Soms wel een beetje als een last dat ik het moest doen. Eigenlijk had ik het idee dat ik moe was en dat moest ik dan toekennen aan de ander dat was heel dubbel, dus dat was heel vreemd.
	Engagement	Behavioral	Hij zit er nu in bij mij, een beetje in mijn systeem. Dan denk je er wel aan.
		Cognitive	Waren het steeds 100 woorden? ZO heb ik het niet ervaren, dat het er zoveel waren, absoluut niet.
		Affective/emotional	Nou ik denk dat zo'n appje voor mij niet geschikt is. Ik zou dan liever persoonlijk contact of, ja in een gesprek dus niet via een app. Dat is dan niet mijn ding.
	Motivation to use IVY	Intrinsic	Ik zag het vaak ook wel als een uitdaging om het foutloos en zo snel mogelijk te doen, daar had ik wel zin in.
		Extrinsic	Nja goed ik kreeg elke dag een melding, […} want ik heb daar in toegestemd. Maar voor mijzelf had het niet gemoeten.

		Reasons for demotivation	In het begin wel veel, […}op het eind was het wel echt een beetje zo van dat moet ik nog doen. Toen was ik niet meer zo gemotiveerd.
	Time investment training		Dat ging eigenlijk heel snel, een keer 10 minuutjes misschien.
	Length of training		Die is goed, de lengte vind ik wel goed. Het is niet te lang in feite.

2.User characteristics	Personality trait		Ik ben van nature al positief en niet iemand die bij de pakken neer gaat zitten en zegt oh ik ben zo moe en ik voel me zo slecht.
	Experience with technical devices/applications		Ik ben wel van de telefoon en dat soort dingen ben ik altijd heel makkelijk mee
	Expectations about IVY app		Ja ik had eigenlijk geen verwachtingen, want ik wist helemaal niet wat voor soort app het was, dus dan ga je eigenlijk al wel blanco in Nou iets meer van, omdat het met name om de vitaliteit gaat, had ik misschien ook meer verwacht, misschien dat er dagelijkse oefeningen meer lichamelijke oefeningen zeg maar in zaten.
	Relevant experience, knowledge and skills		Ik vond het wel heel duidelijk. Ik zit gewoon in die teksten en zo, dat komt mij niet onbekend voor, daar ben ik gewoon volop mee bezig.
3.System IVY properties	Functionality	Usefulness features	Ook die afsluiting elke dag weer leuk van tot morgen, dus dan heb je er al weer zin in. Ja dat is heel goed vind ik.

			Ik vond af en toe als ik dan veeg met die woorden, dan pakte die het niet heel goed. Ik weet niet, kun je dan zien dat het langer duurt, want dat was gewoon dan valt die als het ware een beetje weg
	Design	Visual	Ja vond ik leuk, vrolijke kleuren, wel uitnodigend. Goeie kleuren, ook niet te vrolijk of te overdreven
		Functional	Als je begint dan moet je invullen van moe en vitaal. En voor mijn idee staan die precies verkeerd om. De bovenste lijn schuif je dan bijv. naar gem. 5 en doe je die onderste ook, maar eigenlijk staat die net andersom
	Explanation of training in app		Maar op zich was de uitleg duidelijk genoeg, ik had niet zoiets van dat daar een andere uitleg bij moest.
	Use of words in app	Amount	Ja het moeten er echt niet meer zijn, die hoeveelheid was wel de max.
		Relevance	Ja goeie, heel duidelijk en echt wel wat je ook moet blijven en wil zijn eigenlijk.
		Variation	Alleen is het volgens mij vitaal, fit vermoeid en dank denk ik dat er nog 3 andere

			woorden bij zaten dat is het dan wel zeg maar.
		Option for personalization	Ja dat is misschien wel een hele goeie, dat je aan de hand van een gesprek met iemand de woorden bepaald {…} en dat je aan de hand daarvan traint
4. Contextual factors that influenced use/experience of IVY	Social interaction about use of IVY	Family/friends	Ja met mijn gezin wel in ieder geval en ik heb mensen wel gezegd dat ik mee zou doen.
		Doctors/nurses	Ja de dokter heeft mij netjes nog een berichtje gestuurd dat ik met de app gewerkt had en dat jij mij berichten zou. Nee heel netjes.
	Illness related factors	Course of disease	Maar ik heb ook een andere kuur gekregen sinds vorige week en daar word ik ook vermoeider van. En de eerste kuur was natuurlijk al heel pittig, dat was 2 van die heftige die ik heb gehad en die dus niet wat heeft gedaan.

		Impact of disease	Weet je als die kuur net een paar dagen geleden hebt gehad dan ben je wel iets vermoeider en dan ben je daar in principe minder mee bezig.
	Pilot study related factors	Moment of introduction of IVY	Ja die eerste dan ben je ook echt wel met die kuur bezig […} en dat is wel fijn om daar even die rust te hebben […} dat was wel echt een goedgekozen moment.
		Value of research	Nou het was prima om te doen, ook vooral omdat je weet dat je mensen daar misschien mee helpt.
		Way of introduction IVY	Ja misschien dat de oncoloog er iets meer over had kunnen vertellen, maar op zich denk ik niet dat iedereen er nog op zit te wachten om nog een afspraak te hebben.
	Daily life routine		Ik kreeg wel heel goed een pop-upje weer van denk aan je sessie, maar dat was dan net zo'n tijdstip dat ik dacht, oh ik moet net mijn kind naar bed doen, dus zo komt dat net niet uit dan dan vergeet je het toch wel weer.

5. Suggestions for IVY 2.0	System		Maar ik zou bijna nog meer woorden kiezen, of eh misschien moet je het soms wel bijna in een kruiswoord kiezen dat je er, weet ik veel, meer een spel van maken.
	Implementation		Dus ik zou hem dan bij de 3^e/4^e beetje het moment waar ik nu zit, daar zou ik hem dan eerder aanbieden dan helemaal aan het begin.
6. Hedonic attributes IVY	Stimulation		Het is niet interessant, het is niet van nou ik ga eens kijken wat ik vandaag nou weer krijg. Het is 14 dagen lang hetzelfde riedeltje, het wordt een beetje saai.
	identification		Op een gegeven moment voel je dat die woorden bij jouw passen
	evocation		Ja, omdat je eigenlijk die dingetjes op de

			plek moet schuiven zeg maar, dus dat leek meer op een spelletje dat idee kreeg ik er elke keer bij.
7. Miscellaneous comments	User related		
	Illness related		
	System related		
	Research related		

Appendix C
Persona's based on user-groups

Barbara(44) represents the <u>persuaded</u> <u>embracers</u>

Barbara underlines the importance of vitality. She likes to go for a long walk in the forest with her dog. With her positive vision of life, she tries to stay positive in the current life changing period. She could use a little help with that sometimes. Since Barbara has a lot of appointments in the hospital, she is searching for a low threshold manner in which she can improve her vitality level, at her own pace and at moments that are appropriate to her. A smartphone app would fit to her preferences, because it is accessible at any place and time. Her lack of technical skills would not be a barrier to use it, her husband and children are always willing to help her out if necessary. Because she has a strong belief that a app could improve her level of vitality, she does not need to know if the app has influenced her directly. Nevertheless, she is curious to know if the app is effective and how she can use the app to benefit the most from it.

Cindy (45) represents the <u>undecided engagers</u>

Cindy does not yet understand why she has to improve her vitality. She feels well at the moment and is able to do her regular daily activities. Running is no longer possible, but she never skips her yoga class on Monday's. She could imagine that a smartphone app would be an addition as it would stimulate her to stay active. She likes to see progress and a smartphone app can perhaps help her in getting insight and support her in finding the right balance when she will become fatigued in the future. However, at this moment she is content with the support that she gets from friends and family.

Wilma (42) represents the <u>disappointed skeptics</u>

Wilma can not believe why an app would help her in becoming more vital. She is quickly distracted and needs more stimulation and challenge than a simple, monotonous swiping game. When she does not understands why she is doing the things she does, she gets frustrated and loses motivation. She prefers autonomy in her choices and would not use a app against her own will. In her opinion, apps should be tailored to different kind of users and target groups to benefit the most from it.

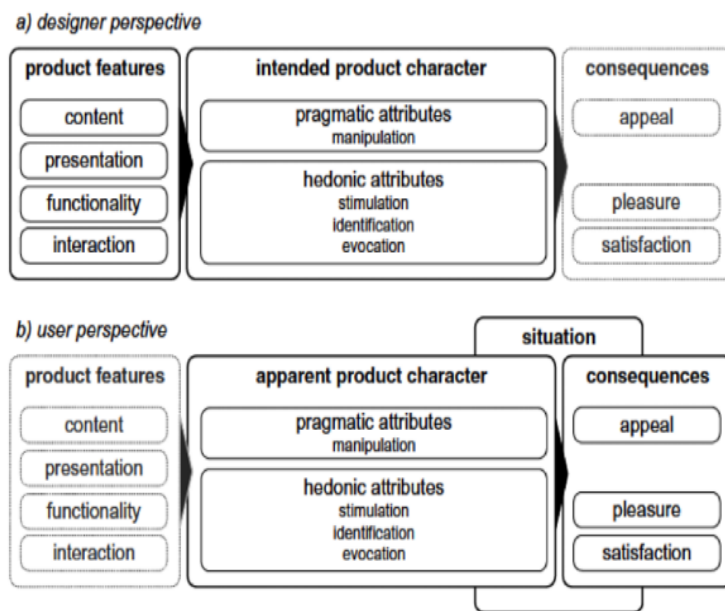# Appendix D:
Theoretical models UTAUT & Hassenzahl

Figure 7

Unified Theory of Acceptance and use of Technology 2 (Venkatesh, Thong & Xu, 2012)

Figure 8

Hassenzahl's model of User Experience (Hassenzahl, 2003)

Appendix E
Tables with facilitators and barriers mentioned in interviews

Table 4

Facilitators mentioned in interviews

Strong point	Example quote
Low threshold character	It takes no effort at all. You only have to push two times on a button to start the app and after 5 minutes you're finished (P16)
Easiness of use	It is easy to do, handy, everyone should be able to use this (P3)
Visual attractiveness	The design is nice, fresh, young and not boring (P16)
Reduction in lay-out	Very sleek and clear (P4)
Length of sessions	Oh really, 100 words? I did not experience it like that (P3).
Reminder	I liked the fact that I received a reminder every day at 8 (P18).
Explanation in app	That was simple, it was clear to me, you did a good job (P6)
Praise	I liked the closing at the end of the day, that invites you to do it again (P4).
Self-monitoring	I liked the bar, to see your progression in the session (P9)
Performance feedback	I liked the function of the red colour in case of a wrong answer (P11)
Supportive function	It was a support to me, since it returned every day, it gave me a boost (P18)
Sound and colours	Also the combination of the buzz and the light, that was fine (P17)
Nice/good/pleasant in general	I liked the app in general, especially during the heavy chemo (P5)

Table 5

Barriers mentioned in interviews

Weak point	Example quote
Lack of variety in words	It could be 100 words, but there are a lot of the same words that come through (P8).
Lack of challenge	When I was tired it lasted longer and when I was distracted I made a mistake, but no there was no challenge at all for me (P10).
Inappropriate stimuli	I never use 'dull', so I really had to think about that word (P6)
Lack of variation in praise	I would do more variation in the basic line of well done, see you tomorrow (P6).
Technical issues	Sometimes when I swiped those words, then it lasted longer, as if it the app got stuck (P4)
Lack of expertise in explanation	The rationale behind the app could be explained a bit more in detail (P2)
Lack of appeal	I did not like anything at all, every day you had to swipe the same words, again and again for 14 days (P8).
Lack of stimulation	Meanwhile, when the same words passed by again, I thought well look at what's on television (P16).
Burden in general	In the end I didn't want to do it at all, I felt relieved when I was finished (P13)

Appendix F

VAS-scales

Participant 14

Participant 18

Participant 2

Participant 17

Participant 16

Participant 6

Participant 13

Participant 5

Participant 15

Participant 8

Participant 11

Participant 9

Participant 3

Participant 4

Participant 1

Participant 10

Participant 7