Bachelor Project Report

Building a Gamified Habit Application

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Abstract

A large part of human behaviour is a function of habits, and thus habits have a notable influence on the well-being of the individual. Although many mobile applications claim to support habit formation, there is a lack of habit applications that are based on theory of habit formation. Gamification shows promise for supporting long term behaviour change such as habit formation but is not prevalent in habit applications. Gamification is a relatively new trend that focuses on applying game techniques to non-game contexts in order to provide motivational benefits. This paper intends to elicit the design of an application that aims to support the formation of habits. Two literature was therefore conducted on habit theory and gamification. Based on these results, an initial set of requirements and a prototype was created. This prototype was used to gather feedback from three potential users leading to nine final requirements grouped into four major categories concerning the daily tracking of habits, long term goals, implementation intentions and rewards. An MVP of the application was developed based on these requirements, the prototype and user feedback.

Contents

Chapter 1

Introduction

> ”We are what we repeatedly do. Excellence, then, is not an act, but a habit.”
> —Will Durant, The Story of Philosophy (1926)

Our everyday life is full of habits: Wide-ranging activities from what we eat and and drink to more complex behaviours such as social interactions and work. Early habit believer and psychologist William James estimated that ”99%, or, possibly, 99.9% of our activity is purely automatic and habitual”. Recent studies show that this assessment is somewhat more pessimistic at approximately 43%, but it nonetheless means that a larger part of our lives is a function of our habits (Mazar & Wood, 2018).

The implication is that if we can form new positive habits or change our existing habits for the better, we can improve our social relationships as well as our mental and physical health. For example, many healthcare interventions requires the regular taking of medicines to get optimal treatment. Medical compliance, however, is often subpar often because of forgetfulness (Unni & Farris, 2011). This can result in serious health risks for the individual, but also cause a very high economic cost to society, e.g. by increasing number of hospital admissions. Helping patients form a habit of taking medicines could alleviate the problem of medical non-compliance (Verplanken, 2018).

Many applications in the mobile application stores (e.g. Apple's App Store or the Google Store) claim to support habit formation and maintenance. A review of habit formation apps by Stawarz et al. (2015) identified 115 apps, but only a very limited subset of those habit applications utilised functionality based on established theory of habit formation with most applications only providing basic task tracking. They concluded that the findings ”(...) suggest a lack of understanding of habit formation and its role in supporting behaviour change”.

Another under-utilised functionality used by habit applications are game elements. Gamification has not only had the predominant focus in health app industry (e-Health) (Lister et al., 2014), but across a range of fields e.g. business, education and marketing (Sardi et

al., 2017). The use of gamification promises *"(...) to motivate and increase user activity and intention"* (Deterding et al., 2011) which, if applied correctly, could foster long term behaviour changes such as habit formation (Rigby, 2015).

1.1 Research Question

The above presents a unique challenge to design and build a mobile habit application grounded in contemporary habit theory with utilisation of gamification. The goal of this project will be to have a working Minimal Viable Product (MVP) of such an application. To do this the following research question will be answered:

RQ: Leveraging habit theory and gamification knowledge, how can we design a user-centred application that aims to support the formation of self-selected habits?

Chapter 2

Background And Related Work

In the following sections, the necessary theory and knowledge that forms the basis of the initial application requirements will be presented. First, a brief introduction to Self-Determination Theory (SDT) as SDT is an integrated part of habits and gamification knowledge. Then an introduction to contemporary theory of habits will be described followed by the topic of gamification. Finally, work related to this study will be presented.

2.1   Self-Determination Theory

Self-Determination Theory is an empirical based theory of human behaviour and personality development. It is concerned with the (social) conditions that facilitate or hinder psychological growth, engagement, and wellness. SDT assumes that the human nature is to be curious, social, physically active, to learn and obtain skills, to gain mastery of both their inner and outer worlds. The theory can be applied to a wide variety of life's domains e.g. learning, work and health. In later years it has become a key framework for health behaviour interventions and studies (Johnson et al., 2016). SDT is concerned with two central concepts to explain behaviour and human development: motivation and our basic psychological needs of competence, autonomy and relatedness (Ryan & Deci, 2017).

2.1.1   Motivation

Motivation can be defined with regards to two dimensions: it is having the energy to take action and then moving that energy in a specific direction (Ryan & Deci, 2017). According to SDT human motivation is not homologous, there exist several different types of motivation on an autonomy-control continuum. This spectrum ranges from forms of motivations that are fully autonomous and reflects an actor's inner interest and values to other forms of motivations that are entirely external, e.g. when the actor is coerced or pressured into doing

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an action the actor does not value. These different motivation types afford different quality of persistence, performance, and health benefits of actions. Roughly, there exists three forms of motivation: Amotivation, which is the lack of motivation to do an action. Intrinsic motivation is when behaviour of the actor is (autonomously) driven by the behaviour itself, either because of interest, aligned internal values, satisfaction or enjoyment of the activity. Importantly, intrinsic motivation is what drives most cognitive and social development (Ryan & Deci, 2017, p. 99). Finally there is extrinsic motivation which is most nuanced as it is regulated in a number of ways. Generally, an actor is extrinsically motivated when guided, pressured or coerced externally e.g. by chasing rewards, avoiding punishment or complying to social standards or demands. When this is the case, behaviour is said to be *externally regulated* (Ryan & Deci, 2017; Deci & Ryan, 2000).

2.1.2 Basic Physiological Needs

An important proponent of SDT is the identification of the three psychological needs which are facilitators of intrinsic motivation (Ryan & Deci, 2017). If satisfied, these psychological needs leads to personal growth and well-being, otherwise to psychopathology. These are competence, autonomy and relatedness. Competence is the innate need to experience mastery and be challenged. It is the need to feel effective and successful in one's environment. The need emerge from the inherent pleasure and satisfaction that accompanies a challenging activity. To experience a true sense of perceived competence, the actor must feel ownership of the activities at which they succeed. Consequently competence is very much tied to the need of autonomy. Autonomy is the need to perceive choices and self-determine a choice rather than being coerced or compelled by external forces. Autonomous actions are characterised by actors using their full resources in terms of energy, talents and creativity to perform the activity. Finally there is the need of relatedness, which is to experience care for others and from others, to feel responded to, respected and important. A person's behaviour can often be explained by the need to feel accepted and approved by different social groups (Ryan & Deci, 2017). In contexts where these three psychological needs are supported (and especially autonomy and competence) intrinsic motivation is supported as well.

2.2   Habit Theory

The following sections give an overall introduction to habit theory starting with a definition of habit as a human phenomena within the field of psychology. Afterwards a model for habit formation is presented followed by the determinants of habit formation. It is these factors that conceivably can be used to define a set of requirements for the application that supports habit formation. It should be noted that more factors for habit formation exists than presented here. Only those that was able to be integrated as application requirements has been included.

2.2.1   Definition of Habit

So what is a habit? Lay recognition of habit is some behaviour that may be unintentional or uncontrollable, because it's something we always do in a given situation – "I can't help it, it is just a habit". Within psychology, most researchers agree on the definition of habit: A habit is a consistent repetition of a behaviour enacted automatically in response to cues in a stable context (Mazar & Wood 2018; Lally & Gardner, 2013; Lally et al. 2009; Wood & Neal 2007)

Following this definition, a 'habit' is a special kind of behaviour with key defining features: habits are automatic, and habits are dependent on a stable context (i.e. environment). The automaticity feature of habits can be understood as automatic responses with specific characteristics: these responses are goal-independent, stimulus-driven, unconscious, efficient, fast (Marien et al., 2018). Goal-independence implies that a habit can function without intention or conscious awareness of the person performing the habit. As such, established habits can conflict with the goals of a person. Such a habit is sometimes colloquially called a 'bad habit'. A goal can vary in complexity, abstractness and accessibility to consciousness, e.g. the implicit goal of 'eating to survive' or the more concrete goal of 'arriving at the workplace at 9 am'. In this case, a 'bad habit' could be understood as the habit of snoozing the alarm when waking up, which contradicts the goal of getting to work on time. While habits are independent of goals, they do interface with goals in different ways. For example, many habits begin as the initial pursuit of some goal such as eating healthier (Wood & Neal, 2007). When the characteristics of habit automaticity are said to be unconscious, efficient and fast, it relates to mental processing required for the behaviour to be executed. In case of habits, when a person receives a stimulus or cue the corresponding response is not effortfully

calculated, but instead retrieved from memory (Mazar & Wood, 2018). The stimulus-driven nature of habits means that habit performance is dependent on cues in a given context. A broad range of cues exist, and potentially any contextual feature can become a cue (Gardner & Lally, 2018): Internal states such as mood can act as cues, so can environmental factors such as physical location, time of day and social context. Abstract representations such as "at work" or "at the bar" and preceding actions leading up to habit performance can also act as cues. If the context is stable (i.e. the cues in context are consistent), then repeating a behaviour in response to a cue develops the cue-behaviour associations (also called 'habit associations') necessary for habit formation (Mazar & Wood, 2018).

2.2.2 Habit Formation

How long does it take to form a habit? And what can be done to promote habit formation? Generally, there is a lack of empirical evidence of habit formation (Gardner & Lally, 2018). At the time Lally et al. (2009) conducted a study on the habit formation process in individuals and the time it takes to form a habit, they reported that they were not aware of any other studies that investigated these issues systematically. In this same study, where 96 participants were asked to do a healthy behaviour of their choosing that they'd like to make a habit, it took the participants an average of 66 days to form the habit with a range of 18-254 days (the study lasted 84 days). This estimated average, however, is very uncertain due to several study limitations e.g., the varying characteristics of different habits and limited number of study participants.

Generally, a habit forms when a person repeatedly acts in the presence of contextual cues. Gardner & Lally (2013) has proposed a model of the habit formation process to understand it better and the factors that influence it. The model consists of four stages and is illustrated in figure 2.1.

At stage 1 (deciding to act), the actor decides on performing a new action, which can result in intention formation about doing the action. At stage 2 (self-regulating), the actor organises resources that translate intention to action (e.g. by planning) potentially leading to action initiation. Stage 3 is distinguished in stage 3a (repeating behaviour) and 3b (developing cue-behaviour associations) which can happen concurrently. If the action is merely repeated the actor is at stage 3a. If, however, the action is repeated such that it develops cue-behaviour associations (i.e. context dependent repetition) the actor is at stage 3b culminating in habit formation. As can be seen from from the model, the actor may revert to earlier stages in the
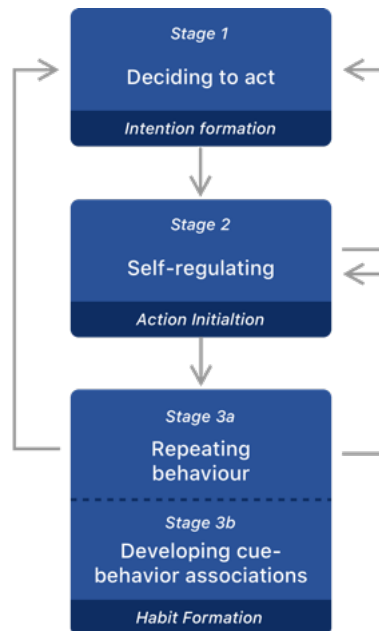
Figure 2.1: A framework for understanding habit formation and its determinants by Gardner & Lally (2013)

habit formation model e.g. if experience of repeated action (stage 3a) does not yield desired outcome and intention formation weakens (Gardner & Lally, 2013). Factors that influence the habit formation process can operate at multiple levels in the model.

2.2.3 Influencing Factors on Habit Formation

Planning

Planning can be used to translate intention into action and thus has an influence on the habit formation process. Planning helps actors remember to act on their intention in a given context (stage 2 of the model above), and can further help strengthen cue-behaviour associations (stage 3b of the model above) (Gardner & Lally, 2018). There exist several types of planning: 'Action planning' where actors specify behaviour in a given situation. 'Coping planning' where actors identify difficulties that hinder action and forms concrete plans to deal with these situations. A more rigid type of action planning called 'implementation intentions' are plans structured by if-then rules such that the explicitly link a cue with a behaviour (thus supporting stage 3b). An example of such an implementation intention is 'After I wake up (the cue), I will go take a run (the behaviour)'. Implementation intentions

has been shown to promote habit formation (Lally & Gardner, 2013), but the effectiveness of the plans depend on factors such as used cues, self-control and motivation (Wood & Neal, 2009). However, planning can play an important factor in the earlier stages of habit formation. For example, they can be an effective tool in shielding the initial development of a new habit or breaking an unwanted habit from conflicting thoughts and feelings (Gardner & Lally, 2018). Despite this, implementation intention are not effective for strong antagonistic habits such as excessively unhealthy eating or smoking (Carden & Wood, 2018).

Cues

The model described above reflects the importance cues have on the habit formation process as cues in stable context together with repeated action potentially lead to habit formation (stage 3b). Changing or setting up cues, i.e. *environment engineering* can be a powerful tool for habit formation and habit change (Carden & Wood, 2018; Wood & Neal, 2009). Cues can however have different properties that make them more optimal for facilitating habit formation. Cues that are salient such as event-based cues (e.g. 'waking up' or 'going to work') might be more effective than time-based cues (e.g. 'at 9:00 a.m.'). Distinct events in daily life that are unlikely to be missed may thus be effective cues for implementation intentions (Lally & Gardner, 2013). Preceding actions as part of a routine (e.g. 'preparing for work') can act as effective event-based cues for a new behaviour as well. The effectiveness of cues for cue-behaviour association might also be dependent on how many (if any) existing behaviours are linked to the cue. The strength of association between cue and behaviour may be inversely correlated with number of other behaviours associated with cues (Gardner & Lally, 2018).

Consistency and Complexity of Behaviour

Consistent repetition of action is important for habit formation (stage 3a), but frequency less so (Gardner & Lally, 2018). A behaviour does not need to be performed everyday to become a habit (e.g. going to the gym two times a week). Complexity of habit is roughly defined by how many steps the habit action consists of and how difficult those steps are to complete. As such, simple actions are faster at becoming established habits compared to complex actions (Lally & Gardner, 2013).

Motivation

In the section SDT the concepts of motivation and the three basic psychological needs (competence, autonomy and relatedness) were introduced. The habit formation process may be facilitated by intrinsic motivation, which can work on all stages of the habit formation

model. Intrinsic motivation can help foster the initial intention to act (stage 1), facilitate translation of intention into repeated behaviour (stage 2 and 3a) and easier develop cue-behaviour associations that is vital for habit formation (Lally & Gardner, 2018). As noted in section 2.1.2, supporting the basic psychological needs also indirectly supports the habit formation process by promoting intrinsic motivation.

Rewards

Early habit research concluded that rewards facilitated habit formation as rewards increase the likelihood of behaviour repetition (stage 3a) (Lally & Gardner, 2013). However, rewards have a more nuanced role in the habit formation process. As with motivation, rewards can be divided into two classes: extrinsic (tangible) rewards and intrinsic rewards. Examples of extrinsic rewards are money, praise or symbols of status while intrinsic rewards are pleasure or satisfaction. Important properties of extrinsic rewards on habit formation are whether they are anticipated after some action and where the reward is contingent on performance of that action (Deci et al., 2000). While rewards (both intrinsic and extrinsic rewards) can help motivate stages 1-3a, extrinsic rewards tends to lead to goal-directed automatic action, where cues become associated with the reward along with behaviour in stage 3b. As noted, habits are goal independent. Goal-directed automatic behaviour likely discontinue following devaluation or removal of reward, while habitual behaviour does not (Carden & Wood, 2018; Gardner & Lally, 2018). Furthermore, it has been shown that extrinsic rewards can hinder the habit formation process by reducing intrinsic motivation to continue doing behaviour if no reward is provided (Lally & Gardner, 2013). If extrinsic rewards are to be used to facilitate habit formation they should inherit certain characteristics. Extrinsic rewards should not be contingent on performance e.g. by rewarding after a certain action or providing bigger rewards for better performance. Consequently rewards should appear random in timing and size to develop cue-behaviour associations rather than outcome-oriented associations (Lally & Gardner 2013, Wood & Neal, 2009). Intrinsic rewards likely promotes habit formation (Gardner & Lally, 2018). Mere performance of an action may be intrinsically rewarding, e.g. by the satisfaction from completing a workout, thus promoting habit formation at all stages. For external influencers (such as an mobile health application or a personal trainer) it can be difficult to instil intrinsically rewarding behaviour. Here it is important to provide gentle guidance on healthy behaviours and let actors decide themselves which behaviours they would like to establish as habits, thus supporting their autonomy (Lally & Gardner 2013).

Feedback

Feedback can take several forms and can have an impact on the habit formation process. External positive feedback on performing new behaviours encourages autonomy and competence of the actor which supports intrinsic motivation (Lally & Gardner, 2013). Self-monitoring is a form of internal feedback where an actor is asked to record some property of their behaviour. For example, if a new behavioural goal is drinking more water during the day, the actor could record how many glasses of water is consumed each day. This can make it easier to recognise compliance with behavioural goal in the early stages of habit formation and remind the actor to adjust behaviour if conflicting in stage 3a. Lastly, considering previous milestones for a behavioural goal can support the need for competence. Later dissatisfaction can be avoided by ensuring future milestones are realistic, while also rewarding for the actor when milestones are passed (Lally & Gardner, 2013).

2.3   Gamification

Throughout history mankind has played games, from the ancient games of backgammon and chess to the modern age of digital gaming providing us with new experiences of digital worlds to explore and challenges to conquer. We devote considerable amounts of focus, energy and attention to games with unparalleled intensity and duration (Deterding et al., 2011). The promise of gamification is to be able to provide the same level of engagement from full-fledged games to other contexts to make non-game activities, products and services more enjoyable and engaging as well. In terms of SDT, the promise of gamification is to support intrinsic motivation as games has been shown to motivate intrinsically (Sardi et al., 2017). In the following sections the topic of gamification will be introduced. First a definition of gamification is presented followed by usage and effectiveness of gamification within the health domain. Then a taxonomy of gamification techniques related to SDT is presented.

2.3.1   Definition of Gamification

Gamification has been a topic of interest from various diverse areas of research such as Psychology, Education, Business, Medical sciences and more (Hamari et al., 2013; Deterding et al., 2011). The most widely accepted definition of gamification' within many of these fields comes from Sebastian Deterding et al. (2011) from the field for Human-Computer Interaction. They offered the following definition: "Gamification is the use of game design

elements in non-game contexts" (Deterding et al., 2011). Deterding et al. (2011) explicate this definition in terms of the core parts of the definition: 1) 'Gamification' relates to games, where actors pursue discrete goals and outcomes structured by playing rules. 2) Gamified applications incorporate game design mechanics characteristic to games, i.e. elements that are found in most games. 3) Gamified applications are not limited to gaming contexts, i.e. users don't have the mindset of using the gamified application to play a game. They are used regardless of specific usage intentions and context. The divide between full-fledged games (i.e. games for entertainment purposes), serious games (i.e. games for non-entertainment purposes) and gamified applications is not clear. What may distinguish gamified applications from the former are that they provide 'flickers' of playful experience in between functionalist modes of usage (Deterding et al., 2011).

2.3.2 Prevalence and Effectiveness of Gamification

Usage of gamification in different domains is as widespread as it is studied in different domains of research (Hamari, 2013). One of the earlier examples of applications employing gamification is Foursquare. This local search-and-discovery application provides users with recommendations based on prior search history and previous check-ins at local places (e.g. the local coffee shop or gym). To motivate check-ins, Foursquare implemented several game mechanics such as badges, points and leaderboards. Since then a whole multi-billion dollar industry around gamification has arisen, with other products and services employing gamification to promote desired behaviour change in users (Walz & Deterding, 2015, p. 3). Within the domain of habits applications, Starwarz et. al (2015) identified that 17% of their sample of 115 habit applications used game mechanics such as points and rewards. One of the more prominent examples of gamified habit applications is Habitica, a role-playing game (RPG) style habit application, where users create an avatar, which they can customise with various items and abilities.

While some studies exist on the effectiveness of gamification on habit formation (Clarke, 2017; Iurchenko, 2017), no systematic reviews have been conducted. Widening the scope to gamification prevalence in mobile health applications, two notable reviews report conflicting results with Edwards et al. (2016) reporting that only 4% of health applications included gamification (systematic review), contrary to Lister et al. (2014) who concludes that use of gamification in health and fitness applications has become common with at least 52,5% of apps containing elements of gamification. These conflicting conclusions might be because of

a different definition of gamification techniques. However, both studies highlight that applications don't follow industry standards or theory of human behaviour, and more research is needed to know the effect of gamification on health outcomes (e.g. physical exercise, medication adherence, diet adherence).

Widening the scope further to gamification implemented in all manner of technologies and not just mobile applications, the effectiveness of gamification on health outcomes has been studied in two prominent systematic reviews by Sardi et al. (2017) and Johnson et al. (2016). These reviews highlight existing evidence of the positive effect gamification can have on health outcomes with Johnson et al. (2016) reporting that 59% of studies documents a positive effect and 41% a neutral or mixed effect. Despite reporting positive effects of gamification on health outcomes, both studies are cautious about their conclusions and similar to reviews done by Lister et al. (2014) and Edwards et al. (2016) concludes more research is needed.

2.3.3   Gamification Techniques and SDT

Ultimately, a major challenge facing gamification in a health context is its long term viability: gamification systems must be designed with theory of human behaviour and motivation in mind to bring about the promise of sustained engagement (Sardi et al., 2017; Lister et al., 2014). Another challenge is implementing gamification with user experience and usability in mind, as several studies documented poor user experience of gamified apps, leading to users ceasing using them (Sardi et al., 2017; Johnson et al., 2016).

Several Gamification Frameworks exists for developing gamified solutions (Mora et al., 2017). One of the most prevalent approaches to gamification is presented by Zichermann & Cunningham (2011). However, this work has been criticised for having a simplistic view on the effects of gamification (Deterding, 2011; Bogost, 2011). It largely ignores theory of human behaviour and motivation, stating that merely adding gamification techniques to some product will lead to increased user engagement and desired user behaviour regardless of context. Later efforts has been made to rectify the issues of integrating gamification and theory of human behaviour, with Self-Determination Theory (SDT) commonly being a guiding underlying theory (Mora et al., 2017). This includes how different gamification techniques relate to the three basic psychological needs of competence, autonomy and relatedness (Rigby, 2015, pp. 130-131). In the following some common gamification techniques are presented along their relation to SDT.

Challenges, Goals and Quests

Challenges are at the core of gamification (Anderson, 2011, p. 157; Alsawaier, 2018). They cater to the human need for competence, i.e. our need to feel challenged and experience mastery as a result of being challenged (Mekler et al., 2017). We naturally seek these challenges to exercise and extend our capabilities (Deci & Ryan, 2000). In the context of gamification, challenges are some abstract objective a user wish to obtain, e.g. "become more fit", "become richer" or "read more". Then there are goals or quests, which are clear concrete objectives or little tasks the user can do progress towards mastery of a challenge. Example of goals are "run 3 km each day", or "read a book each month". According to Anderson (2011, pp. 155-167), these goals must come from an underlying challenge that is intrinsically motivating to the user. Meaningless goals merely nudge users to earn as many points or badges as they can. Additionally, designers should inspire users to chose intrinsically oriented challenges, where focus is on personal growth, health and developing stronger social bonds as these are aligned with the basic psychological needs. Extrinsically oriented challenges, i.e. challenges that pursuit materialistic gain (e.g. "become richer" or "collect most badges and points") are associated with poorer well-being and less engagement (Rigby, 2015).

Another important aspect of goals and challenges is that they should support the basic need of autonomy, as a feeling of competence will not increase intrinsic motivation if not accompanied with a sense of autonomy (Mekler et al., 2017). Thus, users should be able to freely chose or modify goals; forcing goals on users can result in a loss of motivation. Furthermore, successful game design should allow a user to try multiple times to achieve success with some goal (Alsawaier, 2018). It should be noted that the terms "challenge", "quest" and "goals" are used interchangeably in literature.

Feedback

Feedback is the mechanism by which users can know how they are progressing on their goals or challenge. It is the operationalised and visual expression of a user's competence in the system and it offers users personal data they can use for reflection and correction (Anderson, 2011, p. 180). As such, feedback can satisfy the user's need for competence (Mekleret al., 2017). Several gamification feedback techniques exists including (Mekler et al., 2017, Francisco-Aparicio et al., 2013; Sailer et al., 2013):

- Statistics: Interesting metrics related to some goal of the user.

- Progress bars: Can show the user how far they are from reaching a goal.

- Performance graphs: A visual representation of statistics. Can show the user's performance related to prior performance or performance of others.

- Report cards: Contains a conclusion with regard to some goal the user have achieved. Can include the above mentioned performance graphs and statistics.

Feedback should be non-controlling, informative and positive to support the user's needs for competence and autonomy, thus boosting intrinsic motivation. The opposite may decrease intrinsic motivation (Mekler et al., 2017, Francisco-Aparicio et al., 2013). Furthermore, feedback should be assigned informative content in order to make the feedback intelligible for the user (Sardi, 2017).

Rewards

Rewards are tokens that users earn for completing tasks in the system. Rewards in gamification is often implemented as badges or trophies, which are a visual representation of achievement, or as points, which are an accumulating ever increasing value that users earn for completing certain tasks and activities (Alsawaier, 2018, Mekler et al. 2017, Sailer et al., 2013, Anderson, 2011, p. 190). These types of rewards are thus tangible or extrinsic rewards. Extrinsic rewards in a gamification context somewhat mirror the points about rewards in a habit context, however there is a discrepancy between the two domains. Some authors argue that awarding badges for good performance satisfy need for competence and thus supports intrinsic motivation because they are a visual representation of user progress and achievement (Alsawaier, 2018; Sailer 2013). Others argue that such types rewards distract from the core activity itself, leading to short term reward oriented behaviour that thwarts long term engagements and intrinsic motivation. Furthermore rewards contingent on performance are perceived as controlling which undermines the need for autonomy (Mekler et al. 2017; Rigby, 2015). Extrinsic rewards do, however, not invariably undermine intrinsic motivation (Mekler et al. 2017; Rigby, 2015). Under certain circumstances they can support intrinsic motivation. 1) Rewards should be given for engaging, not performance (thus not appearing controlling, undermining need for autonomy). 2) Rewards should be kept unexpected. 3) Rewards should afford a deeper engagement with material. As an example of the latter, instead of giving a badge for running 100 miles, a reward could be access to new content to learn more about running (Rigby, 2015). Rewards should appear along side challenges and goals (Anderson, 2011, pp. 157-158).

Social

Other gamification techniques exists that relate to our psychological need of relatedness. These techniques include leader boards, chats and forums (Sailer et al., 2013; Francisco-Aparicio et al., 2013). Of the above leader boards is the most common technique of gamification, where users are ranked by some metric of success (e.g. earning most points), thus earning respect by their peers and a feeling of competence (Mekler et al., 2017). Chats and forums can be used to establish a sense of community and belonging, reinforcing bonds between users (Francisco-Aparicio et al., 2013).

2.4 Related Work

Only two studies was found to explicitly examine the effects of gamification on the habit formation process using mobile applications (Clarke et al., 2017; Iurchenko, 2017). Both studies were short term and thus could not conclude on the long-term impacts of gamification on habit formation, however Iurchenko (2017) did find a positive impact on the examined health behaviour (maintaining water balance). As opposed to this paper, both of these studies didn't explicate the link between the design of their respective habit applications and theory of habit and gamification.

A review of habit applications with focus on their theoretical grounding by Stawarz et al. (2015) that the majority of applications provided basic task tracking and reminders (self-monitoring), which helps in the early stages of habit formation process (step 1-3a in figure 2.1), however only 3% of applications supported features that help develop context cue-behaviour associations necessary for habit formation (step 3b in figure 2.1). This gap between features in habit applications and habit theory have prompted some to develop guidelines on how to develop mobile applications that support the habit formation process (Renfree et al. 2016; Stawarz et al. 2015, 2014). These guidelines has been aggregated into the following overall guidelines for mobile habit applications:

1. *Combine Reminders and Implementation Intentions*: Applications should not only remind users to do a behaviour, but should remind them of their implementation intention some time before the behaviour is supposed to take place. This should not only help people remember to do their behaviour but also to strengthen cue-behaviour associations necessary for habit formation (Stawarz et al. 2015, 2014).

2. *Avoid Features That Lead To Long Term Reliance:* Many popular habit applications implement features that work as extrinsic motivators that decrease intrinsic motivation to do the habit itself, thus preventing habit formation (Renfree et al., 2016; Stawarz et al. 2015). Users become reliant on the application to do the behaviour in the long term. An example of such a feature is streaks. Renfree et al. (2016) found that streaks helped in the earlier stages of habit formation by helping motivate users to do their behaviour, however when large streaks were lost performance on behaviour ceased to exist or was reduced.

3. *Slowly Diminish Reliance on Application:* Habit applications should be designed such that the user can rely on the application in the earlier stages to do their habit, but remove reliance on the application in the long term. Reminders are another feature that users can come to rely on excessively, preventing automaticity development of behaviour (Renfree et al., 2016). The application should therefore try to slowly wean users off reminders (Stawarz et al., 2014).

This paper will try to contribute by designing and developing a mobile application whose requirements have a clear connection to habit theory and the guidelines provided above. Furthermore, this paper will explore how gamification can be integrated in such an application to support habit formation.

Chapter 3

Research Method

The research method included two overall activities: An iterative requirements engineering process and an incremental development activity. The overall relationship between these processes can be seen modelled as an activity diagram in figure 3.1 below:
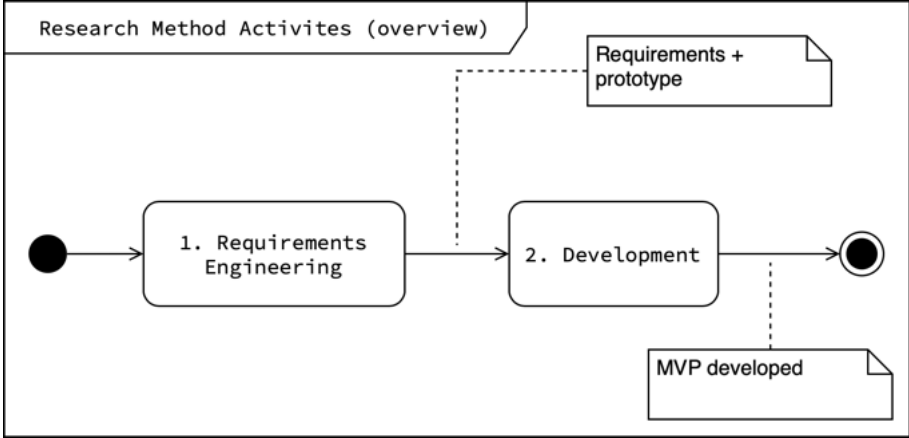

Figure 3.1: The overall activities of the research method

The requirements engineering process resulted in a set of user stories and a prototype that was subsequently used for the following development activity. The requirements engineering process was the most substantial part of the study and is described in depth in section 3.1.

The development process was incremental, as user stories was selected one at a time, designed, implemented in code and tested. As the ambition of the project is to have not merely a prototype implemented in code, but a minimal viable product, it is necessary to ensure good quality of code. To achieve this, I strived to keep code flexible and reduced coupling using SOLID principles (Martin, 2007) and design patterns (Freeman et al., 2004).

3.1   Requirements Engineering

The requirements engineering process has followed the model presented by Sommerville (2011, pp. 82-111). The overall subactivities of the requirements engineering process can be seen modelled in figure 3.2 below. The requirements has been developed iteratively, with the requirements elicitation and specification activities having been done twice.
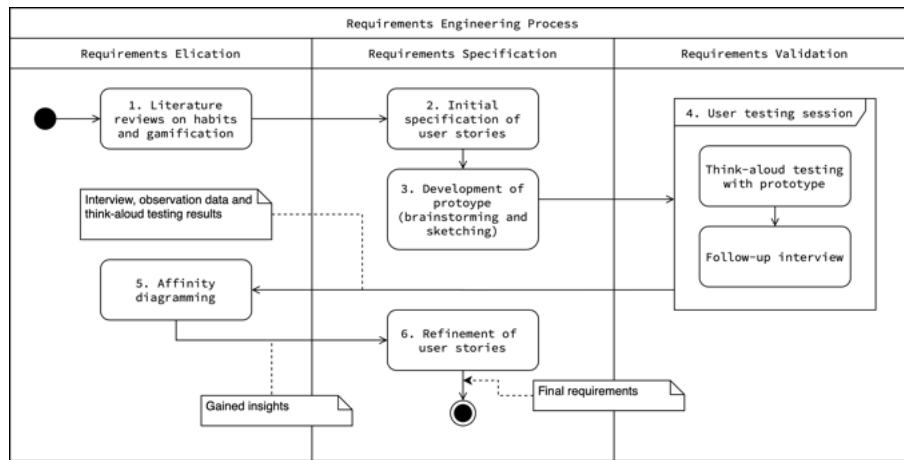

Figure 3.2: Subactivities of the requirements engineering activity

For most software projects, it is a necessity to involve the intended users in the development process to ensure a usable product and quality user experience (Hartson & Pyla, 2012, p. 9). One of the most prominent reasons why software project fails is a lack of attention to user inputs (Hartson & Pyla, 2012, p. 33). To inform a user-centred design the requirements engineering process in this project used techniques from the Human-Computer Interaction Design domain, such as paper prototyping, interviewing and think-aloud testing.

3.1.1   Creation of Initial Requirements

To create the initial requirements, two literature reviews were conducted respectably on habits and gamification to uncover developed knowledge on both of those topics (activity no. 1 in figure 3.2). While the literature review can be an unstructured process (see Biolchini et al., 2005, p.2), the process for the literature reviews in this project was a structured in the following way: First a literature review question was formulated, followed by accompanying search models. Google Scholar was then queried using the search models. Depending on the results the search models was adjusted to produce more relevant results. For each result the

introduction or abstract was read in order to cast away irrelevant results. For each relevant result, interesting references were examined and added to the result set if also relevant. At least 10 papers or chapters from books on habits and gamification has been read to inform the initial requirements of the application. See table 3.1 for review questions and search models and resulting papers.

Review Question	Search Model
What are habits and how are they formed?	Habit AND (formation OR psychology OR promotion OR motivation OR behaviour)
What is gamification?	gamfication
How does gamification relate to motivational theory?	gamification AND motivation

Table 3.1: Review questions and search models used for literature reviews.

Each paper or chapter was then processed for knowledge or insights that could potentially be used to create a user story or be combined with an existing user story as acceptance criteria (activity no. 2 in figure 3.2). User stories was used for the requirements specification as they keep documentation lightweight (Lucassen et al., 2016, p. 205).

Following the creation of the initial requirements, a low-fidelity paper prototype implementation of the requirements was created (activity no. 3 in figure 3.2). The main purpose of creating a prototype is to enable fast feedback on design and functionality of the envisioned system in order easily implement changes to the concept: it is much easier to change the prototype than change a real system (Hartson & Pyla, 2012, p. 393). The low-fidelity paper prototype was specifically chosen because of it's high ratio of value in user experience insight gained per unit of spent effort (Hartson & Pyla, 2012, p. 396). The process of creating the prototype involved brainstorming how each user story could be converted to a user interface along with sketching (see Hartson & Pyla pp. 280-284 on brainstorming and sketching). See appendix A.1 for an example sketch.

3.1.2   Validating Requirements With Users

Before implementing the initial user stories and the prototype in code, a user test session was arranged with potential users in order to gain feedback regarding features and observe any

serious user experience issues (activity no. 4 in figure 3.2). The user testing session consisted of a think-aloud test using the developed paper prototype combined with a brief follow-up semi-structured interview. Think-aloud testing is one of the most value user experience techniques for understanding a system from the perspective of a user while also finding user experience errors (Hartson & Pyla, 2012, pp. 440-444). The interview technique was chosen to gain verbal feedback on the test participant experience of the prototype and the features it simulates, as the interview can be used to gain insight into how individuals understand phenomena and events (Brinkmann & Tanggaard, 2015, p. 32). Specifically the semi-structured interview was used to ensure different test participants deals with the same subjects while also allowing the interviewer (test leader) to dive into interesting points made by test participants. A testing guide was created to guide test leader and test participant through the user testing session (see appendix B.2). By first introducing test participants to the prototype and then immediately interviewing them about it, the test leader and test participants both share a common understanding of the envisioned system leading to more immediate and valuable feedback.

The Test Participant Recruitment Process

The recruitment process for the test participants happened through verbal advertisement at a student residence. Inclusion criteria for test participants included 1) The test participant must have a smartphone. 2) The test participant must have a self-reported smartphone proficiency index of at least 3 and 3) the test participant must have a self-reported interest in using a tool for habit formation of at least 3 (see scale in appendix B.1). Together the inclusion criteria was specified to only include test participants that would realistically use the resulting habit application. A summary of the test participants can be seen in table 4.2. In total three test participants were included in the user testing session.

The User Testing Sessions

A set of tasks for the think-aloud testing was created, designed to have the test participants walk through all initial user stories (see appendix B.2). Test participants were tested one by one with the testing session being video recorded. The test leader first introduced the test participant to the user session, what was going to happen and information about desired behaviour from the test participant (e.g. that they think aloud as often as they can). Following the introduction, the think-aloud testing commenced with the created tasks, with test participant asked to complete the tasks one at a time using the paper prototype. Here the test leader acted as the system by manoeuvring pieces of the prototype as the test

participant interacted with it. For example, if the test participant pushed a menu button, the test leader would present a new screen, a message etc. Once each task was completed, the test leader would note how well the test participant had performed and hand the test participant a new task until no more tasks were left to be done. Task performance was measured according to the following scale:

1. **Passed** (P): The user finished the task without any issues.

2. **Minor Problem(s)** (M): The user finished the task with minor issues.

3. **Serious Problem(s)** (S): The user finished the task, however, the user experienced significant delays.

4. **Critical Problem(s)** (C): The user could not finish the task, and required the help of the test leader to continue testing.

Following the think-aloud testing, the test leader would interview the test participant using the interview guide for the test session (see appendix B.2).

3.1.3   Refinement of Requirements

Refinement of the requirements happened on the basis of the resulting data obtained from the user testing session. All user test session video recordings were transcribed and then analysed line-by-line by highlighting interesting quotes or pieces of the interview (see appendix C for transcriptions and appendix C.1 for an example highlighted page). These pieces of data was then grouped together into categories using affinity diagramming (see example category in appendix C.2), giving the data structure and creating an overview (activity no. 5 in figure 3.2). Based on the insights gained from the affinity diagramming, user stories were modified or created to accommodate user inputs (activity no. 6 in figure 3.2) forming the final requirements.

Chapter 4

Results I: Requirements Engineering

The results section has been divided into three parts. The first section presents the initial requirements and design concepts of the application based on the literature reviews. The following section presents the refined requirements and design concept based on the analysis of user testing session data. Finally, the third section presents the implementation of the MVP using the 3+1 approach to software architecture description using UML presented by Christensen et. al (2012).

4.1 Initial Requirements and Paper Prototype

The initial user stories based on the literature reviews can be seen listed below in table 5.1. The user stories have corresponding acceptance criteria along with a summary of supporting knowledge from habit or gamification literature described in section 2.2-2.4. The user stories can be divided into four overall categories: 1) Daily tracking of habits, 2) long term goals, 3) implementation Intentions and 4) rewards. Each of these categories will presented, along with the corresponding user stories' implementation in the paper based prototype. All components of the paper prototype can be seen in appendix A.2. It should be noted that the presented requirements reflects the aim to support habit formation and not breaking existing habits.

ID	User Story	Acceptance criteria	Supporting knowledge
#1	As a user, I want to register a habit I'd like to have	- The user can register a new habit in the application. - The user can choose specific days or a number of times weekly they would like to do their habit (habit frequency). - The user is able to update habit name and frequency following initial registering of habit.	- H: Allowing users to chose a habit they'd like to develop (i.e. a self-chosen habit) supports their autonomy and thus their intrinsic motivation (Ryan & Deci, 2000). - G: Self-chosen habits can be seen as challenges that users want to master (e.g. "Eat healthy" or "Read more"). - H: Habit formation does not require high frequency of behaviour, but rather consistency (Gardner & Lally, 2018).
#2	As a user, I want to have the option to create a measurable habit, so that I can track my progress on relevant days	- The user is presented with an option to make their habit measurable. - The user can make their habit measurable by choosing a quantity (number). - The user can choose an optional unit for the number. Example: If the user's new habit is 'Drink water' a measurable habit could be to drink 4 (quantity) glasses (unit).	- H: Self-monitoring helps recognise compliance with new habit supporting earlier stages of habit formation (Lally & Gardner, 2013). - G: The measurable habit can be seen as a concrete goal the user can complete to progress towards mastery of their habit, supporting need for competence (Anderson, 2011, p. 157; Alsawaier, 2017). - G: User should be able to create or modify goals to support need for autonomy (Mekler, 2017)
#3	As a user, I want to be able to create action plans so that I trigger myself to do my habit	- The user can create implementation - The user can create implementation intentions of the format 'After I [Cue] I will [Action/Habit]'. - The user can create multiple implementation intentions for a habit. - Implementation intentions are called action plans to align with user language. - The user can update and delete their implementation intentions.	H: Planning in form of implementation intentions can be an important factor for earlier stages of habit formation (Gardner & Lally, 2018; Lally & Gardner, 2013; Wood & Neal, 2009).

ID	User Story	Acceptance criteria	Supporting knowledge
#4	As a user, I want to be able to attach reminders to my action plans, so that I can be reminded in context to do my habit	• The user can attach time-based reminders to their action plans E.g. if a user has an action plan 'After I wake up then I will drink a glass of water' the user should be able to set a time-based reminder approximately at the time they wake up. • The user can attach location-based reminders to their action plans E.g. if a user has an action plan 'After I arrive at the shop I will buy healthy groceries' then a reminder should be able to be delivered when the user arrives at their grocery store. • The user should be able to name the location of their location-based reminder. • Reminders should not be delivered as notifications if a habit is not due for the given day. • Reminders should be able to be snoozed 15 minutes or an hour.	• H: Reminders help users remember their implementation intentions (Gardner & Lally, 2018; Stawarz et al. 2015, 2014). • H: Location based reminders can be better than time based reminders as they can be linked to distinct events in life such as arriving at shop, work or gym (Lally & Gardner, 2013). The environment is a powerful tool for habit formation and change (Carden & Wood, 2018; Wood & Neal, 2009) • H: Combine reminders and implementation intentions (see first guidelines for mobile habit applications section 2.4)
#5	As a user, I want to be able to track the progress of my habits on relevant days, so that I can see how well I do	• The user should be able to mark habits completed. • The user can add or subtract to the quantity of a measurable habit and see this in a progress bar. • The user can see how they have progressed in the past week visualised by a histogram of the week. Each bar of the histogram should be labelled by a weekday. A bars height is determined by the amount of progress of the habit on that day. • The user can see how many days there is left of a challenge.	• H: Self-monitoring helps recognise compliance with new habit (Lally & Gardner, 2013). • G: Performance graphs and progress bars visualise progress towards a goal supporting feelings of competence in system (Mekler et al., 2017; Fransisco-Aparicio et al., 2013; Sailer et al., 2014). It lets users compete against themselves (Anderson, 2011, pp. 179-180).

ID	User Story	Acceptance criteria	Supporting knowledge
#6	As a user, I want to be able to challenge myself to commit to my habit for longer periods of a time, so that I can form my habit	• The user can set a long term goal to commit to do their habit for a period of time. • A period of time can span from one to four weeks with one week increments representing four levels. • The user can only progress to higher levels when they have completed lower levels of long term goals. • The user can repeat a level, update and delete long term goals • A long term goal is considered completed when the last scheduled habit within the challenge time period has been marked as completed. • Long term goals are called challenges to align with user language.	• G: Completing goals help the progress towards mastering the user's challenge (habit) supporting need for competence (Merkler 2017, Anderson, 2011, p. 157). • H: By helping the user committing to do their habit, it encourages consistency of behaviour leading to habit formation (Gardner & Lally, 2018). • H: By limiting levels, the user is encourage to limit use of application reducing technology reliance (see section 2.4). • H: Cumulatively the levels represent 70 days of users committing to their habit. Habits takes in average 66 days to form (Lally et al., 2010). • H: Setting realistic milestones support need for competence and avoid dissatisfaction (Lally & Gardner, 2013).
#7	As a user, when I complete a challenge, I want to see a challenge report, so I can see how well I did	• The long term goal report should contain the following: 1) A positive message about the long term goal being completed. 2) A completion rate in percentage (how many times was habit done versus how many times should it have been done). 3) A performance graph that visualises the progress. 4) A sentence about the user being able to take a long term goal of longer duration. If the performance was >50%, the user is encouraged to repeat the level (and if habit is measurable, reduce quantity). • Long term goals are called challenges to align with user language.	• H: Positive feedback boost autonomy and competence of user (Lally & Gardner, 2013). • G: Performance graphs and progress bars visualise progress towards a goal supporting feelings of competence in system (Mekler et al.; 2017; Fransisco-Aparicio et al., 2013; Sailer et al., 2014). It lets users compete against themselves (Anderson, 2011, pp. 179-180). G: Feedback should be non-controlling, informative and positive to support need for autonomy and competence (Sardi et al., 2017; Mekler et al., 2017, Fransisco-Aparicio et al. 2013)

ID	User Story	Acceptance criteria	Supporting knowledge
#8	As a user, I want to receive information on habits in form of rewards, so that I can know more about habits	- The user should randomly receive rewards when marking habits as completed. Rewards should be spaced with 1-4 day intervals. - Rewards are first presented as a notification and can then be browsed later by the user. - The user should receive two kinds of rewards 1) Habit knowledge: information the user can utilise to become better at forming and keeping habits 2) Habit suggestions: Guiding users to other habits they could do to improve their life.	- G: Rewards should not be stand-alone but appear alongside goals (Anderson, 2011, p. 157-158). H: Extrinsic rewards can support intrinsic motivation if they are not contingent on performance, appears random in size and timing (Lally & Gardner 2013, Wood & Neal, 2009). - G: Extrinsic rewards do not hinder intrinsic motivation if they are offered for simply engaging and are provide deeper engagement with the material, in this case habits (Rigby, 2015). - H: Provide gentle guidance on healthy behaviours and let the user decide on habits they would like to develop (Lally & Gardner 2013) H: Habit knowledge could be used to inform the user to rely less on reminders for habits they've tried to develop for a longer period of time helping the user reduce reliance on the application (see third guideline for mobile habit applications section 2.4)

Table 4.1: The initial user stories based on the literature reviews. Habit supporting knowledge marked with an H. Gamification supporting knowledge marked with a G.

4.1.1 Daily Tracking of Habits

One of the core requirements of the mobile application is allowing users to register habits they'd like to develop (user story #1). The creation of these habits in the application requires two pieces of input from the user, which can be seen illustrated in figure 4.1.
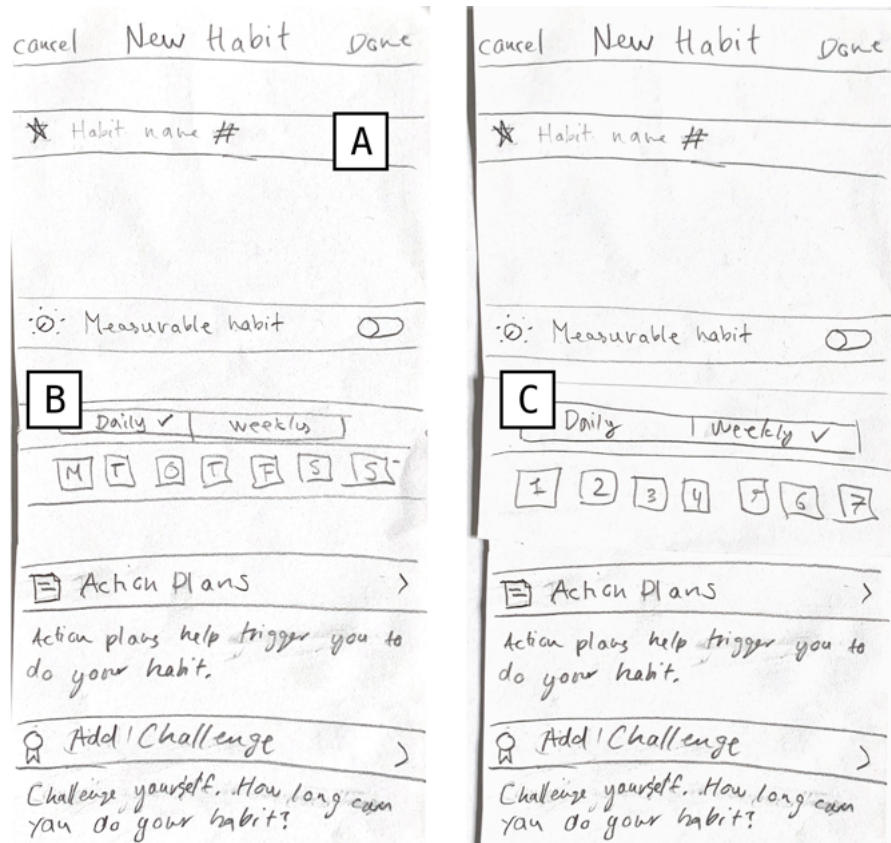

Figure 4.1: The paper prototype implementation of user story #1. A) Input field where user can insert name of habit. B & C) A toggle where users can select either a daily or weekly frequency.

The first input is the name of the habit that the user would like to create e.g. "Eat healthy" or "Practice playing on the guitar" (A on figure 4.1). In this regard, the application is designed to be generic with regards to development of habits, unlike other mobile applications that focus on specific habits such as eating healthy or exercise applications. Freely allowing users to chose their habit supports their autonomy and therefore their intrinsic motivation (Ryan & Deci, 2000). Furthermore, registered habits can be seen as a challenge the user wants to master. The second input is related to how frequent the user would like to do the habit (B & C on figure 4.1). The application supports two modes: doing habits on specific days e.g.

doing the habit on Mondays or doing the habit a certain number of times a week (e.g. 3 times a week). This encourages the user to do the habit consistently with regards to selected days or times per week supporting habit formation Gardner & Lally, 2018).

In the process of configuring a habit, the user can choose to create a *measurable habit*, i.e. a habit that can be measured by some quantity and has an optional unit attached to it (user story #2). This is illustrated in figure 4.1 labels A and B. For example, if the user would like to track their water intake in glasses and they have a goal of three glasses, the quantity field can be set to "3" and the unit set to "glasses". The application does not decide these quantities or units on behalf of the user. The user can create or modify this quantity themselves, thus supporting their autonomy (Mekler, 2017).

User story #5 concerns the user being able to track progress on their habits on relevant days. The user can mark a habit as completed, and if the habit is set to measurable (as per user story #5), the user can add or subtract from the tracked quantity of the habit using the stepper (i.e. the plus-minus button seen near label C on figure 4.2). This progress is visualised using a circular progress bar as can be seen from label C and D on figure 4.2. A histogram shows the recent performance of the habit (label E on figure 4.2). Lastly, the user can see how many days are left of their long term goal (see section 4.1.2). All these components together are called a *task card*.

Together user story #2 and #5 allows the user to self-monitor themselves, which can help users recognise compliance with a new habit, thus supporting earlier stages of habit formation (Lally & Gardner, 2013). The task card represents a concrete goal that the user can do to progress towards mastery of their habit e.g. if the habit is to read more the concrete goal could be to read for 2 hours each day. Marking the habit as completed on the task card visualise the user's progress both in the very short term on the relevant day (using progress ring) and medium term (using histogram), thus supporting the need for competence (Mekler et al., 2017). No streak was included, as that feature was shown to have negative effects on habit formation (Renfree et al., 2016).

4.1.2   Long Term Goals

One of the factors of habit formation is the consistent repetition of behaviour (Gardner & Lally, 2018). To encourage consistent repetition, the application challenges the user to commit to their habit for longer periods of time using *long term goals,* see user story #6.

These long term goals have a time span from one to four weeks with one week increments representing four levels, see label B in figure 4.3. Counted together, the levels represent 70 days of users committing to their habit, which is close to the reported average of 66 days to form a habit (Lally et al., 2010). Furthermore, these four levels potentially represent realistic milestones for most habits with their relatively short time spans, which can prevent early dissatisfaction with intended outcomes of a desired habit (Lally & Gardner, 2013). As users complete these long term goal, they progress towards mastery of their habit, supporting their need for competence (Merkler 2017, Anderson, 2011, p. 157). Lastly, the user is limited to these four levels in order to reduce reliance on the application following the first guideline of mobile habit applications (see section 2.4). It should be noted that long term goals are called *challenges* in the application to align with the user's language.

After accepting the long term goal, the user can see how many days are left of the challenge on the task card of the habit (see label C in figure 4.2). User story #7 concerns the achievement of a long term goal. When a long term goal is reached, the user receives a report (label C in figure 4.3) containing some feedback including a positive message, a completion rate of the habit during the time period and a performance graph (label D in figure 4.3). Positive feedback in combination with the performance graphs lets the user appreciate their reached milestone supporting feelings of competence (Mekler et al.; 2017; Fransisco-Aparicio et al., 2013; Sailer et al., 2013; Lally & Gardner, 2013). If the habit performance was less than 50% the user is encourage to repeat the level, and if the habit is measurable, also reduce its quantity. This allows the user to try multiple times to achieve success, while trying to keep user milestones realistic.

4.1.3 Implementation Intentions

Planning in form of implementation intentions can be an important factor for earlier stages of habit formation (Gardner & Lally, 2018; Lally & Gardner, 2013; Wood & Neal, 2009). Therefore, user story #3 was added to support the creation of implementation intentions in the application. The implementation of user story #3 in the paper based prototype is shown in figure 4.4 with label A, B and C. It should be noted that implementation intentions have been called *action plans* to align with the user's language.

A user can attach multiple implementation intentions to a habit to support multiple pairings of cue-behaviour associations (see label B in figure 4.4). User story #4 concerns attaching reminders to these implementation intentions, helping the user remember their plans (Gardner

& Lally, 2018; Stawarz et al. 2015, 2014).

These reminders can be time-based (e.g. being reminded at 9:00) or location-based (e.g. being reminded at work), see label D and E on figure 4.4. Location-based reminders can be more powerful than time-based reminders as they can more easily be linked to distinct life events such as arriving at work or at home, thus working as more effective cues (Lally & Gardner, 2013). The environment is a powerful tool for habit formation and change (Carden & Wood, 2018; Wood & Neal, 2009). When the conditions for reminder are satisfied (i.e. relevant day, right time or location), the user receives a notification on their lock screen (label F in figure 4.4) containing their implementation intention and the related habit. The user can choose to snooze the notification for 15 minutes or an hour, if necessary.

4.1.4 Rewards

As indicated by the literature of gamification and habits, rewards must be carefully considered if they are to be utilised to support intrinsic motivation. User story #8 concerns giving users rewards according to the recommendations provided by habit and gamification literature (Rigby, 2015; Lally & Gardner, 2013, Wood & Neal, 2009). Rewards will be given to the user at random intervals ranging from one to four days, when marking a habit completed. Users are notified of the reward by a notification (see label A in figure 4.5) and can be browsed in the *Rewards* section of the application (see label B and C in figure 4.5). The rewards will not be contingent on performance and will be offered simply for engaging. Rewards will not be offered as symbolic badges or points e.g. earning 100 points when marking a habit as complete. Instead the user will be given access to engaging material as recommended by Rigby (2015).

Two types of rewards exists: *habit knowledge* and *habit suggestions.* Habit knowledge affords users interesting facts, useful knowledge and guidance on habits, habit formation and effective usage of the application. An example of a habit knowledge reward could be to let users know that they should slowly stop using reminders for habits they have tried to develop for some time to reduce reliance on the application (see third guideline for mobile habit applications in section 2.4). Another example is shown in figure 4.5 label D. These habit knowledge rewards also affords information to the user at a comfortable pace, preventing the user from being overwhelmed, instead of introduce all important concepts and facts about habit information when the user is introduced to the application. These habit knowledge rewards also afford information to the user at a comfortable pace preventing the user from being overwhelmed

compared to introducing all relevant knowledge the user should know the first time the user uses the application. The other type of reward, habit suggestions, provide users with information on other healthy habits they can choose to develop, supporting the need for autonomy (Lally & Gardner, 2013). User story #8 can be seen implemented in the paper based prototype in figure 4.5:

4.2   User Testing Session Results

The user testing session included three test participants anonymised as James, Adam and Emma (P3). Their characteristics can be seen in table 4.2. They all had a self-reported interest in using a tool for habit formation of 4, with their self-reported smartphone proficiency ranging from 3 to 5.

Participant Name	Smartphone	Self-Reported Smartphone Proficiency (1-5)	Self-Reported Interest using Tool For Habit Formation
James (P1)	iPhone 7	3	4
Adam (P2)	Samsung Galaxy 10	5	4
Emma (P3)	iPhone SE	4	4

Table 4.2: Test participant characteristics. N = 3. Names have been anonymised

The results of the think-aloud testing can be seen in table 4.3. Overall the think-aloud testing didn't reveal any critical usability problems, with all test participants passing almost all tasks without any problems. Task B represented the most problematic task for the test participants and especially for Adam. The subtasks B.1 and B.2 of task B for any test participants did not cause any significant problems, however. For Adam, task B seemed to represent a Serious Problem (SP) because he had many menus to navigate to complete the task. He thought he had already created his habit when completing task B.2, and as such he tapped *cancel* instead of *done* on the *New Habit* screen (see figure 4.1). Furthermore all test participants did not immediately understand the *measurable habit* setting (see label A and B on figure 4.5), with only James and Emma eventually understanding it after toggling the setting. This will be elaborated on in section 4.3.1.

Task ID	Task Description	James	Adam	Emma
A	You have just downloaded achiever, and would like to create a new habit. How do you create a new habit?	P	P	P
B	Create you new habit in Achiever.	M	S	M
B.1	Create an action plan for your new habit.	M	P	P
B.2	Commit yourself you new habit by creating a challenge.	P	P	P
C	You have now registered your new habit in Achiever. You have just done your habit today and would like to register it in Achiever. How do you do that?	P	P	M
D	You just earned a new reward in Achiever and would like to see it. How do you do that?	P	P	P
E	A week has passed. You receive a notification saying you should do your habit.	P	P	P
F	You have just earned another reward in Achiever and you would like to see it. How do you do that?	P	P	P
G	Two weeks have passed and you are almost finished with the challenge for you habit. Mark your habit as done.	P	P	P

Table 4.3: Overview of test participant task performance. Scale used for performance is P = Passed, M = Minor Problem(s), S = Serious Problem(s), C = Critical problem(s).

4.3   Thematic Analysis of The User Testing Sessions

Generally test participants was positive towards the paper based prototype, especially liking the rewards offered (elaborated in section #) and the simplicity of the application:

James: *"I think it was pretty easy to get an overview of what things you could do with the app... and it was easy to register what the different things were about (...)"*

Adam: *"(...) It was kind of easy to know where to go."*

Emma: *"(...) I think the app seems simple and not with too many options... that is very nice."*

The thematic analysis of the results from the user testing sessions (i.e. interview and observational data) lead to four insights regarding the application. These insights are used to refine the initial requirements as described in section 4.4.

4.3.1   The Measurable Habit Setting Was Difficult To Understand

No test participant used the *measurable habit* setting from user story #2 that allows the user to attach a quantity to a habit. When Emma and James initially read the setting, they expressed they didn't understand the setting.

Emma: *"Measurable habit... I don't know what that means."*

James: *"Hmm.. let me see... measurable habit... I'm not quite sure what that means yet, but I think I will find out."*

Only James choose to toggle the setting and read the corresponding explanatory text (see figure # label B). James then decided it wasn't need for his habit. Adam seemed very certain about what the *measurable habit* setting meant, but misinterpreted its function as the number of days he would do his habit:

Adam: *"So I guess it is unclear whether it is a daily quantity, but I don't want to write my habit every day."*

When asked later about the setting all test participants agreed that they found the setting difficult to understand, but when explained about its function thought it could be a valuable feature:

Adam: *"I don't know about the quantities was kind of confusing (...) it is not easy to understand that quantities could be multiple times a day or something like that. (...) However I can see it being a nice function."*

Emma: *"Oh yeah, I didn't quite get that* [about measurable habit setting] *(...) Ah that makes sense. I think that is a good idea."*

To reduce confusion of the setting, test participants had two suggestions such as renaming the setting and providing more explanatory information:

James: *"Maybe* [the measurable habit setting] *needs some further explanation for me or another name. I couldn't see its possibilities. (...) I think it just needs some further explanation..."*

Emma: *"I think maybe the name confuses me a little bit (...) but what could it be called instead?"*

Overall the *measurable habit* setting was difficult to understand by the test participants and should be updated to be appear more intelligible for the user.

4.3.2   Rewards Was Mostly Fun And Exciting

The rewards offered in the application are significantly different from rewards offered by other gamified applications, with the focus not being on collecting the most badges and points but giving users access to knowledge on habits. The initial reaction from James and Adam was excitement:

James: *"I press rewards uh.... So excited that I get rewards! Oh... uhhh! (...)* [Reads about habit knowledge reward] *I'm happy I got this information about habits."*

Adam: *"Oh my god. 'You just earned a new habit fact'. (...) Okay thank you for that! (...)* [Reads about habit knowledge reward] *Okay, that was nice. What if I thought it was shit?* [Laughs]*"*

In the follow-up interview both Adam and James mentioned they liked both the habit knowledge reward and the habit suggestion reward given during the think-aloud testing. Both James and Adam noted how the rewards was not similar to conventional rewards found in games:

James: *"I thought it was really nice that it was like informational rewards. (...) And not*

that you earn cash or gold (…) you become smarter about habits and creating them. I like the idea of that."

Adam: *"*[About rewards] *I think they can be kind of lame often… (…) I think like 'oh meditation, how about that?' (…) that is kind of fun."*

The rewards were, however, not as positively perceived by Emma who initially didn't think of the habit suggestion rewards as a reward:

Emma: *"But I don't really understand why the habit suggestion is a reward… is that the reward?"*

To Emma, rewards should more be like conventional rewards e.g. earning a badge for trying to do a habit for 50 days:

Emma: *"Yeah, when I think about a reward I feel like it's more like you get a medal or something (…)"*

Generally the more unconventional rewards designed using the recommendations from literature was positively perceived.

4.3.3   The Task Card Is Too Cluttered Due To The Performance Graph

Only Adam commented on the performance graph seen in the task card during the think-aloud testing (figure 4.2 label E). Here mentioned how he liked the overview the graph gave him, but it also seemed to represent too much information to him, that it felt too cluttered:

Adam: *"I like this little overview of how I did recently… it is like bit much on this habit thingy* [task card].*"*

When asked about the graph later in the follow-up interview Adam elaborated a bit more, stating if he had more habits registered in the application the overview along with other UI elements in the task card would be confusing. Nevertheless he liked the overview.

Adam: *"I think the overview was fine, but it I think it could be too much especially if you like have more than one registered* [habit]… *but I like that I can see 'oh this is how I did this week'. (…) seeing many of these overviews along with everything else might feel a bit confusing"*

Emma also thought the performance graph looked complicated, by presenting her with too much information however she also thought it was interesting information to have:

Emma: *"I think it [the performance graph] looks complicated (...) It is very nice eh... interesting information to have... to see... to see how I did recently (...) But it is too much information to have especially with more habits".*

The above suggest a need to make the performance graph more simple and compact. A suggestion made by Adam and Emma was to show the user a streak instead, both of them referencing the streaks feature from Snapchat. The Snapchat streaks feature is a simple count that increments for each day two friends have messaged or 'snap-chatted' each other. Adam talks about how addicting such a feature is.

Adam: *"I think it could also be nice to just see these streaks for my habits, like how many times have I done it in a row? Perhaps like the streaks from snapchat, which is like super addicting."*

Emma: *"It would be very nice just to see my streak for the habit... you know like snapchat? Me and my friends tries not to lose our streaks messaging each other *laughs* "*

To summarise, the test participants found the performance graph in the task card too detailed and suggested a 'streaks' feature to replace it.

4.3.4   Missing Ability To Browse Past Long Term Goal Reports

The test participants generally found the long term goals (called *challenges* in the application) and their corresponding reports potentially useful features. Emma liked the fact that she could review how well she had committed to doing her habit in the designated time period, and James expressed delight when he could see he only had one day left of his long term goal:

Emma: *"* [Talking about report] *Ah and I can see how I did, and I can see I missed it one day... neat."*

James. *"Last day of my challenge... Jubii!"*

James and Adam also thought it was useful that the task card showed them how many days were left of their challenge:

James: *"No, but I have only 7 days left of my two week challenge. Very nice that is shows*

me that."

Adam: *"It's cool that it motivates me telling me how many days are left of my challenge."*

Emma and Adam both noted that there wasn't a place where they could browse earlier challenge reports that they did. Generally they all commented that it would be interesting to compare previous performances of long term goals, with Adam also mentioning how it's like a game to compete where one compete against oneself:

Emma: *"It's really nice getting those reports but it would also be nice to see what already did before and see how well I did and yeah"*

Adam: *"Especially if you could see and compare those earlier reports to compare them. Can you do that? (...) It would be kinda like competing against yourself, like creating a game for yourself..."*

The above shows that test participants needs to be able to browse past long term goal reports, such that they can compare prior performances.

4.4 Refinement of the Requirements

Based on the insights above the initial user stories seen in table 4.1 was refined. Particularly user story #2 and #5 has been updated while a new user story #9 has been added to the requirements. These user stories can be seen listed in table along with their acceptance criteria and key supporting quotes from users.
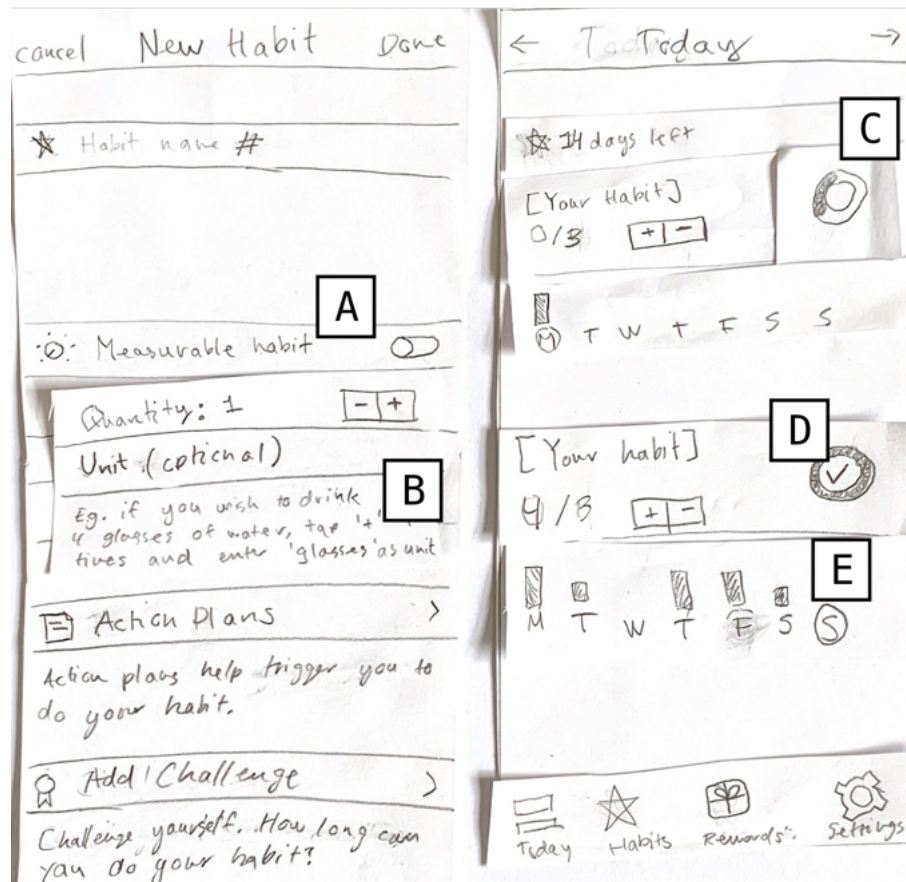
Figure 4.2: The paper prototype implementation of user story #2 and #5. A) The toggle that allows users to create measurable habit. B) The menu that appears when A is toggled allowing the user to enter a quantity and an optional unit attached to their habit. C) The task card allows users to enter and track progress on their habit. This is visualised by the circular progress ring. Furthermore, it shows how many days are left of the attached time period goal (see user story #6) D) When habit is completed E) A histogram showing the user's recent progress in the week.
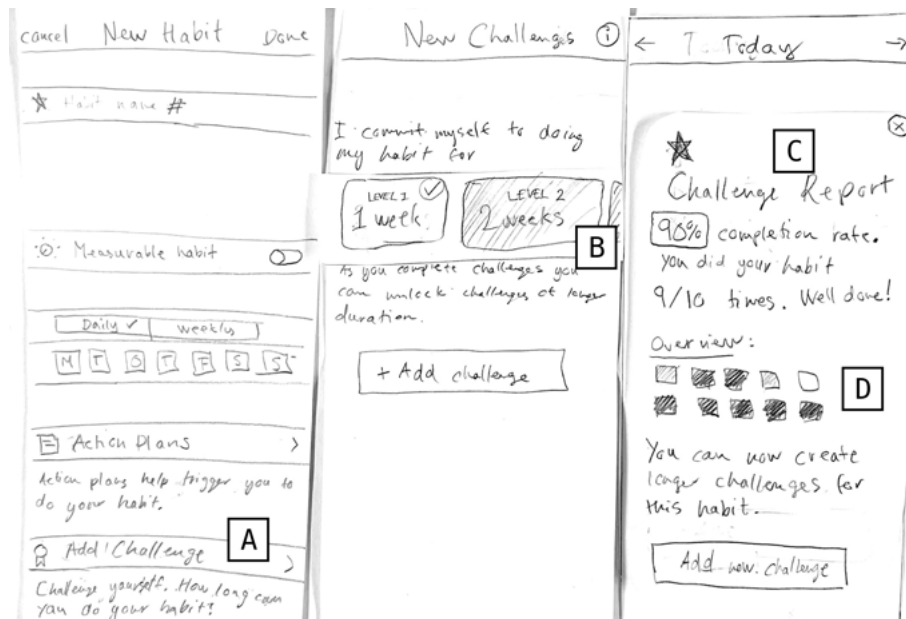
Figure 4.3: The implementation of user story #6 and #7 in the paper prototype. A) The button the user taps to navigate to the 'New Challenge' screen seen in the middle. B) The user starts at level 1, committing themselves to their habit for 1 week. C) A report showing a positive message, a completion rate statistic of their habit and D) a performance graph.
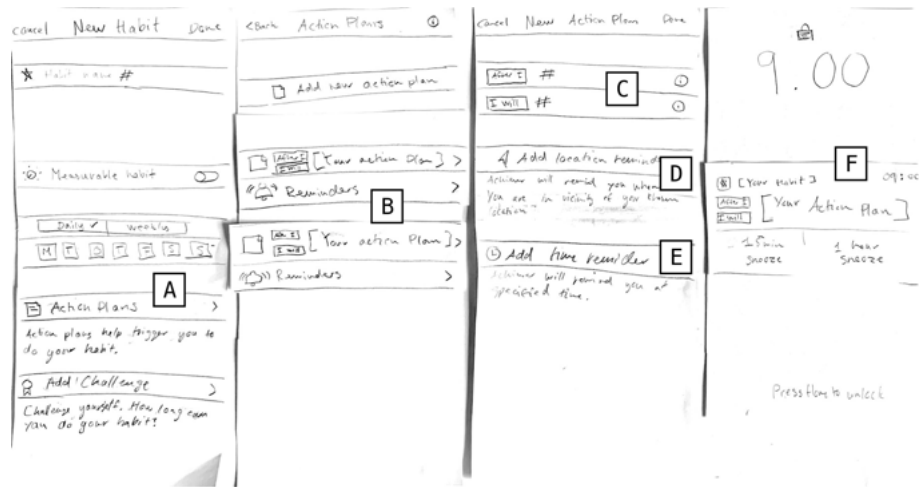
Figure 4.4: Implementation of user story #3 and #4 in the paper based prototype: A) The button the user taps to see the habit's related implementation intentions. B) Existing implementation intentions created. C) Inputs that correspond to the cue behaviour link of the implementation intention in the form 'After I [cue], I will [action/habit]'. D) The button the user taps to add new location-based reminder to the implementation intention. E) The button the user taps to add a new time-based reminder to the implementation intention. F) The reminder as it appears on a users lock screen along with the user's implementation intention.
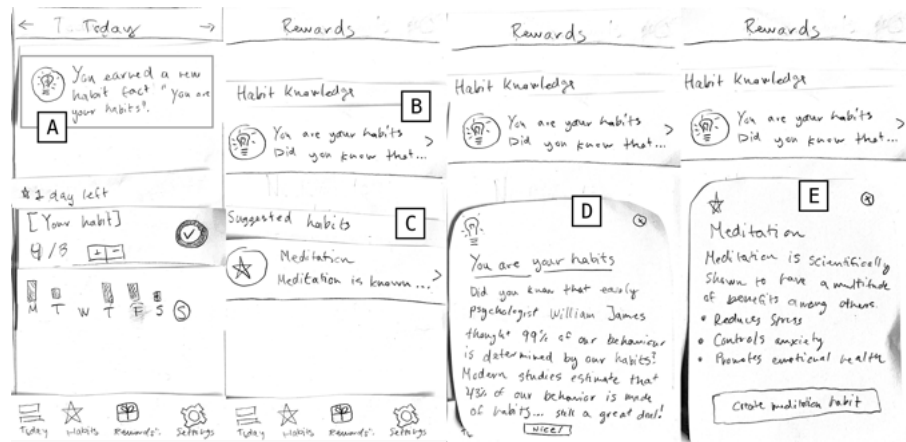

Figure 4.5: The implementation of user story 8#: A) At random times, when the user marks a habit complete, they receive a notification informing them of their new reward. B) List of habit knowledge rewards the user have earned. C) List of suggested habits that the used have earned. D) A sheet showing more information of a knowledge habit. E) A sheet showing more information on a suggested habit.

ID	User Story	Acceptance criteria	Supporting Quotes
#2	(Updated) As a user, I want to have the option to attach a daily goal to my habit, in order to track habits I do multiple times in a single day	• (Updated) The user is presented with an option attach a daily goal to their habit • (Updated) The daily goal is quantified as a number with the default quantity being 1. • (Updated) The user can choose an optional unit for the daily goal. • (New) Users are shown a description of the feature whether the setting is enabled or not • (Updated) Example: If the user's new habit is 'Drink water' a daily goal could be to drink 4 (quantity) glasses (unit).	• James: *"Maybe* [the measurable habit setting] *needs some further explanation for me or another name. I couldn't see its possibilities. (…) I think it just needs some further explanation…"* • Emma: *"I think maybe the name confuses me a little bit (…)"*
#5	(Updated) As a user, I want to be able to track the progress of my habits on relevant days, so that I can see how well I do	• On relevant days, the user should be able to mark habits completed. • The user can add or subtract to the quantity of a measurable habit and see this in a progress bar. • (Updated) The user can see how they have progressed the past 10 days visualised by a history strip (see figure #). • The user can see how many days there is left of a challenge.	• Emma: *"I think it* [the performance graph] *looks complicated (…) It is very nice eh… interesting information to have… to see… to see how I did recently (…)"* • Adam: *"I think the overview was fine, but it I think it could be too much especially if you like have more than one registered* [habit]*…"*
#9	(New) As a user, I want to view past challenge reports, so that I can compare them	• The user should be able to browse past long term goals reports. • These reports should contain the following 1) A completion rate in percentage (how many times was habit done versus how many times should it have been done). 2) A performance graph that visualises the progress.	• Adam: *"Especially if you could see and compare those earlier reports to compare them. Can you do that? (…) It would be kinda like competing against yourself, like creating a game for yourself…"*

Table 4.4: The refined user stories based on gained insights from affinity diagramming.

User story #2 has been updated by changing the term *measurable habit* to *daily goal*, as the term confused users. The acceptance criteria has been updated to reflect this. Furthermore instead of only showing a supporting description of the feature after the user has enabled the *measurable habit* setting (like in figure 4.2 label B), the description will be shown whether the setting is enabled or not. This affords further clarity of the feature for the user.

The acceptance criteria of user story #5 was updated to specify a new type of visual called a *history strip* (see figure #). The history strip is a segmented progress bar, with each segment representing the latest relevant days where a habit has been scheduled. The color intensity of each segment increases as a function of habit progress in terms of quantity, becoming fully saturated when the daily goal is met or the habit is marked as completed. If the habit is marked as completed for the past 10 relevant days, the history strip will appear as one continuous bar in the task card representing a 10 day streak. While test participants suggested a streak feature as a replacement to the histogram, the history strip is designed to afford the same early motivation of keeping a streak without giving the user a feeling of heavy loss if they miss a day. The history strip can relatively quickly be 'build again'. This should prevent the negative effects of streaks reported by Renfree et al. (2016) see second guideline for mobile habit applications section 2.4. Furthermore, the history strip is a more simple visual compared to the prior histogram, which should alleviate the problems of the task card appearing too cluttered.

Finally user story #9 has been created to fulfil test participant suggestion regarding being able to browse past long term goal reports. Here roughly the same information is presented as when the user receives the initial report i.e. a completion rate in percentage of times habit was done versus how many times it should have been done and a performance graph that visualises the progress. This feature is also aligned with literature as considering previous milestones can support the need for competence (Lally & Gardner, 2013).

Chapter 5

Results II: The Developed MVP

The developed MVP was implemented as an iOS application in Swift using various frameworks and technologies. An architectural description of the developed MVP will be presented using a modified version of the 3+1 approach to software architecture description (Christensen et al., 2012). As such this section will consists of two parts with regards to the MVP: a section describing its architectural requirements and a section concerning its architectural description. For the sake of brevity, the architectural description part focus on a high level description of the system while only providing a detailed look at how user story #4 and #7 was implemented. Screenshots of the implemented MVP can be seen in appendix D.3.

5.1 Architectural Requirements

Christensen et al. (2012) categorises the architectural requirements into two parts: scenario-based and quality attribute-based requirements. In this study, the former type of requirements are instead based on user stories.

5.1.1 User Story Based Requirements

The final requirements in terms of user-stories are shown in table 5.1. Table 5.1 gives an overview to what extend the user stories have been implemented. Not all user stories was fully implemented due to a lack of time.

ID	Status	User Story
#1	Implemented	As a user, I want to register a habit I'd like to have
#2	Implemented	As a user, I want to have the option to attach a daily goal to my habit, in order to track habits I do multiple times in a single day
#3	Implemented	As a user, I want to be able to create action plans so that I trigger myself to do my habit

ID	Status	User Story
#4	Partly Implemented	As a user, I want to be able to attach reminders to my action plans, so that I can be reminded in context to do my habit
#5	Implemented	As a user, I want to be able to track the progress of my habits on relevant days, so that I can see how well I do
#6	Implemented	As a user, I want to be able to challenge myself to commit to my habit for longer periods of a time, so that I can form my habit
#7	Implemented	As a user, when I complete a challenge, I want to see a challenge report, so I can see how well I did
#8	Not Implemented	As a user, I want to receive information on habits in form of rewards, so that I can know more about habits
#9	Not Implemented	As a user, I want to view past challenge reports, so that I can compare them

Table 5.1: The implemented user stories in the MVP. Notice how user story #4 is partly implemented while user story #8 and #9 are not implemented

5.1.2 Quality Attribute-Based Requirements

The critical architectural attributes for the application are Usability and Maintainability as defined by Bruegge & Dutoit (2010, p. 126). These two attributes has been used to guide decisions concerning what platforms, technology and frameworks used to implement the application.

Usability is a critical architectural attribute for the mobile application to use. If the application is not easy to use for the user, the user will most likely dismiss the application. One of the larger decisions concerning the choice between cross-platform or native application development was guided by this quality attribute. Implementing the application using cross-platform technologies has the advantages of affording great portability. One code-base could be shared among multiple platforms, i.e. both iOS, Android and the web. Examples of technologies that allow this are the Ionic Framework, Cordova and Googles Flutter framework. However, such frameworks result in slower and less responsive applications compared to native applications, where the software is optimised to run on the given platform. Additionally, native applications can be developed with UI frameworks that are specifically tailored to UI guidelines and standards set by the platform developer (e.g. Apple's Human

User Interface Guidelines) providing a superior user experience to cross-platform applications. Therefore the application was developed as a native iOS application.

Maintainability is another critical software attribute for the mobile application that guided several decisions. One of the larger decisions guided by this quality attribute concerned the choice between an older but established User Interface framework called *UIKit* or the newer, but less documented *SwiftUI* framework. Comparing the two, *SwiftUI* achieves comparable results with UIkit with significantly less code, and thus less code to maintain. Furthermore, SwiftUI code is notably more composable allowing you to create decoupled UI components that you can combine together to form larger components. Although SwiftUI is less powerful and less documented than the more mature UIkit framework, it is overall more maintainable. And being the new UI framework for iOS applications, it is expected to become more powerful over time without trading off maintainability.

5.2   Architectural Description

The architectural description consists of three viewpoints 1) the *module viewpoint* 2) the *component and connector* (C&C) viewpoint and 3) the *allocation* viewpoint. The allocation viewpoint concerns how software elements are mapped to environments of the system. As the system is simply a mobile application, all software elements are mapped to the user's smartphone. As a consequence of this simple mapping, the allocation viewpoints has been omitted below.

5.2.1   Module Viewpoint

The module viewpoint concerns how functionality is mapped to the units of implementation (Christensen et al., 2012). The units of implementation is illustrated in the component diagram of figure 5.1. From the diagram we see that the system consists of six major components.

The `Persistence` component
The persistence component is the component responsible defining the model of the application and how this model is persisted to disk. It defines a number of entities (e.g. `Habit` or `ActionPlan`) used throughout the application and their data transfer objects (DTOs). A
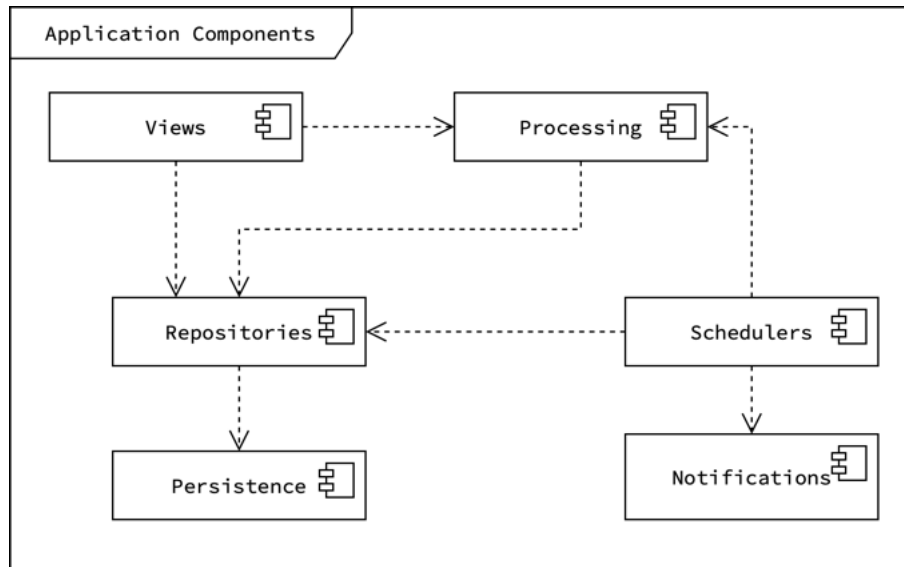
Figure 5.1: The major components of the developed MVP

class diagram of these entities can be seen in appendix D.1. Furthermore, the component configures the *CoreData stack*. *CoreData* is an Object-Relational-Mapper (ORM) makes it possible to interact with a database using entity objects. It is the standard framework of choice for data persistence on iOS. The database used for this application is *SQLite3*. Lastly, this component defines a publisher (i.e. `ManagedObjectChangesPublisher`) that makes it possible for other classes to subscribe to changes in the database, e.g. when an object is created or deleted. As such it is an implementation of the observer design pattern not between classes but between classes and a database. The framework that enables this functionality is *Combine* which is used to process asynchronous events (such as database updates). The component is important for all user stories, as they require persistence. It should be noted that the persistence component does not have any dependencies, making it easy to switch to a new persistence layer, should it be needed.

The `Repositories` component
The repositories component provides a layer of abstraction between the persistence component and other components, which results in better maintainability by decoupling the technology used to access the database (i.e. *CoreData*) from the model. Its main purpose is to provide client classes with an API to perform CRUD operations on the model. An example of a repository is the `CoreDataHabitRepository` that gives client classes access to `Habit` objects. Most repositories also provides a specialisation of the `ManagedObjectChangesPublisher`, so that client classes can subscribe to changes in a collection of model domain objects such

as `Habit`. As an extension of the persistence component it is key for the implementation all user stories.

The `Processing` component
The processing component is responsible the domain logic of the application. It exposes two major API: A status API and a statistics API. The status API concerns the status of habits and challenges. For example, it is used to determined whether a habit is queried for the scheduled day. The statistics API concerns calculating habit statistics such as the completion rate metric used in the long term goal report. The component mostly depends on the repositories component to access model objects e.g. for the computation of statistics. The user stories that map to this component are especially user story #5 and #7 as they concern showing different statistics to the user.

The `Notifications` component
The notifications component is responsible for composing notification objects that can be sent to the iOS notification system. Furthermore, it is responsible for handling notification permissions. A large part of this component is implemented using the abstract factory design pattern for easy extension to other types of notifications if needed. The functionality of user story #4 can be mapped to this component.

The `Schedulers` component
The schedulers component is responsible for scheduling tasks and reminders and is dependent on the publishers from the repositories component in order to this scheduling. For example, the `RealReminderScheduler` uses a publisher from the `RealReminderRepository` to subscribe to any changes to the collection of reminders saved in the database. When a change happens in the reminders, the `RealReminderScheduler` schedules corresponding notifications to the iOS notification system using the notifications component.

The `Views` component
The views component is responsible for rendering the user interface to the user and reacting to user inputs. As such all user stories can be mapped to this component. The views component uses the repositories component to read model objects and present them to the user. Furthermore, it uses publishers exposed by the repositories component to keep the user interface aligned with model data. The user interface is written using the UI framework *SwiftUI*.

5.2.2   Component And Connector Viewpoint

This Viewpoint is concerned with the run-time functionality of the system and the protocols that define the connection between major system components (Christensen et al., 2012). The major run-time components of the system can be seen in the CC overview in figure **??**.
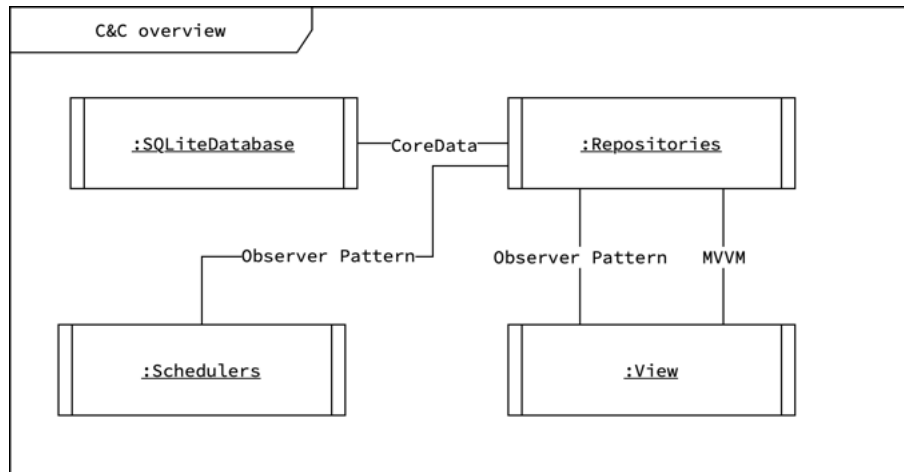

Figure 5.2: Major run-time components of the application and their connections.

There are three types of major connections between run-time components:

- `CoreData`: CoreData is the ORM the repositories use to read and write objects to storage. CoreData manages the conversion of objects to SQL statements that execute read and writes statements to an SQLiteDatabase.

- `Observer Pattern`: The observer pattern lets the schedulers and the view know of any changes of model objects when they are changed in the database.

- `MVVM`: The Model-View-Viewmodel pattern (MVVM) that connects the view (that serves ans both viewmodel and view) to the repositories serving the role of model.

Figure 5.3 illustrates a generalised example of how the observer pattern was used as a connector throughout the application.

First, the user does some action in order to save some data (e.g. creation of a new habit). The view then sends the data (usually as a DTO) to the corresponding repositories using CRUD commands. The repository then saves this data using CoreData. The view has a subscription to a publisher that observes changes in the database (the subject in the
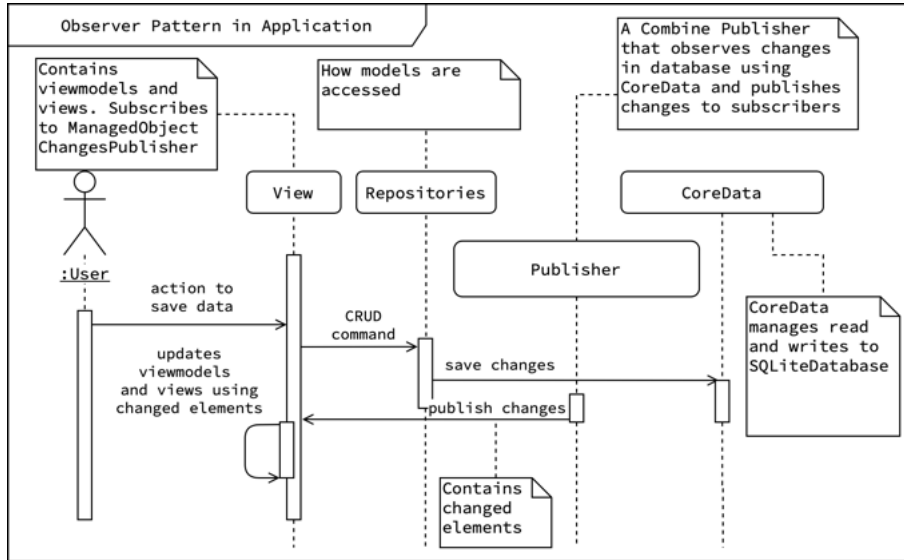
Figure 5.3: Generalised example of observer pattern usage and MVVM in the application

observer pattern). This publisher then publishes these changes (as entity objects) to all its observers (i.e. different subscribing views). The view receives these changes and updates its viewmodels and UI elements to reflect these changes.
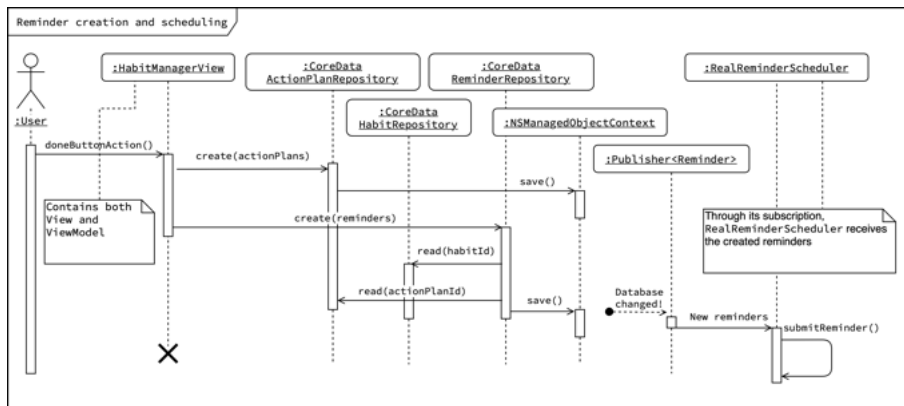

Figure 5.4: The creation and scheduling of reminders in the application.

A more specific example of the observer pattern used as a connector, is the implementation of user story #4 which concerns the creation and scheduling of reminders (seen in figure 5.4). The sequence diagram starts with the user having configured they habit alongside with an action plan and corresponding reminders from the `HabitManagerView`. When the `done` button is taped, the HabitManagerView calls the `create(actionPlans)` method of the `CoreDataActionPlanRepository` to save the user's new action plan in the database

(using NSManagedObjectContext, a CoreData class for fetching and writing objects). For the reminder to be created, the CoreDataReminderRepository first needs to fetch information about the habit and actionplan using their respective repositories. Finally, the CoreDataReminderRepository creates the reminder. This prompts the Publisher<Reminder> to send the changes in the database to the RealReminderScheduler which then processes each reminder, creating corresponding iOS notifications and submitting them to the iOS notification system.
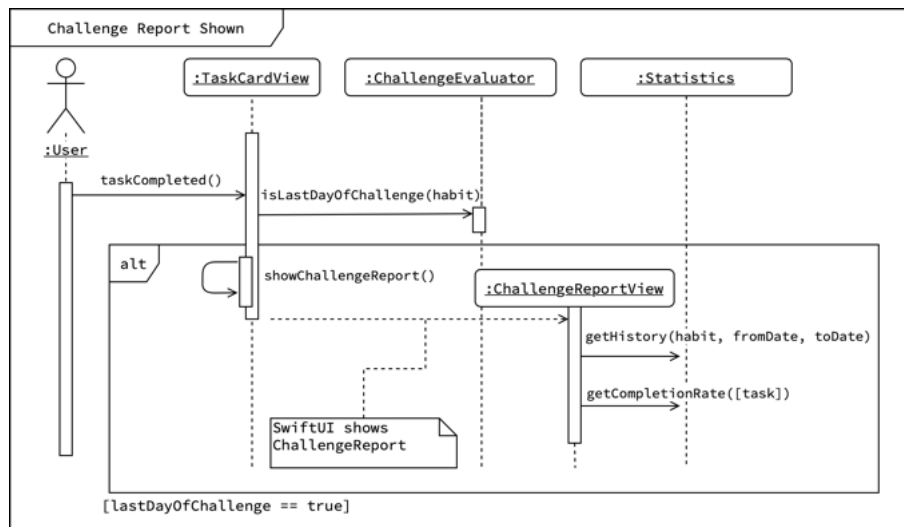

Figure 5.5: Sequence diagram modelling the situation where a challenge report is shown at the end of a long term goal.

Figure 5.5 models how different components work together to present the user with a challenge report at the end of a long term goal, thus being the representation of user story #7 as a sequence diagram. First, the user marks their habit as completed using the taskCompleted() method of the TaskCardView. When this is the case, the TaskCardView asks the ChallengeEvaluator whether this is the last day of the long term goal. If it is, the ChallengeReportView is created. This view then calls the getHistory and getCompletionRate methods of the Statistics object, so that it can create a performance graph for the user and present the user's completion rate.

Chapter 6

Discussion

6.1 Threats to Validity

Several threats to validity exists for this study, but the most major threats concerns the literature reviews, the user testing session and the application design.

6.1.1 Validity of the Literature Reviews

The foundation for the results of this study is the knowledge gathered in the literature reviews concerning habit theory and gamification. The literature reviews were conducted in a structured process (see section 3.1.1), however they were not systematic reviews and as such are much more vulnerable bias. A rather obvious bias that could have been introduced in this regard is the search and selection of papers. This study solely used the Google Scholar database to find papers, however other digital libraries exists which could have been queried (e.g. IEEE-Xplore, Springer Link). Additionally, due to time restraints, the literature search was not exhaustive. The small sample size of papers included in this study is also a threat to validity. While approximately 100 papers and chapters from books was screened for relevance only a little more than 10 papers or chapters for each topic (i.e. habit theory and gamification) was included in this study. Both topics, however, are large in size and therefore large areas of research and theory have probably been excluded. One impact this have had on the literature review on habit theory was that only two papers, even by the same authors (i.e. Lally & Gardner), were most prominent in the section regarding factors that influence habit formation (see section 2.2.2).

6.1.2 Validity of the User Testing Session

In order to create a user-centred application, a user testing session was arranged to gather data regarding the usability of the application, as well as feedback on the requirements from potential users. The selection of test participants for the user testing session was very limited, with only three test participants. While the test participants generally performed well in the tasks given and no major usability issues was found, the increasing the number of test participants might have unveiled more usability issues. Furthermore, the results might be influenced by the experimenter effects whereby a researcher influences the results. For example, if a user had questions about how to proceed in the prototype the test leader might reveal the answer through body language (e.g. a small nod of the head). The results could also be impacted by the very controlled setting for the test participant. The think-aloud testing session does not represent normal user behaviour, with test participants asked to walk through a series of tasks while thinking aloud. As a result the test participant might be way more observant on how to navigate the prototype, naturally wishing to do well in the tasks and impressing the test leader. This could have lead to less discovered usability issues. The say/do problem also limits the validity of the results. The say/do problem states that what users actually do is vastly different from what say they do (Bodker et al., 2008, p. 85). For example, some test participants expressed delight and excitement about the rewards feature of the prototype, and stated they it would be useful to them in a real world setting. But whether the test participants would find the feature useful can only be determined by later observation and not in a controlled test environment.

6.1.3 Validity of the Design

Fun and motivation is not a one size fits all proposition. A gamification technique might seem motivational for one individual, but not for another (Sardi et al., 2017). This study have primarily focused on gamification techniques that support the competence and autonomy of the user, for example by providing the user with the option to create daily goals or view the results of a long term goal using statistics and a performance graph. Due to time constraints this study had to exclude other prominent gamification techniques that support the third psychological need of relatedness. A large part of the promise of gamification is also the social aspect to gaming, e.g. collaborating or competing with other users to reach some goal (see section 2.3.3). Many individuals might not find the application and its gamification techniques motivating because it does not include any social aspects.

A danger that this application has like other habit applications is the encouragement of technology reliance, which prevents the development of automatic response that is characteristic to habits (Renfree et al., 2016). This application tries to discourage long term reliance, e.g. by informing users to use less reminders as they try to form their habit or limiting the number of levels of the long term goals. Despite this, the features of the application relies on the user actively registering whether and to what extend they have done their habit. Especially the gamification features (e.g. history strip and challenge report) are reliant on active user inputs to provide any meaningful feedback. So for the application to be useful the user must continuously enter information leading to technology reliance.

Chapter 7

Conclusion and Future Work

This study has attempted to leverage habit theory and gamification knowledge to design a user-centred gamified habit application that aims to support the formation of habits chosen by the user. It has tried to tackle the challenges of gamification (section 2.3.3), namely designing the system with basis in theory of human motivation and providing a good user experience. It has also tried to take the guidelines for mobile habit applications into consideration (see section 2.4). In combination with inputs from potential users, a set of nine user stories was created with ties to knowledge of habit theory and gamification. The user stories formed four major categories concerning the daily tracking of habits, long term goals, implementation intentions and rewards. Together, these form the features that aims to support habit formation. These user stories was then subsequently partly implemented in a MVP. Furthermore, the study found the design of the application user-centred in terms of usability, as no major usability issues was discovered.

In future work, it would be appropriate to test the MVP in a user testing session again to ensure that the implementation does not pose any major usability issues. While the testing of the paper prototype did not reveal any major usability issues, a digital implementation affords a different user experience and should thus be tested. Such a test session is, however, not expected to yield major or interesting findings. The more interesting question to be answered is whether the application actually supports habit formation. This would require a longitudinal study with several study participants, as habits take a significant amount of time to form. Another interesting direction worth investigating is the comparison of this application and other popular habit applications in terms of ability to support habit formation. This could yield insight into whether a mobile application is an appropriate tool at all for habit formation.

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Appendices

Appendix A

Paper Prototype

A.1 Sketches
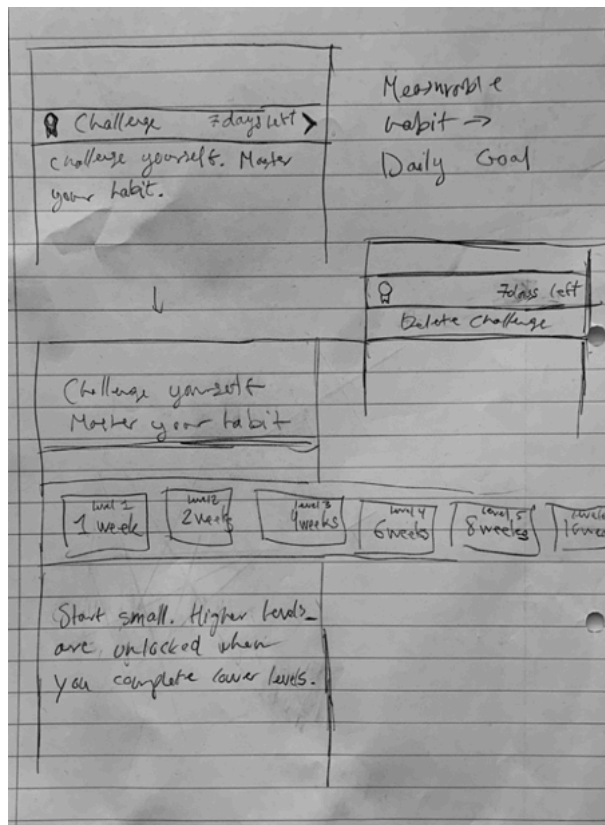
Figure A.1: An example sketch used for the development of the paper prototype

A.2 Paper Prototype Components

Figure A.2: An overview of all the paper prototype components.

Appendix B

User Testing Sessions

B.1 Acceptance Criteria Scales

On a scale from 1-5 how technically proficient are you in using your smartphone? 1: I regularly have problems using my smartphone

5: I have no problems using me smartphone

How interested are you in improving your existing habits or creating new habits?

1: I have no interest

5: I am very interested

B.2 User Testing Session Guide

Before test:

Hello [Participant]. Thank you so much for wanting to join me in testing the habit application 'Achiever'. This session is split into two parts: testing part where you will try out a paper prototype of the application and an interview part where I ask you about your experience of the prototype.

- **You will be given a set of tasks to complete**.

- **I will act as the prototype during the test**

- **I don't test you, I test the prototype**. The prototype is the student, you are the examinator.

- **I may ask you obvious or weird questions:** This is so I can know more about how you regard the prototype.

- **I cannot help you on the tasks:** I will tell you how to proceed if you can't finish a task.

- **A task can have more than one solution**

- **I will read the tasks aloud one at a time. After that I will hand you the task.**

- **I will ask you to think aloud:** This is so I can follow you thoughts, what you feel, is in doubt of and so on.

- **Give me your true thoughts**: Don't be nice for the sake of being nice. Just tell me what your honest thoughts are.

Do you have any questions or remarks?

ID	Description
A	You have just downloaded achiever, and would like to create a new habit. How do you create a new habit?
B	Register you new habit in Achiever.
B.1	Create an action plan for your new habit.
B.2	Commit yourself you new habit by creating a challenge.
C	You have now registered your new habit in Achiever. You have just done your habit today and would like to register it in Achiever. How do you do that?
D	You just earned a new reward in Achiever and would like to see it. How do you do that?
E	A week has passed. You receive a notification saying you should do your habit.
F	You have just earned another reward in Achiever and you would like to see it. How do you do that?
G	Two weeks have passed and you are almost finished with the challenge for you habit. Mark your habit as done.

Follow up interview

- What things works well in the concept?

- What things could be improved in the concept?

- Are there any features you wish was included in the prototype?

- Was the tasks realistic for how you would use the application?

- Do you have any other comments, suggestions, or improvements?

Thank you

B.3   James Transcription

P: Test Participant, T: Test leader

[Introduction from test guide is read aloud]

Do you have any questions or remarks?

P: No I think I understand.

—— THINK ALOUD ——

L: Great… let's start. So you have been looking a little bit in the app store for something to improve your habits… you found this application called achiever which you have just downloaded. And now you would like to create a new habit in the application. How do do you do that?

P: No habits are due today… oh I have no habits here… so uhm I guess in order to create a new habit I would press 'habits' in order to create a new habit. P: Oh I have no habits? I would like to create a habit then…

L: So one thing I haven't told you is that the hastag means you can insert some text in a field.

P: Oh okay. So I can write the name of my habit here.

L: Great so you get you next task now which is 'Configure your habit in achiever' and then there are a couple of subtasks.

P: Create a new action plan for you habit… uhhh…. create a challenge for yourself for your new habit… uhhhhhh okay! Hmmm.. let me see… measureable habit… I'm not quite sure what that means yet, but I think I will find out… I have this urge to maybe do like that to see what it does. Because I'm curious, but maybe I will wait…

L: *laughs…*

P: No, wait I need to find out! I don't know yet if my new habit is measureable, maybe it was and then it would be nice to measure it. So I click this…

P: Ãžhhh unt optional… ahhh oh. No I think I will need this one, so I press that one again….

L: And ÃžÃžhhh have you chosen a habit?

P: Yes.

L: Can you say it out loud.

P: Yes, I think I choose to Ãžhhm… maybe it would be… I think it would be something with exercise. I would like to do some exercise 3 times a week.

L: Good… you can continue.

P: Ã hm… it is not daily, but it is weekly, and then I would press 3, because I think it is three times a week… or maybe this is week 1, 2, 3… no Ãžhhh weekly… and then a 3 and then it's 3 times aweek. Is it?

L: I cannot say…

P: Oh… I press 3 and then it is actions plans… [reads] actions plans help you to do your habits… 'okay'. I need to find out what is this? Excuse me what is this? Hmmm… very easy… add new action plan… hmm… after… I will… I will need to know what this is.

L: Okay, a message appears on the screen. So… action plans consist of a trigger and some action you want to do… and a trigger is something that you do reliably every day, so for example a trigger could be 'after I wake up' or 'after I eat lunch' or 'after I eat breakfast', like these ceremonies you have in your life. That way habits are more able to stick.

P: OKay Ãžh… so this would be after I have my afternoon coffee. I would like a reminder. I will… I guess I will do the exercise. Can I see some information?

L: Okay it says that an action is somehting that relates to your habits, so do some exercises.

P: OKay, so maybe I need to put in the message myself? Okay…

L: Because… ahhh maube… the you want to read a book a week. And maybe you could create an action planned called: after I drink my coffee I will read 10 pages, so it can be a little bit different from your habits, so it's jsut to give you an opportunity to do that.

P: Ohh okay… Yeah… Ãžhhm… add location reminder… hmmm…. I don't think so. I don't need that. Because I think I would more need it a special time of day. Ã hmm… add time reminder. That is what I need. Ã hmmm… It would be like… 15:30… good. Now I press done. Okay… that is good then I press back. Ã hmm… I also what to give my habit name… I will call it my 'exercise challnege'.

P: Okay… this needs to be more than two weeks. I would need a long period of time… as you complete challenges you can create now ones of longer duration… okay! Ã hmmm…. but I don't need to add a new challenge. I will add a new challenge… hmm… oh it says Ãžh… new habit still here… I guess I'm done then…

P: My new habit… jubiii!

L: Great so the next task. You have now registered your new habit in Achiever. You have just done your habit today and would like to register it in Achiever. How do you do that?

P: Ã hhh I press today…

L: And because you didn't choose a measureable habit you can ignore the plus and minus here.

P: Okay… Ãžhh uh. But my habit… I feel like I should Ignore the plus and minus? What happens if I press that one? Oh okay… Ah very nice… beautiful so I will go back now… I would go back.

L: So Ãžhhh… you have finished your task now.

P: Okay very nice.

L: Then this appears. Like a notification

P: You earned a new habit fact 'you are your habits.' Ohhh okay…

L: Great. You just earned a new reward in Achiever and would like to see it. How do you do that?

P: Ã hh I press reward uhhhh… so excited that I get rewards! Ohhh … uhhh! You are your habits, did you know that? Habit knowledge…. Oh very nice I could learn some more about habits.

L: Then this slides up…

P: Did you know that early psychologist willam psychologist… [reads up rest of habit fact].

Still a great deal very nice. Okay. I'm happy I got this information about habits.

L: Great, good… A week has passed. You receive a notification saying you should do your habit.

P: Oh oh… omg achiever I'm so sorry it's been a week. You recieve a notification… oh okay… I would say… not right now. I snooze.

L: Then fifteen minutes pass.

P: Okay… my habit, my action plan… Ãžhh I think I will press maybe this one.

L: Then the phone unlocks and you see your today screen.

P: Oh yeah, I can press habit here again! Easy!

L: Wait a minute I just have to

P: Okau… I imagine I already did my habit, oh… no. Uhh okay.

L: So you chose a habit three times weekly, so obviously it would be five times weekly.

P: No, but I have only 7 days left of my 2 weeks challenge! Very nice that is shows me that. I should press this again. Yes.

L: And then this happens. This a notification again.

P: You earned a new habit suggestion: mediate. Ohh, okay.

L: So… You have now registered your new habit in Achiever. You have just done your habit today and would like to register it in Achiever. How do you do that?

P: Oh my god, what is this. Mediation. I like meditation, so I would like to see what this is about. I'm so curious! ….Ãžhhh [reads about mediation]. Oh create a mediation habit! Very nice. But I also feel like… so I should create a new habit.

L: It's fine you don't have to. So you have completed these tasks.

L: Two weeks have passed and you are almost finished with the challenge for you habit. Mark your habit as done.

P: Last day… jubiii. I would say press this one, no wait I press my habit.

L: And then this slides up.

P: Challenge completed, you had a completion rate of 90%… [read challenge card]. You can

create larger challenges for this habit. I could like prolong this one... hmm... Maybe I would like to try that.

P: No wait, maybe I just needs another two weeks.

—— INTERVIEW: ——

L: Great, that concludes the prototyping part of this session. So now I will just ask you some follow-up questions about what you think. So what things worked well in this concept.

P: I think it was pretty easy to get an overview of what things you could do with the app.. and it was easy to register what the different things were about and I had no start problems creating my new habit. I think that was fairly easy. Although maybe... I'm not that good at habits... but I was think about the amount thing...

L: Measureable.

P: Measureable thing. Maybe need some further explanation for me or another name. I couldn't see it's possibilities.

L: So the idea is that when you havea measureable habit.

P: Hmm like you want to drink two glasses of water.

L: Yes, and then you have this kind of circle thing, which when you clikc the plus button this circle would graduadly fill up and then when you did all your drinking for the day...

P: Like you knwo I do...

L: *Laughs.* Yes, but you think it was like... the word 'measureable habit' was a bit confusing or... ? Or should there just be some explaination already at the start?

P: Maybe that could be... or you could either... choose something you can measure or something like hmmm— maybe.. I don't know. I was just wondering what it was but in the end it didn't mean so much to me, I guess. So I made it through anyways... hmm I don't know.

L: But there is some problems with that I will try to see what I can do...

P: I think it just needs some further explaination... If before I press some box would pop-up, because otherwise I wouldn't want to read it, because I don't want to read a lot.

L: And it is quite a lot of information you would have to enter. Okay, so now we have talked a little bit about what went well and we talked about this measureable thing that could be approved. Do you think there are other parts of the application that could be improved or

confused you in some way?

P: Hmm… no. I wasn't confused, but maybe if I would have to apply it to my daily life, i think I would need reminders to fill in my habit that I have done it. I think it should be fairly… maybe if it just pops up on your screen and then you can tell whether you done your habit or not. That would make it really easy to register I guess. So I wouldn't have to open the app everytime.

L: That is also something I have thought about… Ãžhhh like when you are at the lock screen Ãžhm… Along with snoozing the habit you could have a button that says I have completed it.

P: Yeah, that sounds great

L: Okay… I will have to think about how it should be done, but I have an option to both snooze it and complete it.

P: Or maybe if I couldn't do the habit today, I should be able to snooze it for tomorrow. At the same time.

L: Yeah It will like… if you don't do the… it will remind you on the days that are relevant. So if you have run 2/3 times that week it will remind you the rest of the week tot do it, but if you have done it 3/3 times that week it would not reminder you the other times of the week.

P: Maybe it should do some further reminder saying: you have already done three, why don't you do 4? You are creating a new habit, why don't you do it one more time ehh ehh… unless your are dealing with a bad habit…

L: Yeah, so the idea when starting habits is that you should start small and keep to your goals. so the idea is when you do you challenges and you get this challenge report, now you get the opportunity to maybe increase the difficulty… not like difficulty, but maybe quantity of what you want to do or frequency or whatever.

P: Yeah, maybe that could be some information about how close I am to creating a new habit. BEcause, okay now I have done it for two weeks and.. do I have a new habit? No but maybe if it said 'oh you really close, now you have done it for 4 weeks'… I dunno… something like that. I think it was really nice with that the report I got in the end saying ehmm… saying how well I did in doing my habit. I think that would be fun to compare how I did back then *laughs*...

L: This is also something that I would like to talk to you about, one of those facts would be… the average time to create a habit… in that regard… so I also wanted to discuss with these rewards that you got, what did you think of those reawrds?

P: I thought it was really nice that it was like informational rewards and that you know a little more about this topic and this habit thing. So that was quite interesting I think. And not that you earn cash or gold or like anything… it was like, this is a reward and you become smarter about habits and creating them. I like the idea of that.

L: Yeah? Because many other standard gamification systems they use like…. would you think it was nice if you got a reward saying now you got 200… okay maybe not 200, maybe 10 week challenge of your habit and you got a nice badge for your habit. Maybe it does not matter to you so much…

P: No…

L: Maybe you like something that enhances…

P: Yeah that is true. I think… uhmm I think it is really nice… maybe also motivational quotes… oh maube that wouldn't be a reward. Maybe that would be more like a notifcation you would get.

L: What did you think of the suggested habit reward?

P: Ã hhmmm… this one?

L: Like the meditation reward.

P: I was like nice, maybe I could do that. And then I was like ohhh I don't know if I need like reminders of another habit to make, because for me depedning to much on an iphone that you have to register in is much. I would only use it for one, max two things. But I guess… I was kinda curious… because ohh meditation and getting reminders might help me get it done… I don't know, I think I would try it actually.

L: The idea is when you have your habit and you have it is really now a habit, you can unregister habits and… they are something… like what is something else that is healthy that I could do in my life, and that is a reward that you could do in that regard.

P: I htink it is very nice that it has very… giving me a notifcation about going a differnt way home from work, like… there are so many habits I owuld like to do… yeah but what is ehh…

L: Not much else, other than do you have any comments, suggestions or improvements that

I should consider.

P: I feel like it must have been pretty easy, since I could do it. I don't consider myself very…
I feel like I could use this applicaiton. Yeah! I liked it. And also I really liked the rewards
and doing the things that are nice to you, it is not about money or winning or anything, I
really liked that also. It gives me a feeling of, this is a really app that would like to help
people. OKay…. no secrets no hidden thoughts, no political agenda. *Laughs.* YEah.

L: Good, thank you so much for joining me for this session.

B.4 Adam Transcription

P: Test Participant, T: Test leader

—— THINK-ALOUD —— [Introduction from test guide is read aloud] L: Do you have any
questions or remarks?

P: No.

L: Good. So you have browsed the app store for a habit application and then you ran into
this application called achiever and you have downloaded it and know you want to create a
new habit with the application. And how do you do that? Then I will give you this task
here.

P: Okay… I am reading out loud…. I see at textbox that says 'not habits due today habits
that are due will appear here'. So I guess this is here that my habits will show up. So in
the botton I see four different icons, one that says today, one that says habits, and one says
rewards and then there is settings. So I think that I would press the habits now.

L: Yes, and you can just press that just like that yeah…

P: Got it. Okay… so now I see abother screen that says you have no habits, and then another
textbox that looks like a button that says create habit, and in the top I also see a headline
that says habits and then a plus but I guess, I will go with the button that says create habit.

P: Yep so a new screen appear, the headline says new habit and two buttons that says cancel
and done and textbox that says habit name.

L: By the way # means an input field where you can put in text

P: Yeah, got it. Then it says measure habit, daily weekly… guess that is the day of the week.

Then it says actions plans… [reads up text about action plans], so I would write in the name of my habit here.

L: So you have done you first task now, and you have begun the second task already which is configure your habit in achiever.

P: Okay, so my new habit would be to write my diary. Let's say that. And then I see something below called 'measureble habit', so I guess I would turn that one on the small button, because I would like to measure it somehow. Then it says quantity and it has a preset which is 1. And then there is a unit, and that is optional and then there is an example… [reads example]. So I guess it is a little unclear whether it is a daily quantity, so I don't want to write my diary everyday, but I guess it would be nice to Ãžhm… to have kinda a… a time scale. I will just leave it and then the unit I will write is writing my diary.

P: So now there appears something like a time opstion, so now I can choose between daily and weekly. So if I wanted to write my diary once a day, I don't now I would press monday, …, tuesday. And then actions that help you trigger you habit, I will try to see what that is about… okay there is something called 'add new action plan'. I will press that one and see where it leads me. Okay so now it says cancel new action plan and done. So it says after something I will something. Then there is an i button. I will see what that is

L: Okay so here, a message appears. Here it would explain you habits and when you create a new habit you should do it at specific ceremonial times at the day, such as after I wake up I will write my diary or after I eat lunch I will write my diaries. because those events help you stick to your habit.

P: Okay. So I will write some text there. After I will brush my teeth… I will write my diary. ANd then there is an add location reminder. [reads reminder description] I will not add that. That would be creepy to put in my bedroom. Add time reminder. And then it says Achiever, yeah I will just put something in there, so I will press that 11 o'clock at night then press add. And now I will look over my inputs and I will approve that so I will click done.

P: Okay, so now it says after I… and then your action… hm…

L: Okay the brackets mean some input. And then it says 1 here because you added one reminder.

P: Okay… so that is good. That looks nice. So I guess it would be nice to have some kind of output like congratulations your first habit has been created. But I guess I don't need that so I will just go back. And then last time I press done. So I don't know I will press cancel

now... and then I don't have any habits!

L: [Explained what happened]

P: Ahh, so I pressed action plan... Add challenge, I don't know I will press add challenges. [Reads challenge description] I commit to my habit for 2 weeks. As you complete challenge you can do it for a longer duration. Ohh okay. 2 weeks is ambitious, but I will do it and click add challenge. So 14 days left it says... and now I will press done to finish my habit... You have a new habit it says. So I guess that is kinda nice, now I have a habit.

L: Good, so that means that you have finished task 2. So... for task 3... You have now registered your new habit in Achiever. You have just done your habit today and would like to register it in Achiever. How do you do that?

P: Ã hh okay, so I need to register it somehow, so now I will press this one, your new habit... ahh that sucks, I don't like this.. will press cancel. So this was my habit and I could configure it. So I will go to today, because today is today.

L: And for you, because you didn't create a measurable habit, you can ignore the plus and mius.

P: So for instance if I wanted to drink 3 glasses of water and I only had 2 glasses of water today I would only give myself 2 out of three. Okay... so I will press this weird looking button. And I don't know there is a circle around M for monday I figured. And like maybe this is because today is monday. I like this little overview of how I did recently... it is like bit much on this habit thingy.

L: Great, so...

P: So now it has got a flueben in it.

L: And then this notification happens.

P: Omg. You earned a new habit fact. You are your habits. Okay thank you for that!

L: Good. You just earned a new reward in Achiever and would like to see it. How do you do that?

P: I know. I will press rewards. Okay, habit knowledge. You are your habits did you know that. I don't know if you new that. [Reads habit knowledge]. Okay that is nice. WHat if thought it was shit? *Laughs.*

L: Great! A week has passed. You receive a notification saying you should do your habit.

Then you got this screen here…

P: Okay.. so this is my phone. And there is a push message or a notification or something. I would probably snooze it.

L: And then it is hour later.

P: I guess I will snooze it again. I will press this one and I will unlcok my phone. Some jsut want to watch the world burn *laughs*

P: I did my diary, so I will press here:

L: Good and then, this happens!

P: You earned a new habit suggestion. Meditate. This is nice, but then I would think is this a nice to know or a reward.

L: Yeah and this is where… You have just earned another reward in Achiever and you would like to see it. How do you do that?

P: So I figured that star must have been some kind of reward… so I will press reward here. Oh so this not a habit knowledge, this is a suggested habit. And the application tells me that meditation could be a nice habit for me. I don't know about that, but I will read that one. [reads text about meditation]. I think meditation is not for me so I will cancel this one.

L: Great. Two weeks have passed and you are almost finished with the challenge for you habit. Mark your habit as done.

P: Okay, so this is the last day of my challenge. It's cool that it motivates me telling me how many days are left of my challenge. And now I would like to record that I have done my habit so I will press here… bing… and then [reads challenge report]. And then there is an overview I did and did not do my habit. You can now create longer habits. So I don't know, depending on how I feel like I could add a new challenge. If I really like to my diary it would be nice to extend the habit challenge. I will just press add a new challenge. And then there is a new challenge and I choose 4 weeks now and I guess it refers to my diary reading habit somehow. So I would like to do it for another 4 weeks. I press 4 weeks.

—— INTERVIEW ——

L: So this actualy concludes the first part… so now I have some follow-up questions to you. So what thing do you think worked well in this concept.

P: I think the icons and the icons linked to the text was kinda self explanatory, so it was

kinda easy to know where to go. And that was not so challenging. ANd I think like.. So in the beginning I pressed. Oh I forgot how I made my first habit, but that was not too hard I think. Ã hm... and then I had to configure the habit... I think that was kinda easy as well.

P Ã hmm.... I dunno about the quantities was kinda confusing, I think maybe its hard to now if you have a special habit in your mind, like read a book, then it is not so easy to understand that quanities could be multople times a day or somehting like that. So I think that button was confusing also becuase you didn't know that it was weekly or daily at that point. Of course if you were clever you could remmeber the page before, but you know with these apps it is also trial and error so you go back and forth if you don't understand it completely... so that was not too complex. However, I can see it being a nice function.

P: Ã hm... and then I think it was kinda easy to knda register what you have done once you have done your habit and you know depending on what kind of habit you know... if I want to drink four glasses of water, I want to be reminded by the end of the day, becuase then I will record it. I write my diary, and I'm in my zen it kinda sucks to take up my phone and register it... it the night time 11 oclock or something like that. With something related to bedtime or somehting like that I would often forget it or be annoyed, I would get the notification at 11 oclock... but I think about other habits like morning yoga or drink a cup of coffee in the morning, then it is easy to record by the end of the day...

L: Would it help if... one thing that you didn't notice the errors here... you can go back in time if you want to register it... and also a nice idea to solve that is on the notification you could have an option already here so you don't actually have to into the application and register it.

P: That would be nice directly from the notification you could mark the habit as complete and also the retrospective for the day before, something like that would also be kinda nice. You might forget it. Once you tweak the configuration of your habit, like you say like I wanna be reminded at this location, maybe if it your first app and you don't think these things thoruhg.... but maybe some instructions page on how to set up a nice habit. Could be a guide for being succesful. Five steps for succesful habit. But some kind of landing page. But you could maube have an icon in the button. Like a guide one or hints...

L: Maybe something I have on most of these screens are infomation buttons that could be pressed to provide additional information and that could maybe be added here so... this nice infographic kinda thing... give it a nice name or whatever, step two... like the steps for success...

P: I think the drawback for presenting too much information in an app is that people never read it and it takes up space and is kinda like... all these info buttons could suck. Some apps have a nice small video where they explain the concepts behind the app and these are the major positive implication it can have, but also how to set it up... super easy. I don't know about that, it is a paradox cus it is nice to have the freedom but also some information.

L: So The idea behind these rewards are that instead of giving you a lot of information at the start about how to do good habits... that would happen gradually as you use the application. So this was maybe this was a bad example because it was just a habit fact that doesn't add anything to you doing the habit, it is just an interesting fact, but there would be other rewards for saying like how do you do these challenges. What is the purpose of action plans, why do we do that. It is a balancing act, because you would also like to from the start give information on how to create and maintain habits.

B.5 Emma Transcription

P: Test Participant, T: Test leader

[Introduction from test guide is read aloud]

L: Do you have any questions or remarks?

—— THINK-ALOUD ——

P: No... not really.

L: Great. THen let us begin: You have just downloaded achiever, and would like to create a new habit. How do you create a new habit?

P: So achiever is your app?

L: That is my app yes.

P: Okay, so this is my phone I guess?? And then I can see I have no habits today. And then I have this menu... so I guess I would try this... I click on habits.

P: Okay, so now it says that I can create I habit, so I will do that. THen I get this menu. Okay so...

L: So something I forgot to tell you is that # means you can enter something...

P: Okay… so everytime there is a hastag I can enter something?

L: Yes

P: So I can write the name of my habit… so guess what I want to achieve…? MEasurable habit… I don't now what that means… and then I can say that it is gonna be a weekly or daily habit and which day I wanna do it… ehmm… action plans.

L: Great, so I will give you a new task now: Configure your habit in Achiever. And then there are some subtasks

P: What do you mean by configure:

L: Yes It means, enter information about the habit you would like to do.

P: Okay, so I guess that is where I am now.

L: Do you have a habit in mind?

P: Yeah maybe we coud say I would like to run every second day? But it only says daily or weekly… so maybe I should make one for every second day? If I want to do it… I don't know how to do it becuase if I would like to do it monday, wedneday and friday and sunday it would be the same next week? oKya… then what is action plans… action plans trigger you to do your habit. Can I still click?

L: You can click anywhere you want to. I want to click on the challenge…

P: Ah okay… so I guess I can scroll thise one and then chose how many weeks I want to do it for.

L: But you can't actually.

P: I can't? But then I guess I will have to do it for two weeks. Okay then I can add challenge. Oh okay so what happens if I press this one?

P: Ah okay so I guess the challenge is a duration of long I'm gonna do the challenge. Ehh… adn then the action plan… it is this… okay and then I can… so I can add new plan.Okay so here I can write something again… after I something I will… okay I'm not quite sure I get it. Can I click this infobutton?

L: Yes. So I wil just tell you a message now. So it lists you some moments in your day where it is opportune to ehh like daily routine that are opportune to do your new habit in. So forexample after I wake up I will do a run. And this is to remind yourself and trigger you

to do yuor habit when you think about it.

P: Okay, let's say I type that, after I wake up I will run.. and then…

L: It could also be after I eat lunch, or after I eat breakfast or after I brush my teeth or any kind of trigger…

P: Yeah… ehm… okay so this is just like a message to myself I will get. Locations so I get this is at home… ah okay I can add a location so I guess around somewhere here… good. then I will add that. Is it not addded yet? Now there is two… was that because I clicked twice… now I have to location reminders. I don't know how to get that box to disappear. I will click… ahh so this is not a button [talking about the map pin]

L: haha no…

P: I don't know how to remove the other haha.

L: It's okay just ignore it for now.

P: And time reminder… I will want to do that… okay so I can scroll this. I will set it to 7:30 and then clikc add… Great and then done. Now that is my plan and my remider… And then I will just go back.

L: And then… this is not something I have done… but it says one here because you have one plan.

P: Ah okay… should I do more?

L: Do you feel like I am done?

P: Yes!

L: Great! Good. You have now registered your new habit in Achiever. You have just done your habit today and would like to register it in Achiever. How do you do that?

P: Okay… ehm… So I want to hmm… I think I wanna go back. And can I… I don't have any rewards. Ah okay… I will click today…

L: So just some explaination you can ignore the plus and minus here…

P: Okay.. so the plus and minus. AH… can I click on this? I click [nothing happens]. I click on the ring… so now checked I did it today I guess.

L: Yes! So now until task… no then there comes this notifcation here. You just earned a

new reward in Achiever and would like to see it. How do you do that? Then this thing just disappears again.

P: Then I would like to click on rewards.

P: You are your habits.. did you know that... then you can click up.

L: This thing kinda slides up here...

P: [reads habits]. So it is like a fact? A reward? It gives me some informationn... which is very informative *laughs*.

L: A week has passed. You receive a notification saying you should do your habit.

P: Okay so it is 9 oclock and I get this notifcation... So I press to unlock... okay then I can see that there is 7 days left of my challenge... Have I done my habit... then I would do it and then I would add it here.

L: Great...

P: So I get the point is more I would get the reminde,r and then I would do it and then I would go to the app.

L: And then you see this notification.

P: You earned a new habit suggestion...

L: So... You have just earned another reward in Achiever and you would like to see it. How do you do that?

P: Then I will go to rewards again... Okay then there is suggested habits... is that the reward? Ahh... [reads about mediatation] so it tells me about mediation and why its good and ah I can make it a new habit! So if I want to meditate as a habit then I would click on this...

L: And then this menu appears where it says meditate here...

P: Ahh and then I could enter information again

L: Good now

P: But I don't really understand why the habit suggestion is in rewards. That is like not really a reward like... I don't now... it's like... yeah..

L: Let us talk about it later! Let us go to next task. Two weeks have passed and you are almost finished with the challenge for you habit. Mark your habit as done.

P: Okay… so I guess I click on this one…

L: Then This slides up [talking about report card]

P: Ah and I can see how I did, and I can see it I missed it one day… neat… okay so this is like a report that I can see a report on how well I did. Can I press this? Can I then… what If I want to continue? For instance if I ran for two weeks… can I just? Okay now I can choose for instance for four weeks and then it will continue… ah I see.

L: Yes, now we are done with the paper prototype. Then I have these follow-up questions.

—— INTERVIEW —— L: So what things did you think worked well in this concept?

P: Hmm… okay… I like that it gives you reminders to do the things and also that it is like positive feedback… its not like you get punished for not doing it… I like the thoughts of getting those rewards as encouragement to do habits as well…

L: Yes? So you said something about that the habit suggestion was not… you didn't interpret that as a reward but soemthing else, can you explain what you mean?

P: Yeah, when I think about a reward I feel like it's more like you get a medal or something like well-done you did a good job here is a reward and this is more like encouraging me to do something actively… I think it should rather be another menu like if you run do you want to do yoga or something… I think it should be like… I don't now… I don't feel like something i get like… for me the rewards were when you do your habit rather then get rewards..

L: So you were a little bit confused about whre it was a reward, when it was a habit suggestion… but what do you think about receiving these habit facts…

P: I think I am a little bit confused like when will I get these facts and is it… if it is because you did your challenge then you get a reward or…

L: Actucally you will not get a reward for your challenge other than the report card… so these rewards will appear randomly as you use the application instead… eh so that is how it works accoring to some theory… but you feel like you miss getting medal and then you can see wooow I got a medal or…?

P: Yeah, yeah, or like I could go back and see what challenges I already did or yeah… so I can like.

L: So the history of challenges would also be nice to see…

P: Yeah and maybe see how well I did maybe if did two more weeks and I got 100% then it

would be nice to see that I improved.

L: Ah so you would like some place whre these reports that is somewhere that yiu can see those somewhere you can see Ahh the first time I did this challenge I did so well the next time I did the challenge for four weeks I did this well so it is not kind of forgotten...

P: Exactly that would be nice to have. Hmm...

L: Good. So we have talked a little bit about how we can improve these rewards ehmmm... but do you think there is anything else that could be improved upon... What did you think of the action plans?

P: Hmm... That is more like to describe the challenge to myself... But I think it could be explained a bit more...

L: Okay... then there was this measureable habit... where you were like what is that? I don't know what that is.

P: Oh yeah I didn't quite get that. And then I can say yes or no.

L: Yes and then this menu would appear.

P: Okay eh... ah okay hthen I can add... so I guess if I want to drink 4 glasses of water I can add it to the application throughout the day.

L: Yes and that is also the point of the like the plus and minus button you see here. And then this ring would gradually fill out.

P: Ah that makes sense. I think that is a good idea. I think that maybe the name confuses me a little bit.

L: What should it be instead?

P: Hmm yeah, that is a good question. THis is more like what can I do... yeah... but what could it be called instead.

L: I will figure that out *laughs*. Do you think these are useful features?

P: I think it could be useful that the thought that is based on what is typed into the app... I think it is like a nice feature... I don't now about knowledge habits...

L: THere would be other facts about habits and how tocreate them like 'start small' and 'did you now it takes 66 days to form a new habit'.

P: Ah okay so it is like a way to encourge me to how to do my habits and not like if I forget to do it I should be beating myself.

L: The idea is I don't want to overwhelm the user with information but they randomly get... they get a new fact about habits...

P: I think if that is the point then I think it's like ehm so you don't have to think like I don't do everything perfectly and I should not be too hard on myself regarding everything that I should do... but if it is more like this i realistic, then I think it makes sense.

L: Are there any features you wish was included in the prototype?

P: I think mostly what I have already said... it's really nice getting those reports but it would also be nice to see what already did before and see how well I did and yeah...

L: Are you most interested in statistics where you challenge yourself...

P: I think it depends on what kind of habit I would like to change... I would like to have like... But if is just a reminder to drink more water... then it wouldn't matter much.

L: But what about the percentage and the overview on the report card?

P: Yeah, I think that is interesting for me to see, as I can see how I did previously.

L: And then have this report saved somewhere.

P: Maybe like a calendar where I could the period of the challenge that I did.

L: Yeah okay.... hmm... what do you think of this graph here [the graph in task card]?

P: THis is the one you would get... I think it looks a bit complicated... it's too much information to have. I don't know if it could be simplified, but of course it is very nice eh... interesting information to have... to see... to see how I did recently. But it is too much information especially with more habits. Maybe with a number...

L: Hmm I see... if you do have any idea on how I could simplify it?

P: Maybe with a number? It would be very nice just to see my streak for the habit... you know like snapchat? Me and my friends tries not to lose our streaks messaging each other *laughs*.

P: Haha, yeah... My little brother would also go crazy if he lost his streak with friends. So this star... you think it was was representative of a challenge [talking about star in task card].

P: Yes, I understood it was how many days were left in the challenge.

L: Great! Do you think the tasks was realistic for how you would use the application?

P: Yeah, I think it is not too much work. You don't want it to be very difficult, and I think it was pretty simple. I like that it is not an app I would need to spend a lot of time in.

L: Do you have any comments, suggestions or improvements?

P: Yeah… what do these arrows do?

L: These arrows let you go forward and backwards in time…

P: Nice great.. I would have missed that. But I think the app seems simple and not with too many options… that is very nice. I don't have any more…

L: Good then let's say that's it!

Appendix C

User Testing Sessions Analysis

C.1 Interview Analysis Example

C.2 Affinity Diagramming Category Example

[About the measurable habit
being confusing]

James

P: Create a new action plan for you habit... uhhh.... create a challenge for yourself for your new habit... uhhhhhh okay! Hmmm.. let me see... measureable habit... I'm not quite sure what that means yet, but I think I will find out... I have this urge to maybe do like that to see what it does. Because I'm curious, but maybe I will wait...

L: laughs...

P: No, wait I need to find out! I don't know yet if my new habit is measureable, maybe it was and then it would be nice to measure it. So I click this...

P: I think it was pretty easy to get an overview of what things you could do with the app.. and it was easy to register what the different things were about and I had no start problems creating my new habit. I think that was fairly easy. Although maybe... I'm not that good at habits... but I was think about the amount thing...

L: Measureable.

P: Measureable thing. Maybe need some further explanation for me or another name. I couldn't see it's possibilities.

Emma

P: So I can write the name of my habit... so guess what I want to achieve...? MEasurable habit... I don't now what that means... and then I can say that it is gonna be a weekly or daily habit and which day I wanna do it... ehmm... action plans.

L: Okay... then there was this measureable habit... where you were like what is that? I don't know what that is.

P: Oh yeah I didn't quite get that. And then I can say yes or no.

L: Yes and that is also the point of the like the plus and minus button you see here. And then this ring would gradually fill out.

P: Ah that makes sense. I think that is a good idea. I think that maybe the name confuses me a little bit.

L: What should it be instead?

P: Hmm yeah, that is a good question. THis is more like what can I do... yeah... but what could it be called instead.

Adam

P: Okay, so my new habit would be to write my diary. Let's say that. And then I see something below called 'measureble habit', so I guess I would turn that one on the small button, because I would like to measure it somehow. Then it says quantity and it has a preset which is 1. And then there is a unit, and that is optional and then there is an example... [reads example]. So I guess it is a little unclear whether it is a daily quantity, so I don't want to write my diary everyday, but I guess it would be nice ehm... to have kinda a... a time scale. I will just leave it and then the unit I will write is writing my diary.

P Øhmm.... I dunno about the quantities was kinda confusing, I think maybe its hard to now if you have a special habit in your mind, like read a book, then it is not so easy to understand that quanities could be multople times a day or somehting like that. So I think that button was confusing also becuase you didn't know that it was weekly or daily at that point. Of course if you were clever you could remmeber the page before, but you know with these apps it is also trial and error so you go back and forth if you don't understand it completely... so that was not too complex. However, I can see it being a nice function.

Appendix D

Developed MVP

D.1   Class Diagram of Entities
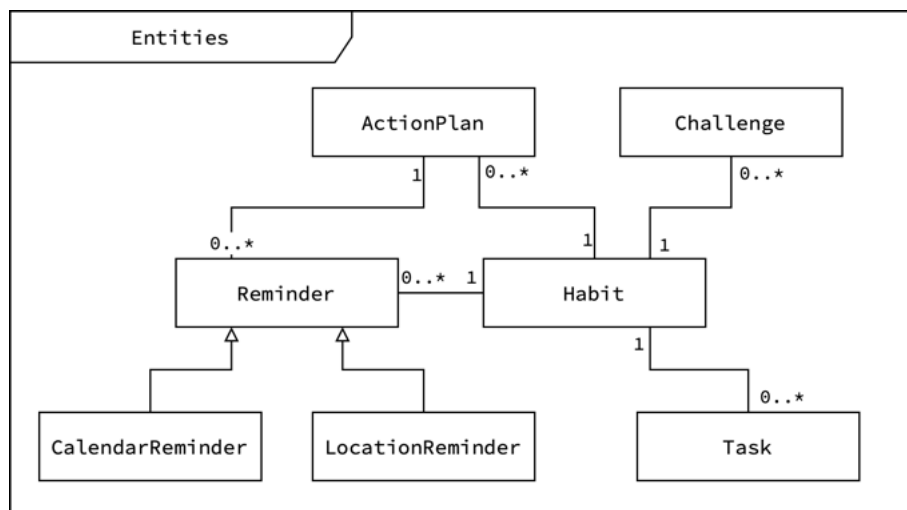
D.2   Link to Code

The following link allows downloading of source code: https://www.dropbox.com/sh/88nhwt0ecpdkjbu/AAAZbPA25TEVC5UeT4NwAWl6a?dl=0

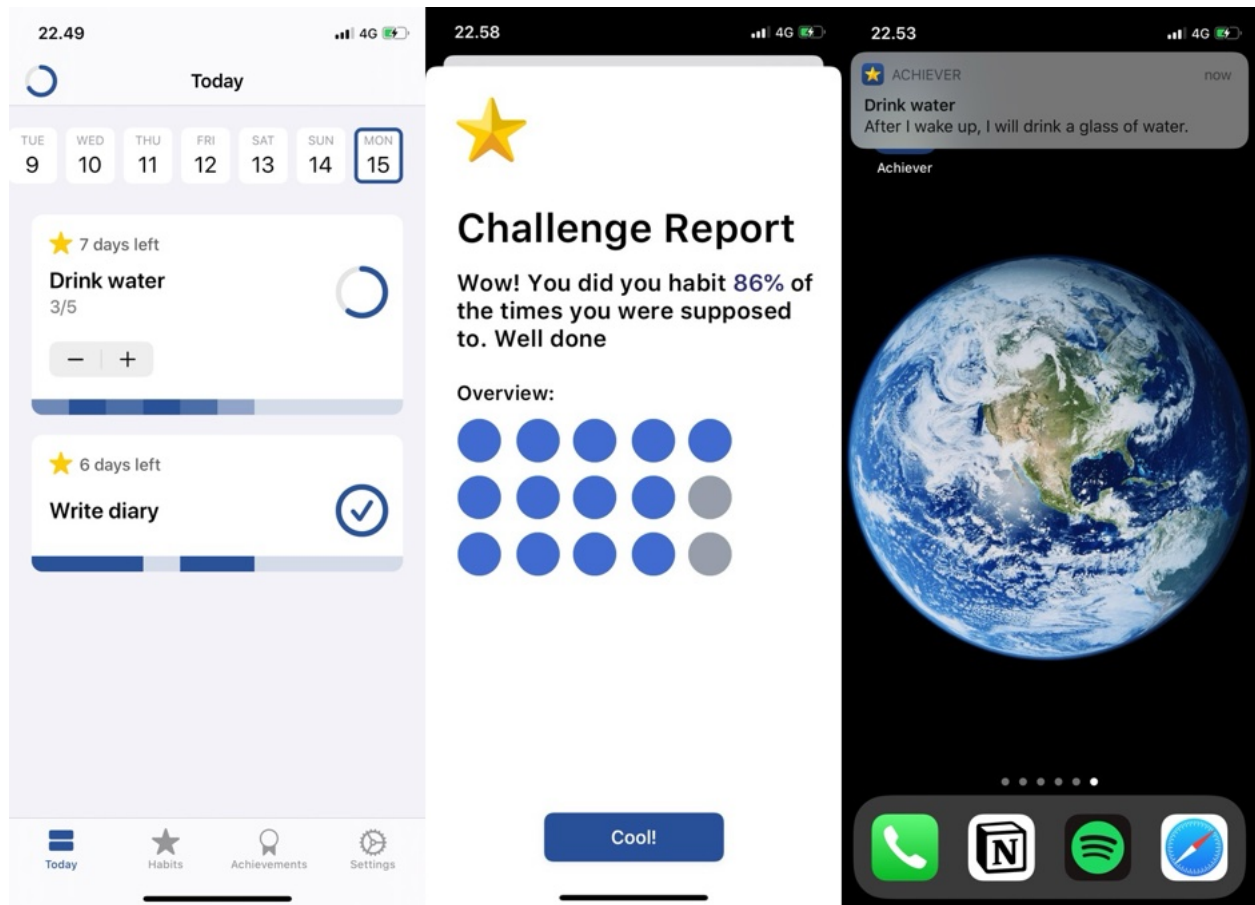## D.3   Screenshots of the developed MVP

Figure D.1: Left: The task card showing the history strip, days left of challenge and daily goal progress. Middle: The challenge report. Right: A time-based reminder showing an action plan
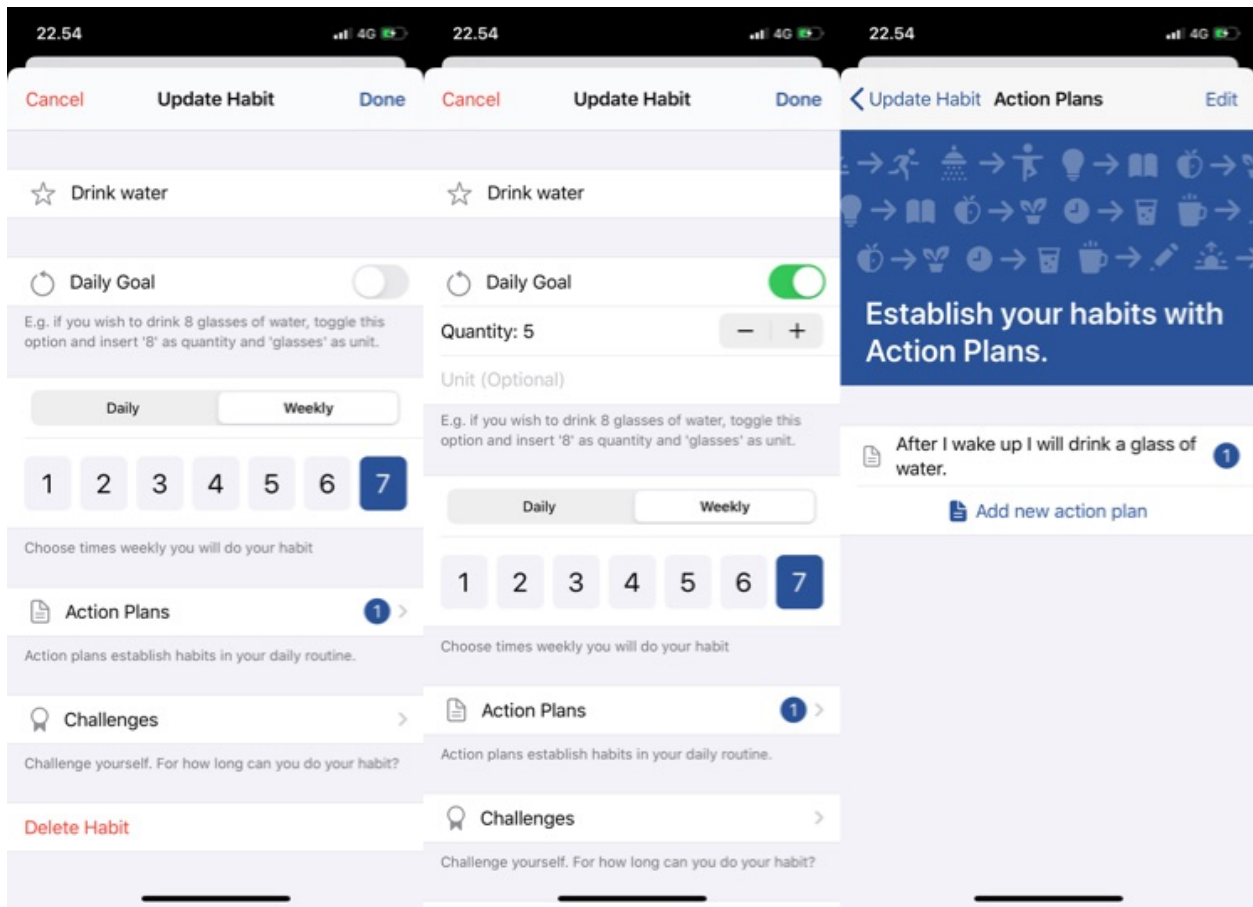
Figure D.2: Left: The habit settings screen. Middle: The habit settings screen showing the daily goal option. Right: The menu showing action plans added to a habit.
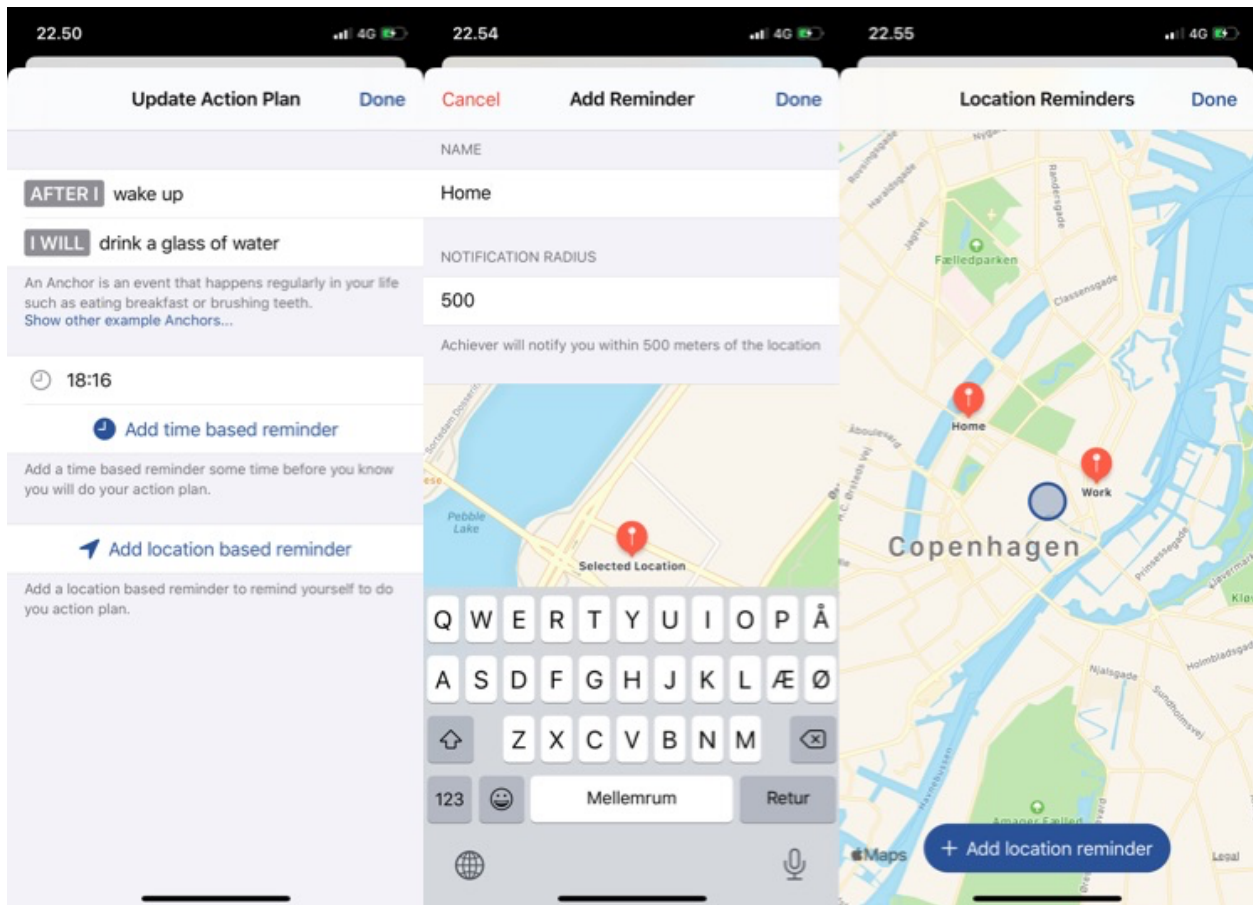
Figure D.3: Left: Updating an action plan. As can be seen multiple reminders can be attached to the action plan. Middle: Adding a location-based reminder. Right: Showing a map of attached location-based reminders.
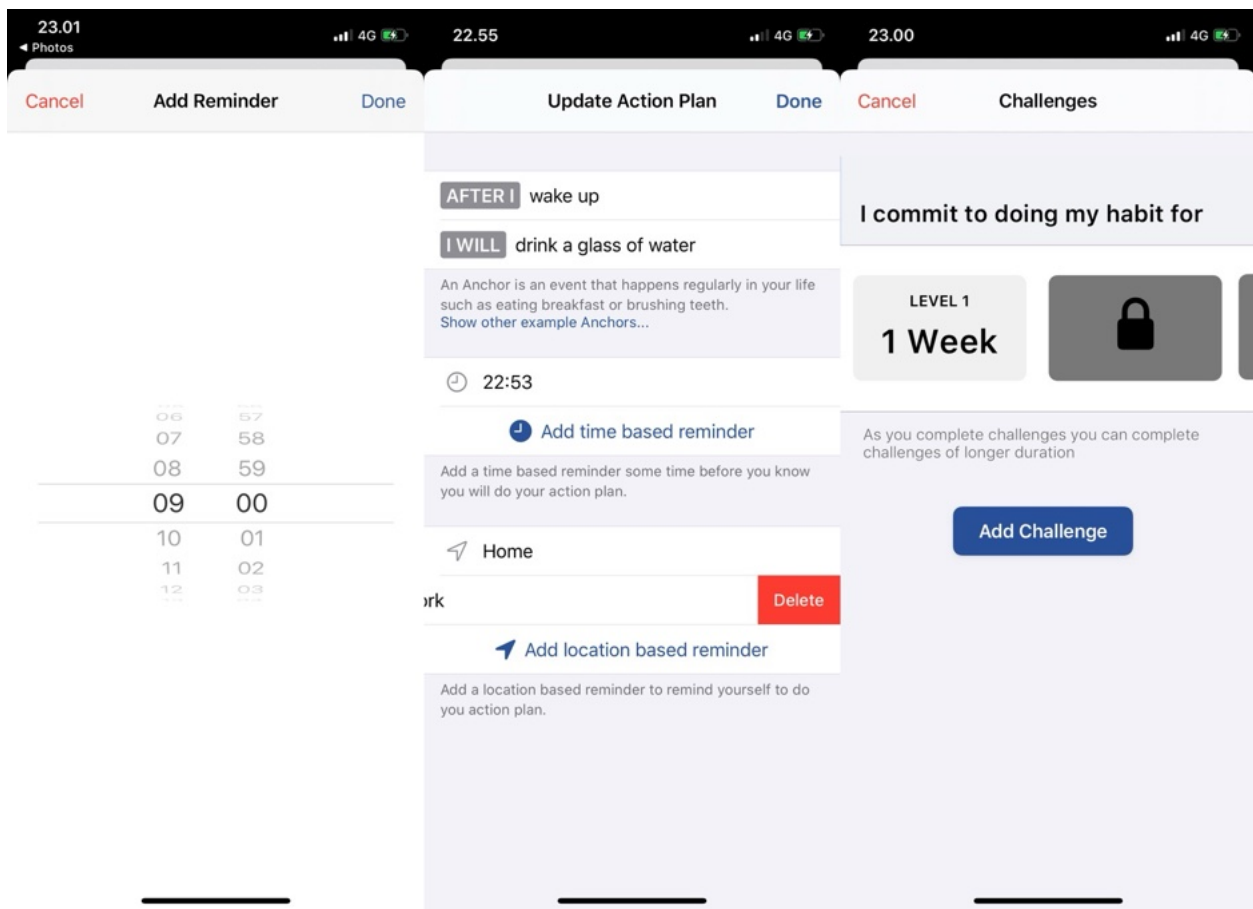
Figure D.4: Left: Configuring a time-based reminder. Middle: Deleting a location-based reminder. Right: The add challenges screen.