Goal-setting in the context of a mobile health application: the case of YAS.life

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Abstract

According to the World Health Organization, insufficient physical activity is one of the leading causes of global mortality. As previous research indicates, mobile health applications -and the use of goal-setting within these applications- can lead to healthier behaviors. This study is the first academic research specifically investigating the impact of goal difficulty on health goal success for mobile health applications. The analyses are based on individual behavioral data from the "YAS" application, a publicly available health application. In line with previous research on goal setting, this study provides empirical evidence that goal difficulty negatively influences goal success in the context of mobile health applications. Moreover, the results indicate that user ability has a moderating effect on the goal difficulty – goal success relationship, wherein the relationship between goal difficulty and goal success is steeper for people with high ability. The results of this study offer important insights into managerial decisions related to the design of mobile health applications, and for health psychology in general.

Keywords:	mobile health application, mhealth, goal-setting, goal success, goal difficulty, ability
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Súmario

De acordo com a Organização Mundial de Saúde, a atividade física insuficiente é uma das causas principais da mortalidade global. Conforme estudos anteriores indicam, as aplicações de saúde móvel – e o uso da formulação de objetivos nessas aplicações – podem levar a comportamentos mais saudáveis. Este estudo é a primeira pesquisa académica a investigar especificamente o impacto da dificuldade do objetivo no sucesso do objetivo de saúde para aplicações de saúde. As análises são baseadas em dados comportamentais individuais da aplicação "YAS", uma aplicação disponível ao público. De acordo com pesquisas anteriores em formulação de objetivos, este estudo corrobora a evidência empírica de que a relação entre a dificuldade do objetivo influencia negativamente o sucesso do objetivo. Para além disto, os resultados indicam que a habilidade do utilizador tem um efeito moderador na relação dificuldade do objetivo – sucesso do objetivo, em que a relação entre a dificuldade do objetivo e o sucesso do objetivo é mais acentuada no caso de pessoas com habilidade elevada. Os resultados deste estudo oferecem contributos importantes para as decisões de gestão relacionadas com o design de aplicações móveis de saúde, e para a psicologia da saúde em geral.

Palavras-chave:	aplicações móveis de saúde, mhealth, formulação de objetivos, sucesso do objetivo, dificuldade do objetivo
Título da dissertação:	Formulação de objetivos no contexto de uma aplicação de saúde móvel: O caso da YAS.life
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Glossary

DVG	–	Digital Healthcare Act
mHealth	–	mobile health
NCDs	–	noncommunicable diseases
WHO	–	World Health Organization

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1. Introduction:

According to the World Health Organization, in 2016, 27.5% of adults aged over 18 years old were insufficiently physically active; specifically, they engaged in less than 150 minutes of moderately intensive physical activity per week. The consequences are significant: people who do not exercise are at 20% to 30% higher risk of mortality, making failure to exercise one of the leading causes for global mortality (World Health Organization, 2018a). Due to the prevalence and risk associated with lack of physical activity, new and effective solutions to improve health-related behaviour are needed, such as mobile health applications (Middelweerd, Mollee, van der Wal, Brug, & te Velde, 2014) and wearables. These digital technologies monitor daily health behaviours and encourage users to deploy effective health interventions (Patel, Asch, & Volpp, 2015). Applications use a variety of behaviour change techniques and gamification elements (Zichermann & Cunningham, 2011). One of the most popular of these techniques is goal-setting (Free et al., 2013).

What influences goal success? A major contributing factor is goal difficulty. Goal-setting theory suggests that goal difficulty is linearly and negatively correlated with goal success (Locke, 1968). The purpose of this thesis is to combine findings from goal-setting theory and counterfactual thinking and test them in the context of a mobile health application. The current study aims to analyse the relationship between goal difficulty and goal success, as well as the moderating factor of user ability. This research is based on data from the "YAS" application, a publicly available and free health application developed by the German insurtech MAGNUM EST Digital Health GmbH. The data contains 419 step goals from 283 users over 10 months, from May 2019 to February 2020.

The results of the present study support the conclusion that there is a negative relationship between goal difficulty and goal success. Furthermore, the moderating effect of ability on the goal difficulty – goal success relationship was confirmed. Interestingly, the findings of the analyses show that for people with less ability, goal difficulty impacts goal success less. Overall, this study contributes to the existing body of literature by focusing on the isolated impact of goal difficulty on goal success in the context of a mobile health application. Moreover, the results provide insight for effective product design of mobile health applications related to goal-setting.

The structure of the work is as follows: the next chapter (i.e., chapter two) reviews health application research and discusses findings in goal-setting theory which drive my hypotheses. The methodological approach presented in chapter three builds the foundation of the analysis. The fourth chapter provides information about the analysis, the results, and possible limitations.

In chapter five, the implications of the results are discussed before providing the outlook of this research paper.

2. Literature review and theoretical framework

This chapter is a literature review of health application research and research on gamification and goal-setting in mobile health. Additionally, I delineate success factors for goal achievement and derive the hypotheses for goal success in mobile health applications.

2.1 Literature review of the impact of mobile apps to improve health

First, I provide background on global health challenges, especially noncommunicable diseases. Next, I describe the potential health benefits of mobile applications.

Major health challenges can be solved by modifying behaviour

According to the World Health Organization (WHO), noncommunicable diseases (NCDs), such as cardiovascular disease, cancer, and type 2 diabetes, are "one of the major health challenges of the 21st century" (World Health Organization, 2018b). In September 2011, the prevention and control of NCDs was declared a global health goal at the United Nations General Assembly in New York (General Assembly U.N., 2011). NCDs tend to be of long duration and are the result of a combination of genetic, physiological, environmental, and behavioural factors. Behavioural factors such as physical inactivity, unhealthy diet, tobacco use, and the harmful use of alcohol increase the risk of being diagnosed with NCDs (World Health Organization, 2018b). Fortunately, the risk of NCDs can be decreased by lifestyle modifications. Behaviours such as diet and physical activity are modifiable risk factors for these diseases; improvement of these conditions is essential to reduce the financial and health burden of these NCDs (General Assembly U.N., 2011).

The potential impact of mobile apps to improve health

Advancements in technology have always been a major driver in improving human health (World Health Organization, 2019 and given the global scale of NCDs, preventative interventions that can reach large populations at low cost are needed. Smartphones and tablets have become an integral part of daily life as evidenced by large increases in usage rates since their introduction in 2007 ("Smartphone users worldwide 2020 | Statista," n.d.). The development of mobile communications devices has also spurred rapid growth in health and fitness apps which provide behavioural interventions to large user groups (Middelweerd et al., 2014).

Mobile applications allow people to measure their health-related behaviours outside of medical practices and could have profound application in the prevention of NCDs. These digital solutions, focusing on different aspects of improving individuals‘ health outcomes (e.g., prevention or disease cure), offer the potential for a dynamic engagement of patients and providers in healthcare and a new means of improving health (Sama, Eapen, Weinfurt, Shah, & Schulman, 2014).

In recent years, the development of these applications has birthed a new market: Mobile Health (mHealth), a global market that is expected to reach nearly 100 billion U.S. dollars in 2021 and to more than triple in value by 2025 (“Total mHealth market size worldwide 2025 forecast | Statista,” n.d.)[1].

Systematic reviews have found modest evidence for the efficacy of application interventions to improve diet, physical activity, and sedentary behaviours for NCD prevention (Free et al., 2013; Schoeppe et al., 2016). As Free and colleagues (2013) demonstrated, the efficacy of mobile health applications differs mainly for different diseases and which behavioural change techniques they use.

2.2 Gamification and goal-setting in mobile applications

This section addresses the importance of gamification in mobile health applications and subsequently explore the behavioural change technique of interest for this study: goal-setting.

The importance of gamification in mobile health applications

To provide users with an engaging experience, mobile applications use gamification elements. As Zichermann and Cunningham (2011) outline, there is a vast number of different gamification elements in place for mobile applications. Several studies indicate that goal-setting, self-monitoring, feedback, rewards, social support, and coaching can lead to behavioural modifications (Sullivan & Lachman, 2017). Applications often use multiple behavioural change techniques to engage users and to modify their behaviour (Free et al., 2013; Middelweerd et al., 2014). A review of mobile applications found that goal-setting is among the most common behaviour change techniques (Free et al., 2013).

Goal-setting in mobile health applications

Although goal-setting research originates from an organizational/work context (see the subsequent section 2.3 for a review of goal-setting theory), the benefits of setting goals can be transferred to the field of health behavioural change (Strecher et al., 1995). Goal-setting has been found to have a beneficial impact on patients' health in the context of many different

[1] This market value estimation from 2018 is likely to increase even more due to the recent developments related to the Covid-19 pandemic

diseases, such as diabetes (Anderson, Christison-Lagay, & Procter-Gray, 2010; DeWalt et al., 2009) mental health (Clarke, Crowe, Oades, & Deane, 2009), stroke rehabilitation (Rosewilliam, Pandyan, & Roskell, 2014), and other chronic illnesses (Von Korff, Gruman, Schaefer, Curry, & Wagner, 1997).

Recently, the benefits of goal-setting have been investigated for mobile applications. Several studies have shown that the health benefits of goal-setting are replicable for smartphone applications (Culley & Evans, 2010; Årsand et al., 2012; Ramanathan, Swendeman, Comulada, Estrin, & Rotheram-Borus, 2013). In the following section, I will focus on goal-setting theory and on the factors that impact success.

2.3 Success factors for goal achievement

To my knowledge, this is the first academic research specifically investigating the impact of goal difficulty on goal success for mobile health applications. Having identified the outcome potential of mobile technology interventions and the importance of goal-setting, I will now address the impacts of goal success in mHealth applications. I will summarize the main findings in the goal-setting literature and formulate hypotheses on the effects of goal-setting on goal success in mobile health applications.

The negative effect of goal difficulty on goal success

With the publication of his article "Toward a Theory of Task Motivation and Incentives" in 1968, Edwin Locke laid the foundation of modern goal-setting theory. A goal is defined as "what the individual is consciously trying to do" (Locke, 1968). Later on, Locke and his colleague Gary Latham became renowned for their work in goal-setting research and in their work "Building a Practically Useful Theory of Goal-setting and Task Motivation," they summarized 35 years of empirical research on goal-setting theory (Locke & Latham, 2002).

According to Locke, more difficult goals are associated with lower probabilities of achievement. Surprisingly, although setting difficult goals decreases one's likelihood of achieving a goal, difficult goals[2] result in a higher level of performance (i.e., output) than easier goals. That is, people increase their performance because more difficult goals require more effort, while the chances of goal failure increase at the same time. The goal-performance relationship is highest when (1) a goal is difficult yet attainable and (2) a person is committed to attaining the goal. Another key finding of Locke´s research is that goals should also be specific to increase performance. Overall, difficult and specific goals produce a higher level of output compared to scenarios in which no goal is established or when someone is told to "do

[2] Locke defines difficult goals as goals which are set at the 90th percentile of performance

your best" (Locke, 1968). Furthermore, Locke and Latham state that goals mediate how performance is affected by factors such as monetary incentives, feedback, commitment, and ability (Locke & Latham, 2002). Although there are other goal-setting theories, it is beyond the scope of this review to analyse them in detail[3]. While other theories contribute to a better overall understanding, most of the research has focused on Locke's theory, which will therefore be the baseline for this work.

Much of the early research by Locke focused on industrial and organizational settings, however Locke and Latham argue that prior findings can be transferred to the context of sport[4] (Locke & Latham, 1985). Thus, the effect of subjects reaching difficult goals less frequently (Locke, 1968) is also valid in the context of physical exercise. Thus, I hypothesize:

Hypothesis 1: *Goal difficulty has a negative effect on goal success.*

The moderating effect of individual ability on the relationship between goal difficulty and goal success

Difficult goals require high effort and have a lower probability of success than easy goals (Erez & Zidon, 1984). However the more difficult the goal, the higher the performance outcome (Locke, Motowidlo, & Bobko, 1986). A key underlying principle in Locke´s goal-setting theory, which has been cited several hundred times, is the concept of the ability to achieve a goal. He argues that the positive relation of goal difficulty to goal performance is limited. Although people work hard to reach a challenging goal, individuals will only do so when the goal is within their capabilities. As goals become too difficult, the performance suffers, and people reject the goal because it is unattainable.

Much research indicates that individual ability has a moderating effect on performance in goal-setting theory (Garland, 1983; Locke & Latham, 1985; Locke, Mento, & Katcher, 1978). Locke and Latham argue that for tasks within the person's ability, more difficult goals result in higher output than do easy goals (Locke & Latham, 1985). However, if the goal is unrealistically difficult, a person's effort is likely to result in failure. Locke hereby directs to the

[3] Other well-known researchers in the area of goal-setting include Garland, Elliot, Barron, Maehr and Nicholls. Much research has focused on goal-setting in the context in school (Harackiewicz, Barron, Carter, Lehto, & Elliot, 1997; Urdan & Maehr, 1995) and motivation (Nicholls, 1984). Garland (1993) proposed a theory to explain the linkages between individual task goals and performance. Urdan and Maehr (1995) investigated academic achievement motivation and Elliot published a paper on the measurement of achievement goals (Elliot & Murayama, 2008). Nicholls (1984) enriched this research with conceptions of ability, subjective experience, task choice, and performance.

[4] Although there is little doubt about the general validity of Locke's theories, it must be mentioned at this point that this recontextualization has been criticized (Weinberg & Weigand, 1993). This criticism was in turn sufficiently addressed by Locke himself (Locke, 1994)

importance of self-efficacy research of Bandura[5] and points out that such a failure can weaken feelings of self-efficacy and reduce motivation to perform the activity (Bandura, 1977).

The Dunning-Kruger effect

Dunning and Kruger highlight the importance of ability in the context of self-assessment. In their article "Unskilled and unaware of it: How difficulties in recognizing one's own incompetence lead to inflated self-assessments", the two authors argue that less skilled people tend to overestimate their abilities more than those who are more skilled (1999). Specifically, Dunning and Kruger state: *In essence, we argue that the skills that engender competence in a particular domain are often the very same skills necessary to evaluate competence in that domain – one's own or anyone else's* (Dunning and Kruger, 1999; p. 1121).

According to the so called "Dunning-Kruger Effect" individuals lack what cognitive psychologists call metacognition (Everson & Tobias, 1998) or metamemory (Klin, Guzmán, & Levine, 1997). These terms refer to the ability to know how well one is performing, when one is likely to be accurate in judgment, and when one is likely to be in error. Because of metacognition or meta-ignorance (as Dunning terms it) the scope of their own ignorance is often invisible to people with less skills (Dunning, 2011). This meta-ignorance is described by Dunning (2011) as "ignorance of ignorance". In sum, Dunning and Kruger (1999) state: *We propose that those with limited knowledge in a domain suffer a dual burden: Not only do they reach mistaken conclusions and make regrettable errors, but their incompetence robs them of the ability to realize it* (Dunning and Kruger, 1999; p. 1121).

Accordingly, less-skilled performers presumably have less of the knowledge needed to make informed guesses about their relative (future) performance. With a specific focus on the context of this study, the effect of flawed self-assessments has also been validated in the domain of health decisions (Dunning, 2004). It is beyond the scope of this thesis to present the Dunning-Kruger effect in its entirety[6], but the fundamentals of this theory provide interesting points for the interpretation of goal-setting theory. In particular, framing the findings of the Dunning-

[5] Bandura states in his well-known concept that "Perceived self-efficacy is concerned with judgments of how well one can execute courses of action required to deal with prospective situations" (Bandura, 1982). He argues that an individual's sense of self-efficacy will determine whether effort is expended and how long effort is sustained (Bandura, 1977). Although Self-efficacy has also found to be a mediator between Goal-Setting and Physical Activity (Iwasaki et al., 2017), it is beyond the scope of this review to further elaborate on this.

[6] Several studies indicate that well over 50 % of people believe themselves to be above-median performers (Dunning, 2004). According to the Dunning-Kruger effect self-assessment of individuals in general often is flawed. Interestingly, other people's predictions of a person's outcomes prove more accurate than that person's self-predictions (Dunning, 2004). Another key finding of Dunning and Kruger is that skilled performers can better assess their own skill, so they are less overconfident in their relative self-assessments.

Kruger effect in the context of mobile health applications should help us to understand why people with different levels of ability succeed or fail in pursuing their own stated health goals,

Based on previous research on goal setting and the Dunning-Kruger effect, I hypothesize that the relationship between goal difficulty and goal success is different for people with high ability compared to people with low ability. For individuals with less ability, the chances to attain any type of goal is very low, and therefore difficulty does not influence goal success. This assumption is in line with Locke´s goal-setting research. According to Locke, people stop trying to attain a goal when goals become too difficult (Locke & Latham, 2002). However, while I expect to find this type of negative relationship for users with high ability, I also presume a different outcome for their lower ability counterpart. That is, I suspect a negative relationship between goal difficulty and goal success for very capable users because they can be more knowledgeable in assessing the means to achieve their goal. In contrast, users with less ability are already satisfied with achieving any type of goal and they are less knowledgeable about their own potential. According to Dunning and Kruger, these individuals will be more prone to overestimate their abilities (1999) and therefore to fail their health goals regardless of the goal difficulty. In sum, building upon the first hypothesis, the effect of goal difficulty on goal success appears to be moderated by ability, which lays the foundation for my second hypothesis:

Hypothesis 2: *Ability moderates the effect of goal difficulty on goal success, such as (a) for people with low ability the relationship is not significant, while(b) for people with high ability the relationship is negative and significant.*

3. Methodology

In this section, I explain the origin of the data used in this study (3.1). Next, I present the company MAGNUM EST Digital Health GmbH and describe their offered digital health application. Afterwards, I outline the methodology (3.2) used to retrieve the primary data used for the subsequent analyses.

3.1 Introduction to MAGNUM EST Digital Health GmbH (YAS.life)

Company

MAGNUM EST Digital Health GmbH was founded in 2016 by Dr. Magnus Kobel. Under the name YAS.life, the company develops digital white-label applications for health and life insurance companies and businesses in the field of health management and prevention. Besides the publicly available B2C-app called “YAS”, YAS.life has developed seven B2B applications (state May 2020). YAS.life communicates its Unique Selling Point (USP) to its paying B2B customers as follows:

> *"YAS.life's customizable white label solution motivates policyholders by smart gamification elements and rewards to adopt a more health-conscious lifestyle, helping health and life insurers to reduce their claims. We aggregate data of users to provide insurers with valuable information on how to calculate more attractive and more profitable products, e.g. new health plans. In addition: Through our engagement platform we generate digital touch points with the policyholders and thus, offer the insurer a perfect opportunity for up- and cross-selling. Our white label solution can be implemented within three months and requires no IT resources from the insurance company."*

The company describes its services and products as follows:

> "*Our bonus program uses the gamification approach to support policyholders and employees in integrating health-conscious behaviour into their everyday lives on a permanent basis and rewards preventive behaviour such as exercise, fitness, and measures for a healthy life with attractive premiums from the areas of nutrition, lifestyle, and prevention. The YAS-app is a health companion that motivates you to live a healthier life and guides you along every step of the way. The YAS app makes adopting healthy habits personalized, simple, and fun."*

While the access to most B2B applications is restricted to policyholders of YAS.life´s clients, the B2C YAS application can be downloaded for free in the iOS App-Store and on Google Play in Germany. The YAS-app was published in 2017. Over time, the application was developed further to include additional features related to health behaviour.

Product

After downloading the application, users are asked to connect the application with a fitness tracker. The YAS-application does not track the fitness data itself but retrieves data from external fitness trackers and fitness applications[7]. Through the synchronized fitness data users earn points for steps, activities and challenges. One can earn a maximum of 25 points per day, whereas every 5.000 steps equal 5 points[8]. Within the YAS-application different gamification

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[7] By May 2019 the integration of the following fitness trackers was possible: Google Fit, Apple Health, Samsung Health, Fitbit, Garmin or Polar fitness trackers. Trackers were chosen by YAS.life based on trackers with the highest usage rates and most relevant and updated system.

[8] The YAS points systems works as follows: >= 5.000 steps = 5 points; >= 10.000 steps = 10 points; >= 15000 steps >= 15 points; >= 20000 steps = 20 points; >= 25000 steps = 25 points. In addition, users receive 10 points for an activity with increased heart rate and a duration of 20 minutes. For an activity with increased heart rate for more than 30 minutes users receive 15 points. A prerequisite for users to receive points in the YAS application is that the activity is trackable by an external fitness tracker. Non-trackable sports activities such as yoga can be

techniques are used to motivate users towards a more active and health-conscious lifestyle. These techniques include features such as:

- personal goals, where users can set a health goal for themselves (see more details in data, sample and measures)
- preset challenges, where users must reach a certain point score or goal level within a preset period of time[9]
- rewards, which users can redeem with points they earn[10]
- groups, which users can set up to compare themselves with friends

In addition, YAS.life provides the user with health-related content and uses push notifications as reminders to motivate the application users.

3.2 Data, sample, and measures

For the analysis, the data of the publicly available B2C-application "YAS" from the German insurtech MAGNUM EST Digital Health GmbH was used. The subject of study was the "goal"-feature of the application. This feature was implemented in the YAS-application in May 2019. To ensure consistency of the analysis only users who registered after May 1st, 2019 were included. The end date of the analysis was set to end of February 2020 to exclude expected changes in behavior related to the Covid-19 pandemic. The analysis is based on a data export from April 30.

Within the goal feature, users can choose between different types of health goals. Goals are offered for the area of mental wellbeing (e.g. sleep), prevention (e.g. setting reminders for preventive medical checkups), nutrition (e.g. fruit intake), and fitness. Fitness goals can be set for weight training, cardio, and daily steps. Only fitness goals of the subcategory "daily steps" are included in the analysis. I have chosen "steps" as a variable for two reasons. Firstly, "daily steps" is a very comparable variable (e.g., it is hard to measure the intensity of cardio and weight training) and secondly, steps can be measured accurately by wearables (Case, Burwick, Volpp, & Patel, 2015), which then pass this information to YAS.life. Within the YAS-application users are exposed to a variety of features (see Introduction to MAGNUM EST Digital Health GmbH – Product). To better analyse the goal-feature itself, I decided to mitigate a possible bias of app

added as manual activity in the YAS application. For adding a manual activity a user receives 5 points. If a user adds more than one manual activity per day, she does not get any extra points. A Screenshot from the the YAS points system can be found in the appendix

[9] In contrast to personal health goals, users receive additional points in the YAS-application when they successfully complete a challenge

[10] Rewards are offered in different categories such as sport, food, health, and wellness and are provided by external partners of YAS.life. By May 2020, YAS.life offers rewards from 21 partners in the YAS-application. Rewards are offered at different point levels: 250 points, 500 points, 750 points, 1,000 points. The voucher for 250 points corresponds to a value of approximately 10€ or at least a 20% discount

usage experience (for further explanation see comments about "ability" below), and therefore restricted the database further. Consequently, only users who set up a step goal within 31 days after registration are included in the database. Narrowing down the database to step goals only and limiting the time window for registration and time of goal creation results in a database size of 419 observations.

Methodological approach for the analyses

The focus of the analyses is the goal feature of the YAS application. The dataset presents a nested structure wherein the main independent and dependent variables are at the goal level (Level 1), while the moderator is at the user level (Level 2). The dependent variable in the model is *goal success* (Level 1). The main independent variables used in the analyses are *goal difficulty* (Level 1) and *user ability* (Level 2). Below the variables used in the model are described in more detail.

Goal success: According to Merriam Webster a goal is defined as "the end toward which effort is directed". Users can either reach the requirements to attain this end or not. As there are only two possible outcomes for this variable (success or fail) *goal success* is coded as a binary variable (0= failure; 1=success).

Goal difficulty: When app users set themselves a step goal, they can choose between three different types of goal difficulty levels:

- 1= Easy goals: Users must reach 10.000 steps three times a week
- 2= Medium goals: Users must reach 10.000 steps five times a week
- 3= Hard goals: Users must reach 10.000 steps seven times a week

When setting up a goal in the YAS application, a user is exposed to three different buttons first. Due to the labelling of the goals as "easy", " medium" and "hard", it is expected that users do not only trust the app providers expertise in the judgement of a goal difficulty level, but also that a user can hardly estimate how difficult it is to attain a certain step number for them individually. Therefore, users assume the differences between the goal difficulty levels to be equal, which means that goal difficulty can be thought of as a Likert scale[11]. Accordingly, goal difficulty is coded as 1, 2, 3 in the database[12]. In the YAS application a goal can be set at any point in time and will start the day after. Goals of the same category (e.g. steps) can not be set in parallel, but only sequentially. The duration of a goal can be set to two, three, and four weeks.

User Ability: To operationalize user ability the variable *steps at registration* was used. Using

[11] Likert scaling assumes that the distance between each choice is equal; for more information see Albaum (Albaum, 1997)

[12] The results of the analyses are statistically invariant if a different metric is used (e.g., 10.000 steps/ 3/ 5/ 7)

steps per day as a measure for user ability has the benefit of being a comparable method for assessing users' physical activity level. Although there are scientific discussions about certain thresholds for recommendations for steps per day (Tudor-Locke & Bassett, 2004), it is generally useful to assess the level of health literacy based on an activity that is present at any point in life: steps one takes. Since the YAS-app does not measure directly users' steps but synchronizes data from an external fitness tracker to the application, the time of the day in which the application is downloaded does not matter. YAS.life uses different gamification concepts from the first day (e.g. a so-called starter challenge[13]) to motivate users from the beginning. Because users are exposed to a variety of features in the application (see Introduction to YAS.life - Product), it is important to measure the activity level of the user on the first day. Different operationalization methods such as using a longer time period for daily steps to measure ability are not suitable as users are motivated and educated by YAS.life within a short period of time already. Hence, using the first day to measure ability is the only point in time where users have equal conditions.

4. Model and results

In this chapter, I describe the statistical approach for the data analysis (4.1). Subsequently, I report descriptive statistics (4.2.1) and the results from the main analyses (4.2.2).

4.1 Data and models

The database used in the analysis consists of 419 goals, hence 419 observations. However, as users can set themselves multiple goals (not in parallel, but sequentially), the number of unique users is less than the number of goals: in total, the database has 283 entries of unique users. For the analyses, I will use the variables *goal success*, *goal difficulty* and *user ability*. Further, it is worth noting that the variables used in the analyses are at different levels. In this case the variables *goal success* and *goal difficulty* are measured on a goal level, whereas ability measured as *initial steps at registration* is measured on a user level. Thus, due to hierarchical structure (user level > goal level) one can expect non-independence of observations. To be able to fit the model more precisely, I use Multilevel Mixed-effects Probit and Multilevel Mixed-effects Linear Probabilty Model. All the analyses were performed in STATA

[13] very easy pre-set challenge, in which users must reach 15.000 steps within the first three days after installation. This feature is used to let the user start with a positive experience

In the model, the goal is to measure the effect of the independent variables " difficulty level" (i.e., *goal difficulty*) and " user ability" (i.e., *initial steps at registration*) on the dependent variable *goal success*. In statistics, the simplest approach to model a relationship between two or more explanatory variables on a dependent variable is through a multiple linear regression. When the dependent variable is binary (either 1 or 0) a probit analysis should be conducted (instead of a linear regression). In the study, the dependent variable has only two possible outputs: when you set yourself a goal you can either fail or succeed. To analyze the probability of *goal success* it is therefore more applicable to use a probit regression model. For my first hypothesis I assume that while *goal difficulty* increases, *goal success* decreases.

4.2 Descriptive statistics

The dataset used for the analysis is based on a data export from April 30 and includes observations between 1 May 2019 and 29 February 2020. Details about the dataset are presented in "3.2 Methodological Information". In the data I did not find any unrealistic observation. The values for "initial steps at registration" lie between 48 and 44.136, whereas the mean for this variable is above 9.000. From this I can already note that the average YAS app users seem to be more active than the mean of the German population, which is according to a recent publication from Stanford university 5.205 (Althoff et al., 2017). It is notable that the dataset contains five entries with a high step count with more than 30.000 steps on the day of the registration and eight observations with less than 500 steps this day. Although those observations are extreme, they are not unrealistic because someone could have been sick in bed (in the minimum case) or could have ran a marathon (in the maximum case). Hence, I did not exclude any observations due to the findings in the descriptive statistics.

Out of the 419 goals, easy goals have been set more often than difficult goals. The data contains 188 easy goals, 157 medium goals and 74 hard goals. Due to the restrictions/conditioning of the dataset most of the goals in the analyses are the first goals a user has set. A possible explanation for the higher proportion of easy goals could be that users start with an easy goal first before they try out more challenging goals. In total, 78 goals have been completely successfully, of which 36 goals are easy, 30 medium and 12 difficult. As already noted above, users have the possibility to set a new goal after completing the previous. It is natural that the number of users (283) is therefore lower than the number of goals set.

4.3 Test of hypotheses

First, I investigate the relationship between goal difficulty and goal success. I start by using a Multilevel Mixed-Effects Probit where I control for user ability (i.e., initial steps). As I hypothesized a negative linear relationship between goal difficulty and goal success, I included ability in the model (Hypothesis 1). Subsequently, I tested for interaction effects between the explanatory variables to investigate a possible moderation of ability on the suspected relationship between goal difficulty and goal success (Hypothesis 2). For the second hypothesis, I conducted a Multilevel Mixed-Effects Probit and a Multilevel Mixed-effects Linear Probabilty Model (i.e., the latter used to interpret the interaction coefficients). Before testing Hypothesis 2, I present below the results of the linear effect of goal difficulty on goal success (i.e.,which are in line with the literature on goal setting).

Table 1. The negative effect of goal difficulty on goal success

VARIABLES	**Multilevel Mixed-Effects Probit**
Goal difficulty	-0.77***
	(0.28)
User ability	0.00***
	(0.00)
Constant	-1.67**
	(0.42)
Observations	419
Number of groups	283

Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05

Based on the findings presented goal difficulty has a negative and significant impact on goal success. The results of the model show that the users´ likelihood to achieve a goal is reduced with an increase in difficulty of the goal. In this analysis, I further control for initial steps at registration. I find a significant and positive effect on goal success for this variable. Due to the different scales of initial steps at registration (a continuous variable with values up to 44.000 in out database) and goal success (binary variable) it is hard to interpret the magnitude of this effect. From this I conclude that one additional step at registration increases the likelihood of reaching a goal, but not on which scale.

Hypothesis 2 - Results

In Hypothesis 2, I suggested a moderation effect of user ability on the relationship between goal difficulty and goal success. In the table below, I present the results of the model.

Table 2. The effect of goal difficulty on goal success moderated by user ability

VARIABLES	**Multilevel Mixed-effects Probit**	**Multilevel Mixed-effects Linear Probabilty Model[ab]**
Goal difficulty	-0.02	0.43*
	(0.35)	(0.21)
User Ability	0.00***	0.22***
	(0.00)	(0.05)
Goal difficulty X User Ability	-0.00*	-0.06*
	(0.00)	(0.02)
Constant	-2.70***	-1.68***
	(0.66)	(0.43)
Observations	419	419
Number of groups	283	283

Standard errors in parentheses

*** p<0.001, ** p<0.01, * p<0.05

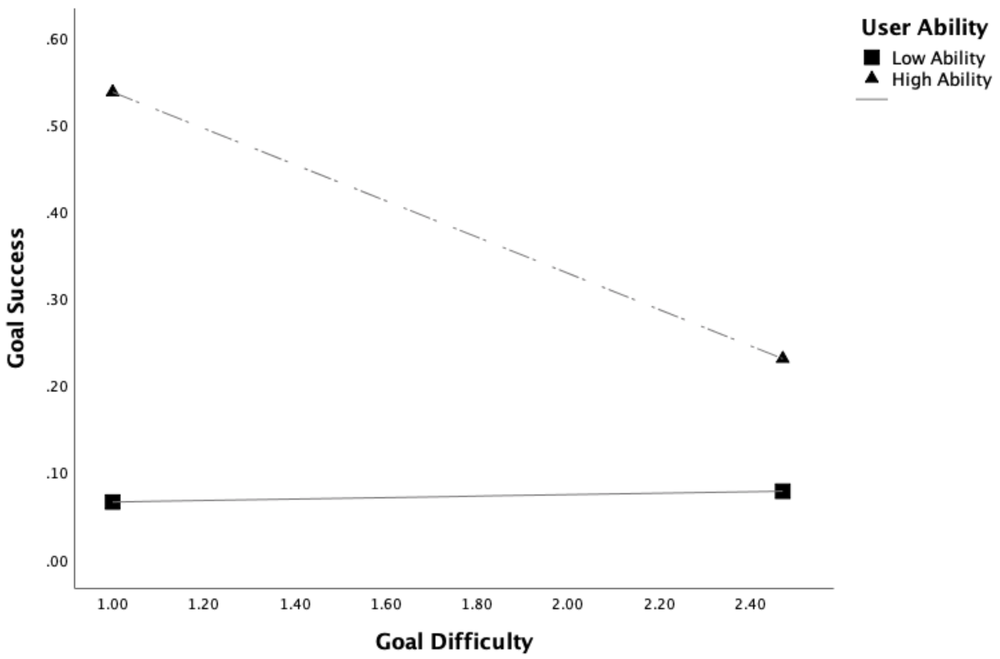
[a] Used for coefficient interpretation and graphing

[b] Log Initial steps at registration for interpretation and graphing

Starting with the Multilevel Mixed-effects Probit model (i.e., first column in Table 2,) I find significant results for the coefficients of user ability and the interaction effect of user ability with goal difficulty. Accordingly, these findings confirm Hypothesis 2. However, the interpretation of interaction coefficients in Probit model presents strong challenges.

Accordingly, I follow recommendation by Angrist (2001) and Angrist and Pischke (2008) and use a Multilevel Mixed-effects Linear Probabilty model (i.e., second column in Table 2) for the interpretation of the interaction coefficients (i.e., the coefficient significance is consistent with the results of the probit model). A simple slope test (at -1 SD and + 1 SD of my moderator "user ability") indicated that for users with low ability, goal difficulty was not related to goal success (-1 SD ; coefficient = .13, ns), whereas for users with high ability, the effect of goal difficulty on goal success was negative and statistically significant (+1 SD; coefficient = -.92, p<.001). These findings are plotted in Figure 2.

Figure 1. The effect of goal difficulty on goal success moderated by user ability



Specifically, Figure 2 presents the moderating effect of ability on the relationship between goal difficulty and goal success. For users with low ability (i.e., low values for initial steps at the registration), I find that their likelihood to attain a goal (or to fail a goal) does not decrease (increase) with increasing goal difficulty. For users with high ability (i.e., high values for initial steps at registration), I find that the likelihood to attain a goal decreases with goal difficulty.

Data limitations and potential implications

Although my work offers important implications for research on goal setting and mobile health applications, it is not exempt from limitations. With regard to measurement method of the data, it is important to highlight that YAS.life does not collect the step data itself; but retrieves the daily step count and other health activities from external fitness trackers. Unfortunately, these trackers use different hardware and algorithms for data measurement and are therefore not perfectly comparable (Henriksen et al., 2018). Furthermore, two of the data providers used support both wrist-worn wearable devices and simple smartphone applications. Accordingly, the tracked step numbers might vary between wearables and smartphones trackers because people do not always have their smartphones with them, but rather wear a wearable. As the usage of the trackers can be reasonably assumed to be randomly dispersed over the data set, this limitation is neglectable. The distribution of the tracker data can be seen in the appendix.

Second, the step goal feature within the YAS-application allows users to choose between a goal duration of two, three and four weeks. Although, taking this variable into account would be of great benefit, it was not possible to include *duration* as a control variable in any analysis I conducted. Because of a bug in the backend implementation of YAS.life this variable was measured differently within the first months after the feature release and was therefore unusable for the analysis. Due to the limited number of observations it was not possible to add more restrictions to the database and only analyse the data after the bug was fixed. In general, I believe that including *goal duration* in the analysis is of great interest for future research.

In the present study gender was not included in the analysis. Findings regarding gender differences on health goal orientation have been somewhat inconsistent (Hanrahan & Cerin, 2009). While some studies outline a gender specific effect of goal orientation (Duda, 1993) and even report a significant gender specific effect to the overall success of health apps (Grellhesl & Punyanunt-Carter, 2012), other studies suggest that there is no gender specific effect of goal orientation in the context of sport (Gill, 1997). In the YAS-application users are not obliged to insert user-specific information such as age or gender, but this data can be shared voluntarily by the user. Since I experienced a strong drop in observations in the data set when including demographic variables into the analysis, these variables were not included in the analyses.

Furthermore, according to goal-setting theory one of the strongest moderators is goal commitment (Locke & Latham, 2002). To ensure one is committed to a goal, the person does not only have to believe that she has the ability to attain a goal (self-efficacy), but this goal must also simply be important to her[14]. If someone rates his expectancy as low because he has decided not to try, then this of course would decrease the probability to attain a goal. In my model, there was no possibility to measure users' commitment of their stated goal. I believe that including measures for goal commitment (e.g. a pop-up question for the user "how important is this goal to you?" during the goal-setting process) is crucial to validate the findings of the study and

[14] How to ensure and to increase the importance of goal attainment has been analysed in various studies (Hollenbeck, Williams, & Klein, 1989; Latham & Saari, 1979).

might represent an important boundary condition of the relationship between goal difficulty and success.

Additionally, there can be concerns about the way in which user ability was measured in the analyses. In the Methods section, I explain the choice of *steps at registration* in detail. So far there is no best practice defined to measure ability in the context of mobile health. For future research, I believe that different tests of ability might be able to corroborate my findings.

Finally, in the analysis I do not control for seasonality effects. As research has shown, people are more active during summer and spring (Pivarnik, Reeves, & Rafferty, 2003). Since the time window between registration and goal creation was limited to one month, this effect however gets mitigated. Future research can examine the relationship, fluctuations, and variance of goal difficulty and goal success among different times of the year.

5. Implications

In this study, I investigated the negative effects of goal difficulty on goal success (Hypothesis 1), as moderated by user ability (Hypothesis 2). The findings of the study support both hypotheses. In this chapter, I will offer an overview of the main findings and their managerial implications. Mobile applications have the potential to have a leverage effect in tackling current health challenges such as lack of physical activity, making goal-setting a key behaviour change technique. In my first analysis, I found a linear effect of goal difficulty on goal success. Chances to attain a goal are highest for easier goals, followed by more difficult and hard goals. Thus, it is important to encourage users of mobile health applications to set easier goals for themselves in the beginning because the chances of success are the highest. This is important for keeping the user's motivation high (i.e., by attaining a goal, hence generating a positive feeling or small victories) and for exploiting the benefits of gamification engagement. Especially in the beginning of application usage, when many people form their opinion about the application, it is then crucial to generate positive emotions and provide learning opportunities for users to develop their ability. Application designers and providers should then consider measures that realistically state the difficulty of medium and hard goals for users, especially for those who are "unskilled and unaware".

The findings for Hypotheses 2 supported one of Locke's core findings of goal-setting theory: ability has a moderating effect on the relationship between goal difficulty and goal success. Figure 2 suggests that goal difficulty decreases goal success for people with high ability. In contrast, for individuals with limited ability, it will be more difficult to attain any type of goal they might choose. Locke and Latham state that the probability of achieving a goal decreases as difficulty increases (Locke & Latham, 2002). Expanding these previous results, I found that the likelihood to attain a goal decreases linearly with increasing goal difficulty only for people with high ability; while, the relationship is not significant for low ability users. A possible explanation for this effect might be that, in contrast to capable users, people with limited capabilities are less motivated and knowledgeable about their own limits. This explanation is also in line with the findings of Dunning and Kruger (1999). People with low ability tend to overestimate their abilities even more than very capable individuals. Due to their limited ability these users estimate their future performance (i.e., to attain a goal) very inaccurately. Independently from goal difficulty, low ability users are already satisfied with attaining any goal and sometimes overcommit towards even more difficult goals. In fact, one might wonder whether these users choose only easy goals. In the analyses, however, I found that – independently from their ability – users with limited abilities choose different types of goal. A possible explanation for this effect might be that physical (biological) endurance can be relatively high also for people that are categorized as low ability subjects. Thus, many of these individuals might still choose hard goals, and even achieve some of them, because of their biological predisposition.

As demonstrated by a negative effect of goal difficulty on goal success, goal difficulty is an important determinant of goal success for users with high ability. A possible explanation is that users with high ability are better able to gauge the difficulty level of the goals they choose, and yet they face the typical challenges associated with goal setting, namely the harder the goal they choose, the higher their likelihood to fail.

The findings of this thesis are important for mobile application designers, companies developing mobile health applications, and health insurance providers. In particular, because the increasing use of mobile application as preventive interventions [15], physicians should be aware of the importance of the patient's ability when recommending mobile health applications that are based on goal-setting. In general, mobile health application designers should structure this type of application mirroring the design of video games (for an example see Figure 4-Apx in the appendix). In fact, based on my findings (see Hypotheses 1 and 2), it would be better to

[15] In Germany, the “Act to Improve Healthcare Provision through Digitalisation and Innovation”, also known as the “Digital Healthcare Act” (DVG) came into force at the end of 2019. Thanks to this new regulation doctors will be able to not only recommend but prescribe mobile health applications to their patients. Before doctors can prescribe the applications, the Federal Institute for Drugs and Medical Devices Application tests the application for safety, functionality, quality, data security and data protection. Further, manufacturers must prove to the Federal Institute that their app improves patients’ healthcare. The statutory health insurance will pay for this service (Bundesgesundheitsministerium, 2019).

allow users to choose more difficult goals only after that a significative number of easy goals has been achieved[16].

6. Outlook

According to the World Health Organization insufficient physical activity is one of the leading causes for global mortality (World Health Organization, 2018a). Due to the global scale of this problem, governements and healthcare policy makers desperately need preventive interventions that can reach large populations at low cost. One of the most promising solutions can be found in the mobile health sector; a global market that is expected to reach nearly 100 billion U.S. dollars in 2021. Asides from the importance of this issue for public health, there is also a growing managerial interest in this topic among companies within the insurance industry. In fact, (Re)Insurance companies have an inherent interest for the overall well-being of their insured because insurers' good health mitigates their economic risk, eventually reducing the insurance industry's overall costs.

Mobile applications offer the potential for a dynamic engagement of individuals and a new means of improving health (Sama et al., 2014). As previous reasearch indicates, mobile health applications can lead, through behavioural modifications, to an healthier lifestyle (Free et al., 2013). One of the most popular behavioral modification technique is goal-setting.
This study is the first academic research specifically investigating the antecedents of health goal success for mobile health applications. One strength of the study is that is based on real behavioral data from the "YAS" application, a publicly available and free health application in Germany developed by the German insurtech MAGNUM EST Digital Health GmbH.

Goal-setting theory suggests that goal difficulty is linearly and negatively correlated with goal success (Locke, 1968). In the context of a mobile health application, this study presents empirical evidence of this relationship. In addition, the findings support my hypothesis that user ability has a moderating effect on the goal difficulty – goal success relationship.

[16] Unlocking more difficult goals would mean a substantial change to the design of the goal-setting feature within the YAS-application. The effect of locking/ unlocking goals of a higher difficulty would let the goals appear more as achievements towards the user (Groening & Binnewies, 2019). Although Groening and Binnewies (2019) state that such an achievement design resembles classical goal-setting, the users´ performance is likely to change. Their results suggest that achievements have the potential to enhance performance and even outperform the effect of classical goal-setting. Further, they argue that achievements satisfy specific needs better than conventional goal-setting, such as the need for competence, autonomy or cognitive closure. The authors also point out that an early unlocking of many achievements within a short time, makes them appear to be too easy. By that, the positive effect of achievements on performance would suffer. This finding is in accordance to the classical goal-setting theory which postulates that difficult goals are more beneficial for effort and persistence than easy goals (Latham, 2015).

Namely, while the relationship between goal difficulty and goal success is significant and negative for people with high ability, it is linear for people with less ability (i.e., because the latter tend to fail goals regardless of their difficulty). My study contributes to previous research on goal setting and health behaviors by focusing on the impact of goal difficulty on goal success in the context of mobile health applications, a promising research context that has been overlooked by this research stream. Accordingly, the results of this thesis provide relevant insights into the product design of mobile health applications that adopt goal-setting dynamics.

References

Albaum, G. (1997). The Likert Scale Revisited. *Market Research Society. Journal.*, *39*(2), 1–21. https://doi.org/10.1177/147078539703900202

Althoff, T., Sosič, R., Hicks, J. L., King, A. C., Delp, S. L., & Leskovec, J. (2017). Large-scale physical activity data reveal worldwide activity inequality. *Nature*, *547*(7663), 336–339. https://doi.org/10.1038/nature23018

Anderson, D. R., Christison-Lagay, J., & Procter-Gray, E. (2010). Self-management goal setting in a Community Health Center: The impact of goal attainment on diabetes outcomes. *Diabetes Spectrum*, *23*(2), 97–105. https://doi.org/10.2337/diaspect.23.2.97

Angrist, J. D. (2001). Estimation of limited dependent variable models with dummy endogenous regressors: Simple strategies for empirical practice. Journal of Business & Economic Statistics, 19, 2-28.

Angrist, J. D., & Pischke, J. S. (2008). Mostly harmless econometrics: An empiricist's companion. Princeton, NJ: Princeton University Press.

Årsand, E., Frøisland, D. H., Skrøvseth, S. O., Chomutare, T., Tatara, N., Hartvigsen, G., & Tufano, J. T. (2012). Mobile health applications to assist patients with diabetes: Lessons learned and design implications. *Journal of Diabetes Science and Technology*, Vol. 6, pp. 1197–1206. https://doi.org/10.1177/193229681200600525

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191–215. https://doi.org/10.1037/0033-295X.84.2.191

Bandura, A. (1982). Self-efficacy mechanism in human agency. *American Psychologist*, *37*(2), 122–147. https://doi.org/10.1037/0003-066X.37.2.122

Bundesgesundheitsministerium. (2019). Driving the digital transformation of Germany's healthcare system for the good of patients - Bundesgesundheitsministerium. Retrieved June 12, 2020, from https://www.bundesgesundheitsministerium.de/digital-healthcare-act.html

Case, M. A., Burwick, H. A., Volpp, K. G., & Patel, M. S. (2015, February 10). Accuracy of smartphone applications and wearable devices for tracking physical activity data. *JAMA*

- *Journal of the American Medical Association*, Vol. 313, pp. 625–626. https://doi.org/10.1001/jama.2014.17841

Clarke, S. P., Crowe, T. P., Oades, L. G., & Deane, F. P. (2009). Do goal-setting interventions improve the quality of goals in mental health services? *Psychiatric Rehabilitation Journal*, *32*(4), 292–299. https://doi.org/10.2975/32.4.2009.292.299

Culley, C., & Evans, J. J. (2010). SMS text messaging as a means of increasing recall of therapy goals in brain injury rehabilitation: A single-blind within-subjects trial. *Neuropsychological Rehabilitation*, *20*(1), 103–119. https://doi.org/10.1080/09602010902906926

DeWalt, D. A., Davis, T. C., Wallace, A. S., Seligman, H. K., Bryant-Shilliday, B., Arnold, C. L., … Schillinger, D. (2009). Goal setting in diabetes self-management: Taking the baby steps to success. *Patient Education and Counseling*, *77*(2), 218–223. https://doi.org/10.1016/j.pec.2009.03.012

Duda, J. L. (1993). Goals: A social cognitive approach to the study of achievement motivation in sport. In R. N. Singer (Ed.), *Handbook of Research on Sport Psychology* (pp. 421–436). New York: Macmillan.

Dunning, D. (2004, December 24). Why incompetent people think they're amazing - David Dunning. https://doi.org/10.1111/j.1529-1006.2004.00018.x

Dunning, D. (2011). The dunning-kruger effect. On being ignorant of one's own ignorance. In *Advances in Experimental Social Psychology* (Vol. 44). https://doi.org/10.1016/B978-0-12-385522-0.00005-6

Elliot, A. J., & Murayama, K. (2008). On the Measurement of Achievement Goals: Critique, Illustration, and Application. *Journal of Educational Psychology*, *100*(3), 613–628. https://doi.org/10.1037/0022-0663.100.3.613

Erez, M., & Zidon, I. (1984). Effect of goal acceptance on the relationship of goal difficulty to performance. *Journal of Applied Psychology*, *69*(1), 69–78. https://doi.org/10.1037/0021-9010.69.1.69

Everson, H. T., & Tobias, S. (1998). The ability to estimate knowledge and performance in college: A metacognitive analysis. *Instructional Science*, *26*(1/2), 65–79.

https://doi.org/10.1023/A:1003040130125

Free, C., Phillips, G., Galli, L., Watson, L., Felix, L., Edwards, P., … Haines, A. (2013). The Effectiveness of Mobile-Health Technology-Based Health Behaviour Change or Disease Management Interventions for Health Care Consumers: A Systematic Review. *PLoS Medicine*, *10*(1), e1001362. https://doi.org/10.1371/journal.pmed.1001362

Garland, H. (1983). Influence of ability, assigned goals, and normative information on personal goals and performance: A challenge to the goal attainability assumption. *Journal of Applied Psychology*, *68*(1), 20–30. https://doi.org/10.1037/0021-9010.68.1.20

General Assembly, U. N. (2011). *Resolution A/RES/65/238: Scope, modalities, format and organization of the High-level Meeting of the General Assembly on the Prevention and Control of Non-communicable Diseases*. *11759*(April), 1–4.

Gill, J. (1997). A cross-cultural extension of goal perspective theory to Korean youth sport. In *Journal of Sport and Exercise Psychology* (Vol. 19). Retrieved from http://hk.humankinetics.com/JSEP/journalAbout.cfm

Grellhesl, M., & Punyanunt-Carter, N. M. (2012). Using the uses and gratifications theory to understand gratifications sought through text messaging practices of male and female undergraduate students. *Computers in Human Behavior*, *28*(6), 2175–2181. https://doi.org/10.1016/j.chb.2012.06.024

Groening, C., & Binnewies, C. (2019). “Achievement unlocked!” - The impact of digital achievements as a gamification element on motivation and performance. *Computers in Human Behavior*, *97*, 151–166. https://doi.org/10.1016/j.chb.2019.02.026

Hanrahan, S. J., & Cerin, E. (2009). Gender, level of participation, and type of sport: Differences in achievement goal orientation and attributional style. *Journal of Science and Medicine in Sport*, *12*(4), 508–512. https://doi.org/10.1016/j.jsams.2008.01.005

Harackiewicz, J. M., Barron, K. E., Carter, S. M., Lehto, A. T., & Elliot, A. J. (1997). Predictors and consequences of achievement goals in the college classroom: Maintaining interest and making the grade. *Journal of Personality and Social Psychology*, *73*(6), 1284–1295. https://doi.org/10.1037/0022-3514.73.6.1284

Henriksen, A., Haugen Mikalsen, M., Woldaregay, A. Z., Muzny, M., Hartvigsen, G., Hopstock, L. A., & Grimsgaard, S. (2018). Using Fitness Trackers and Smartwatches to Measure Physical Activity in Research: Analysis of Consumer Wrist-Worn Wearables. *Journal of Medical Internet Research*, *20*(3), e110. https://doi.org/10.2196/jmir.9157

Hollenbeck, J. R., Williams, C. R., & Klein, H. J. (1989). An Empirical Examination of the Antecedents of Commitment to Difficult Goals. *Journal of Applied Psychology*, *74*(1), 18–23. https://doi.org/10.1037/0021-9010.74.1.18

Iwasaki, Y., Honda, S., Kaneko, S., Kurishima, K., Honda, A., Kakinuma, A., & Jahng, D. (2017). Exercise Self-Efficacy as a Mediator between Goal-Setting and Physical Activity: Developing the Workplace as a Setting for Promoting Physical Activity. *Safety and Health at Work*, *8*(1), 94–98. https://doi.org/10.1016/j.shaw.2016.08.004

Klin, C. M., Guzmán, A. E., & Levine, W. H. (1997). Knowing that you don't know: Metamemory and discourse processing. *Journal of Experimental Psychology: Learning Memory and Cognition*, *23*(6), 1378–1393. https://doi.org/10.1037/0278-7393.23.6.1378

Latham, G. P. (2015). Motivate Employee Performance through Goal Setting. In *Handbook of Principles of Organizational Behavior* (pp. 161–178). https://doi.org/10.1002/9781119206422.ch9

Latham, G. P., & Saari, L. M. (1979). Importance of supportive relationships in goal setting. *Journal of Applied Psychology*, *64*(2), 151–156. https://doi.org/10.1037/0021-9010.64.2.151

Locke, E. A. (1968). Toward a theory of task motivation and incentives. *Organizational Behavior and Human Performance*, *3*(2), 157–189. https://doi.org/10.1016/0030-5073(68)90004-4

Locke, E. A. (1994). Comments on Weinberg and Weigand. In *JOURNAL OF SPORT & EXERCISE PSYCHOLOGY* (Vol. 16).

Locke, E. A., & Latham, G. P. (1985). The Application of Goal Setting to Sports. In *JOURNAL OF SPORT PSYCHOLOGY* (Vol. 7).

Locke, E. A., & Latham, G. P. (2002). Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. *American Psychologist*, *57*(9), 705–717. https://doi.org/10.1037/0003-066X.57.9.705

Locke, E. A., Mento, A. J., & Katcher, B. L. (1978). The interaction of ability and motivation in performance: an exploration of the meaning of moderators. *Personnel Psychology*, *31*(2), 269–280. https://doi.org/10.1111/j.1744-6570.1978.tb00446.x

Locke, E. A., Motowidlo, S. J., & Bobko, P. (1986). Using Self-Efficacy Theory to Resolve the Conflict Between Goal-Setting Theory and Expectancy Theory in Organizational Behavior and Industrial/Organizational Psychology. *Journal of Social and Clinical Psychology*, *4*(3), 328–338. https://doi.org/10.1521/jscp.1986.4.3.328

Middelweerd, A., Mollee, J. S., van der Wal, C. N., Brug, J., & te Velde, S. J. (2014, July 25). Apps to promote physical activity among adults: A review and content analysis. *International Journal of Behavioral Nutrition and Physical Activity*, Vol. 11, p. 97. https://doi.org/10.1186/s12966-014-0097-9

Nicholls, J. G. (1984). Achievement motivation: Conceptions of ability, subjective experience, task choice, and performance. *Psychological Review*, *91*(3), 328–346. https://doi.org/10.1037/0033-295X.91.3.328

Patel, M. S., Asch, D. A., & Volpp, K. G. (2015, February 3). Wearable devices as facilitators, not drivers, of health behavior change. *JAMA - Journal of the American Medical Association*, Vol. 313, pp. 459–460. https://doi.org/10.1001/jama.2014.14781

Pivarnik, J. M., Reeves, M. J., & Rafferty, A. P. (2003). Seasonal Variation in Adult Leisure-Time Physical Activity. *Medicine & Science in Sports & Exercise*, *35*(6), 1004–1008. https://doi.org/10.1249/01.MSS.0000069747.55950.B1

Ramanathan, N., Swendeman, D., Comulada, W. S., Estrin, D., & Rotheram-Borus, M. J. (2013). Identifying preferences for mobile health applications for self-monitoring and self-management: Focus group findings from HIV-positive persons and young mothers. *International Journal of Medical Informatics*, *82*(4), e38–e46. https://doi.org/10.1016/j.ijmedinf.2012.05.009

Rosewilliam, S., Pandyan, A. D., & Roskell, C. A. (2014). Goal setting in stroke rehabilitation: Theory, practice and future directions. In *Rehabilitation Goal Setting: Theory, Practice and Evidence* (pp. 345–372). https://doi.org/10.1201/b17166

Sama, P. R., Eapen, Z. J., Weinfurt, K. P., Shah, B. R., & Schulman, K. A. (2014). An evaluation of mobile health application tools. *JMIR MHealth and UHealth*, *2*(2), e19. https://doi.org/10.2196/mhealth.3088

Schoeppe, S., Alley, S., Van Lippevelde, W., Bray, N. A., Williams, S. L., Duncan, M. J., & Vandelanotte, C. (2016). Efficacy of interventions that use apps to improve diet, physical activity and sedentary behaviour: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, *13*(1). https://doi.org/10.1186/s12966-016-0454-y

Smartphone users worldwide 2020 | Statista. (n.d.). Retrieved June 1, 2020, from https://www.statista.com/statistics/330695/number-of-smartphone-users-worldwide/

Strecher, V. J., Seijts, G. H., Kok, G. J., Latham, G. P., Glasgow, R., DeVellis, B., … Bulger, D. W. (1995). Goal setting as a strategy for health behavior change. *Health Education Quarterly*, *22*(2), 190–200. https://doi.org/10.1177/109019819502200207

Sullivan, A. N., & Lachman, M. E. (2017, January 11). Behavior change with fitness technology in sedentary adults: A review of the evidence for increasing physical activity. *Frontiers in Public Health*, Vol. 4, p. 289. https://doi.org/10.3389/FPUBH.2016.00289

Total mHealth market size worldwide 2025 forecast | Statista. (n.d.). Retrieved June 1, 2020, from https://www.statista.com/statistics/938544/mhealth-market-size-forecast-globally/

Tudor-Locke, C., & Bassett, D. R. (2004, December 23). How Many Steps/Day Are Enough? Preliminary Pedometer Indices for Public Health. *Sports Medicine*, Vol. 34, pp. 1–8. https://doi.org/10.2165/00007256-200434010-00001

Urdan, T. C., & Maehr, M. L. (1995). Beyond a Two-Goal Theory of Motivation and Achievement: A Case for Social Goals. *Review of Educational Research*, *65*(3), 213–243. https://doi.org/10.3102/00346543065003213

Von Korff, M., Gruman, J., Schaefer, J., Curry, S. J., & Wagner, E. H. (1997, December 15). Collaborative management of chronic illness. *Annals of Internal Medicine*, Vol. 127, pp. 1097–1102. https://doi.org/10.7326/0003-4819-127-12-199712150-00008

Weinberg, R., & Weigand, D. (1993). Goal Setting in Sport and Exercise: A Reaction to Locke. In *JOURNAL OF SPORT & EXERCISE PSYCHOLOGY*. Human Kinetics Publishers, Inc.

World Health Organization. (2018a). Noncommunicable diseases country profiles 2018. World Health Organization. Retrieved from https://apps.who.int/iris/handle/10665/274512

World Health Organization. (2018b). Prevalence of insufficient physical activity. (2018). World Health Organization. Retrieved from https://www.who.int/gho/ncd/risk_factors/physical_activity_text/en/

World Health Organization. (2019). WHO guideline: recommendations on digital interventions for health system strengthening. Geneva: World Health Organization; 2019. Licence: CC BY-NC-SA 3.0 IGO.

Zichermann, G., & Cunningham, C. (2011). *ZICHERMANN, G.; CUNNINGHAM, C.Gamification by design: Implementing game mecha-nics in web and mobile apps. In O'Reilly Media; 2011*. Retrieved from http://storage.libre.life/Gamification_by_Design.pdf

Appendix

Figure 1-Apx. Screenshot of the points system in the YAS-application

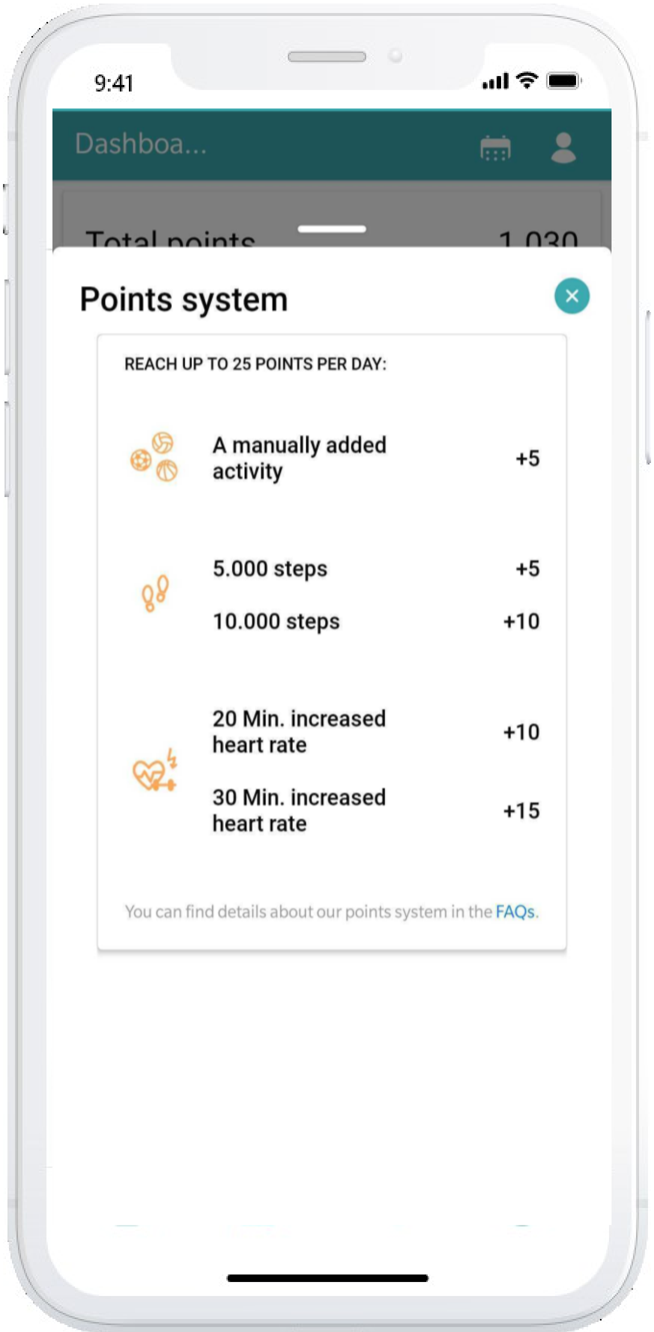


Figure 2-Apx. Screenshot of the fitness goal

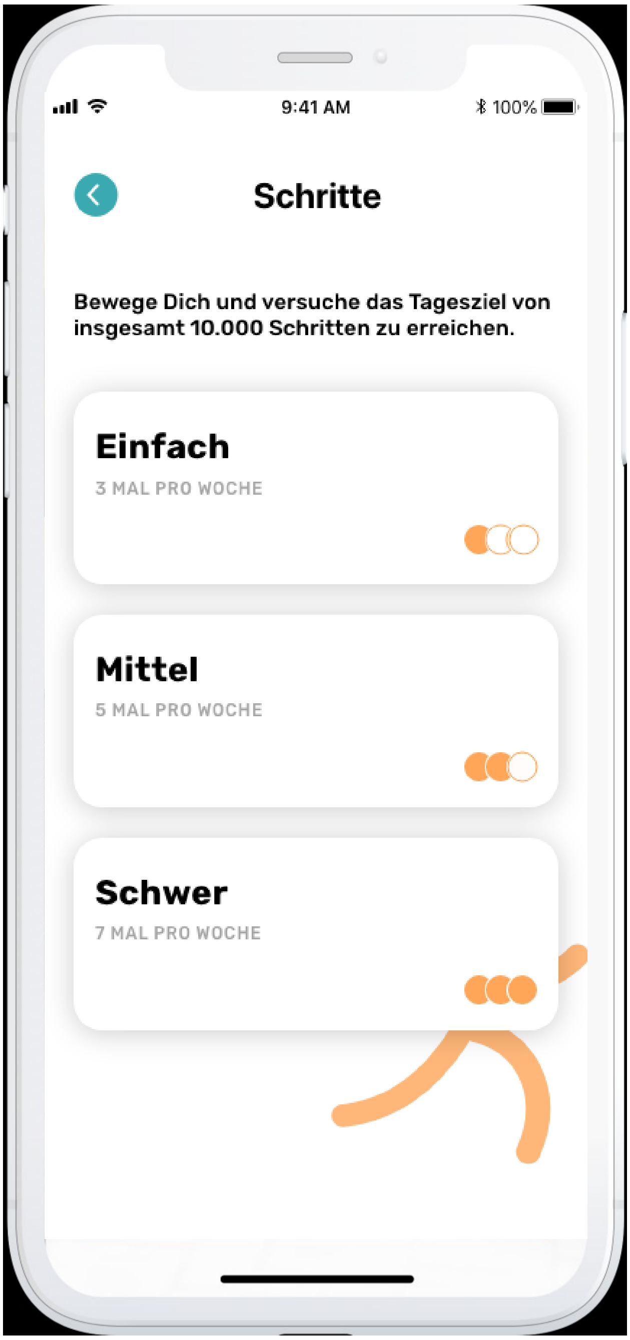


Figure 3-Apx. YAS App: trackers by unique users

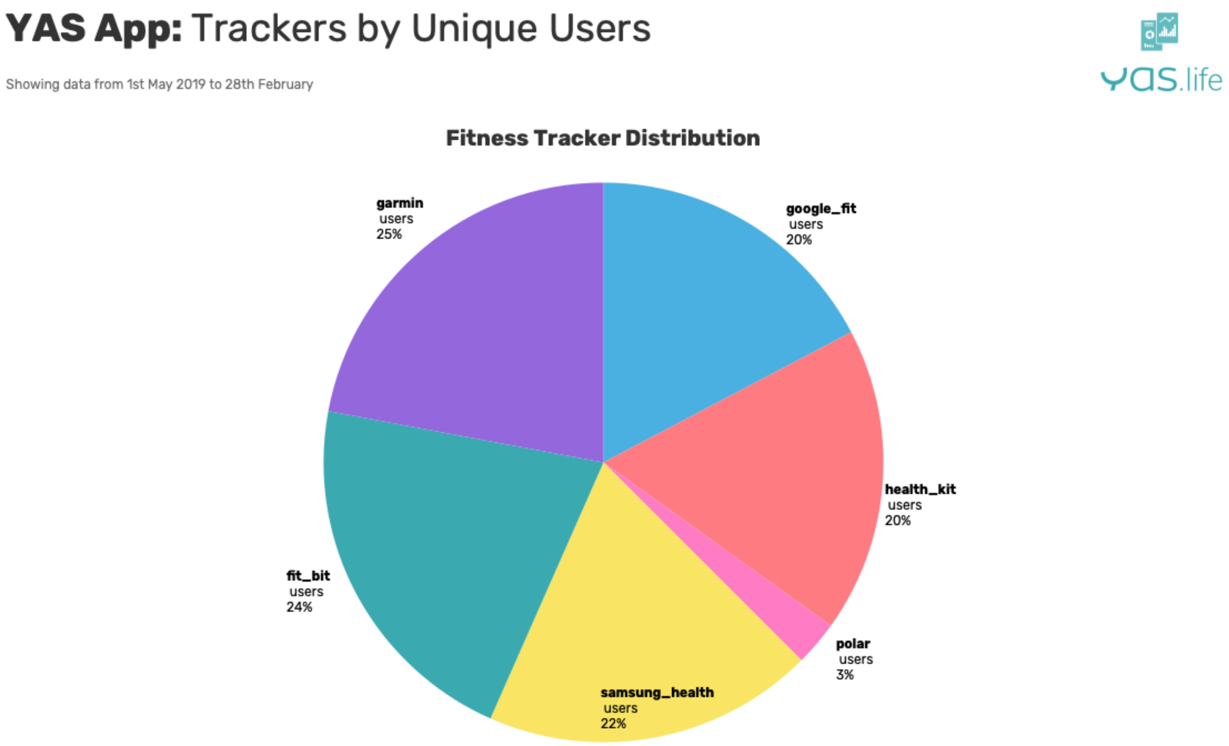


Figure 4-Apx. Locked activities: example from the video game "Angry Birds:

Users can start/ unlock the next level only after they have successfully completed the previous level.