

# GOAL: An eHealth Application for Rewarding Healthy Behaviour. The First Experiences of Older Adults

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Abstract: It is important to motivate older adults to lead an active lifestyle. Mobile games and applications can motivate older adults to increase physical, social and cognitive activity. Such a mobile application platform is developed within the GOAL project (H2020 project no. 731656). The aim of this paper is to introduce GOAL, to provide an overview of ongoing evaluations and to present the intermediate results concerning the usability of end-user acceptance of this technology among older adults. GOAL consists of three core components: the GOAL Website, the GOAL Web Portal and the GOAL Mobile Applications. The evaluation has an iterative approach. In total, there are four evaluation phases. During the first three phases, subjects are invited for a pre-test and post-test assessment. During phase 4, subjects are invited to use GOAL by sending out a mass email to get people to sign up to GOAL for themselves. The results of phase 1, 2 and 3 of the evaluation (especially the suggestions by the target group) lead to several points of improvement for the GOAL system, to increase the adoption of this technology by older adults. Over the phases, the level of usability increased and subjects become more and more enthusiastic about GOAL.

## 1 INTRODUCTION

In the European Union, demographic ageing is a trend. The number of people aged 65+ will almost double over the next 50 years, from 85 million in 2008 to 151 million in 2060 (World Health Organization, 2015). With aging, occurrence of multi-morbidity and the need of social and health support increases as well. Ageing is a dynamic process and there is great diversity in how older adults age (Buckinx et al., 2015, Suzman et al., 2015). However, preventive strategies are important to face the challenge of age- and health- related problems. An effective strategy for healthy ageing is to be physically active (Zaleski et al., 2016). Being physically active has many benefits: it prevents the development of chronic health-related problems, it improves psychological well-being and social outcomes (Bauman et al., 2016), and can slow down muscle loss and prevent a decrease in strength

(Mijnarends et al., 2013, Tak et al., 2013, Zaleski et al., 2016). Despite the benefits of being physically active, the overwhelming majority of older adults do not meet the minimum physical activity levels needed to maintain health (McPhee et al., 2016). Unfortunately, a sedentary lifestyle is currently predominant in European older adults. Among older adults, inactivity and a sedentary lifestyle are linked to numerous negative health outcomes, comparable to the negative health outcomes of smoking, excessive alcohol intake and obesity (Booth et al., 2000, Lee et al., 2012). It is thus important to motivate older adults to be physically active.

However, it is a challenge to find effective ways to support older adults to increase their level of physical activity and develop habitual physical activity behaviours. It is known that older adults are less interested in improving their health, but more interested in retaining the health they already possess (Lockenhoff and Carstensen, 2004). Moreover, they

are more interested in intrinsically enjoyable activities, such as group activities (Devereux-Fitzgerald et al., 2016), as they emphasise fun and enjoyment of social interaction as a motivation to be physically active.

The engaging nature of games can also provide a motivating and enjoyable means to comply to exercises and to increase physical activity (Taylor et al., 2011, Kato, 2010). Games can be provided to older adults in the old-fashioned way, such as board games but also as a mobile application for their smartphone or tablet as the use of these technologies for health-related purposes is rapidly increasing (Gordon and Hornbrook, 2018). Next to this, gamification (the application of game elements to nongame field) engages older adults to use, and keep using technology (Minge et al., 2014, de Vette et al., 2015).

A new mobile application to motivate older adults to be active is developed in the GOAL project (H2020 project no. 731656). Within this project a mobile application rewards healthy behaviour, such as being physically active, training the memory and participating in social activities, with GOAL coins. These coins can be used in mobile games. In the future, these coins are also tradable for tangible rewards. As the adoption of technology remains limited in the older population (Heart and Kalderon, 2013, Mitzner et al., 2019), during the development of GOAL the target population is asked to use GOAL and share their experiences. To increase the adoption of GOAL, the expectations and needs of the older adults are used to improve GOAL before its introduction to the market. The aims of this paper are to introduce GOAL, to provide an overview of the current evaluation, and to present the intermediate results concerning the usability and end-user acceptance of this technology.

## 2 METHODS

From the point of view of the end-user, GOAL consists of the three core components: the GOAL Website, the GOAL Web Portal and the GOAL Mobile Applications. The Website is the “entry-point” to the platform. This website leads the end-user to a signup page for new users. Within the Web Portal the end-user is able to set up an account or log in into the portal using already existing credentials. Upon registration or login, the user is exposed to the main dashboard of the web application from which they are able to navigate to the main sections of the application including the Wallet (providing an overview of

GOAL coin transactions), the Physical activity dashboard, Games and access to a Social Marketplace. The GOAL Mobile Application is the information centre the user utilizes to get all GOAL-related info and access the different GOAL services. It offers users’ profile management, GOAL coins’ information, games’ information and access, tasks management and uniquely for the mobile version, physical activity tracking. The information is summarized in an overview screen, from where the user can navigate to details screens for physical activity, GOAL coins, games and social marketplace tasks (see figure 1).

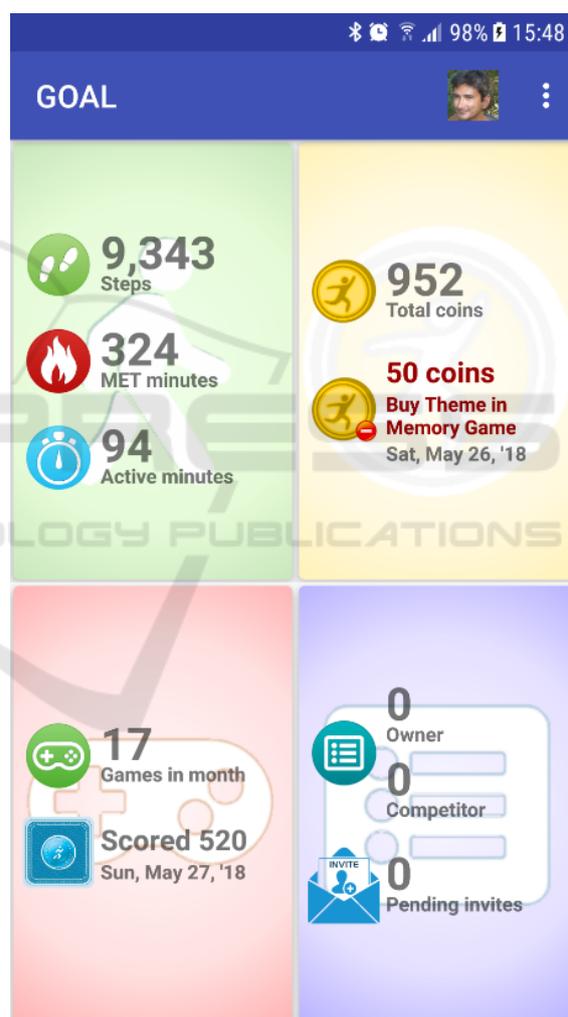


Figure 1: Overview screen of the GOAL Mobile Application.

The GOAL Mobile Application measures and displays physical activity in terms of steps, floors climbed, energy burned and minutes spent at different activity intensities. Both instantaneous values

(together with a clear view of the percentage of the goals reached in all activity categories) and plots of past data are offered, in an attempt to inform and motivate the user. The GOAL coin is the single currency quantifying performance in different aspects of the users' daily life. Coins are earned when goals are met, or tasks are fulfilled. Coins can be spent in an attempt to motivate others via tasks, or in games. The coins' overview screen shows the current number of coins, the number of coins earned or spent in different intervals and a list of every coin transaction in those different intervals, together with an explanation and a date. Games are important both for cognitive stimulus and for entertainment. The games overview screen shows all games and scores played thus far, as well as a list of the GOAL games, either already installed, or available on Google Play. The GOAL Mobile Application is also the home of the GOAL Motivational Agent. From every screen of the GOAL Mobile Application, the motivational agent can be reached with a simple tap of the "Agent" button. Whenever the user calls for the agent, he/she can have simple interactive dialogues with this agent. The social marketplace functionality is accessed via the tasks overview screen. The offered functionality is split into two categories: tasks the user creates, and the tasks the user undertakes. For task creation, the user is given an overview of the tasks he/she has created and a form to create more. For tasks undertaking, the user gets an overview of the tasks in which he or she participates, the remaining duration, and when applicable, the progress made.

The "Island Exploration Game" (Figure 2) is a gamification layer on top of the physical activity data measured from the user. The user needs to complete a path through a tropical island by performing physical activity. The user has a week to finish the path. The path is cut into seven pieces, all with a milestone at the end. The amount of steps needed to get to a milestone is equal to the user's personal daily step goal. When a milestone is reached, the user can play a mini-game. When a "hut" on the island is unlocked, the user can enter it to play a puzzle game to earn the hut's rewards. The mini-game is a '24 game'. The user drags numbers and operators into the correct boxes, to make the expression equal 24. Successfully completing these mini-games will grant the user with additional GOAL Coins.



Figure 2: Screen of the Island Exploration Game.

GOAL supports the integration from "3<sup>rd</sup> party" health applications. From the product perspective, commercial health apps such as Fitbit, Nokia Health or Samsung Health could integrate their applications with the GOAL platform and report user's health and wellbeing data to the platform. In this way, users can continue using their preferred fitness tracker, food logging app, weight manager or relaxation app while benefitting from the additional motivation to use those apps through the GOAL platform. During the evaluation period, five "3<sup>rd</sup> party" applications are available; the "Activity Coach" app for Android, developed by Roessingh Research and Development that interfaces Fitbit step data into GOAL and the following games:

- PairMe! is a cognitive game developed by Athens Information Technology, addressing memory functions. It is a card-based game, where a deck is arranged in a grid and the player attempts to turn two cards depicting the same image. The user can spend his GOAL coins to unlock new card themes or shortly glimpse at the remaining cards.

- Let's quiz is trivia game developed by Nurogames to test user's cognitive abilities by giving them a set of questions from various knowledge areas with a multiple choice to find the correct answer within a given timeframe. The user can spend GOAL coins to reduce the number of possible multiple-choice answers, making it easier.
- World of Kingdoms is a role-playing game developed by Nurogames for Android and iOS devices. The game brings a beautifully designed world where players have to build their villages and kingdoms along with defence structures and armies, plan the respective strategies to protect themselves as well as gain gold to improve their village. Using the GOAL credentials will transfer the available GOAL Coins to the World of Kingdoms account.
- The "Forward To" game is designed as a health-promoting application within the H2020 SmartLife project that puts emphasis on a story that takes place in a post-apocalyptic world and can be played indoors and outside with a focus on mini challenges that require physical activities that are tracked by a smart textile the player has to wear.

## 2.1 Participants

For the iterative evaluation process, a phased introduction of the GOAL platform is desirable and the involvement of real end-users is also very important. Before real end-users are involved, GOAL is tested by end-users close to the research & development setting, mostly younger end-users as students. The target population for GOAL is older adults with the desire to stay active and to change their behaviour in a positive way. For phase 1 and 2, students and colleagues are asked to participate. For phase 3 and 4, older adults are asked to use GOAL. According to Dutch law, the nature of the research (usability and user-experience) in this study does not require formal ethical approval. However, all participants gave their informed consent prior to participation.

## 2.2 Setting

The total duration of this observational study is 28 weeks. To facilitate improvement of GOAL and its uptake by users, an iterative approach is followed (van Velsen et al., 2018). Therefore, during this study, the GOAL platform and technology will be updated and improved based on the outcomes of the evaluation. In total, four versions of the GOAL

platform are evaluated during four phases of the evaluation. Every phase contains test-weeks and weeks for analysis and technical modification. The duration for phase 1 and 2 is 6 weeks. During these phases, subjects are invited for a pre-test and post-test assessment. After a short introduction subject are asked during the pre-test assessment to performed four basic task: installation of the GOAL application (1), account creation and set-up (2), visiting the GOAL web portal (3) and installation of additional GOAL apps (4). During the post-test assessment the first experiences with the platform are discussed as well as the advantages and points for improvement. Between pre- and post-test is a period of 7 days. During phase 3, the set-up of the pre- and post-test assessments is the same, only the time between the two appointments is 2 weeks. During the first 3 phases GOAL is evaluated in a controlled setting; individuals are invited to participate, subjects receive assistance by installing GOAL and subjects are to use GOAL for a certain amount of time. After phase 3, the maturity of GOAL should be sufficient for large-scale implementation. Therefore, during phase 4, subjects are invited to use GOAL by sending out a mass email to get people to sign up to GOAL for themselves. After installation and registration on the GOAL platform, these people are asked by email whether he/she is willing to participate in research and complete the online questionnaire after the test-weeks.

## 2.3 Measurements

Considering the maturity of the technology and the aim of the technology, this first evaluation of GOAL focus on the endpoints: Usability and end-user acceptance (DeChant et al., 1996, Jansen-Kosterink et al., 2016). Pre- and post-test participants are asked to complete questionnaires concerning usability and end-user acceptance. Moreover, subjects are asked about problems encountered during use, and observations during task execution are written down.

### 2.3.1 Usability

The usability of GOAL is assessed with the System Usability Scale (Brooke, 1995). The SUS presents ten statements about the perceived usability of the application. Participants could indicate on a 0 to 4 scale to what extent the presented statements were true for them. To obtain the final SUS score, the sum of the participants' answers was multiplied by 2.5. The SUS score ranges from 0 to 100 (low and high usability, respectively). The English version of the

SUS was translated into Dutch, as there was no validated Dutch version available.

### 2.3.2 End-user Acceptance

End-user acceptance of GOAL is assessed by means of a questionnaire with summated rating scales, based upon the Technology Acceptance Model (TAM) (Davis, 1989). TAM originates from the 1980s and has been used numerous times to assess and explain the acceptance of new technology. We expanded TAM with factors that have been found to shape the user experience of eHealth technology: Enjoyment (Crutzen et al., 2011), Aesthetics (Baumel and Muench, 2016), Control (Hawkins et al., 2010), and Trust in the technology (Van Velsen et al., 2016). We hypothesize that these factors affect the core factors of TAM that explain the intention to use (perceived usefulness and ease of use).

## 2.4 Data Analysis

All outcome measures will be inspected for normal distribution of data using corresponding histogram plots including normal curves and normal probability plots prior to selection of appropriate statistical tests. Descriptive statistical methods will be applied for each of the outcome measures (demographic characteristics, usability, end-user and acceptance). Presentation of data will be done by calculation of mean  $\pm$  standard deviation, or median with range.

## 3 RESULTS

The evaluation of GOAL started in the first week of September 2018 and is still ongoing. Phase 1 through 3 have ended, while phase 4 has not started yet. Therefore, only the results of phase 1, 2 and 3 are presented.

### 3.1 Phase 1

During the first phase, the base version of GOAL was used. This version includes the GOAL mobile application that can be paired with the Activity Coach. In total five participants completed the first phase of the GOAL evaluation. Of the subject, four were female and one was male. Their age was between 23 and 26 years old; all were students and worked on a bachelor or master assignment or working as junior researcher at Roessingh Research and Development. Five subjects completed the pre-test and four subjects completed the post-test of phase

1. Pre-test the SUS score was between 28 and 75 points (n=5). The opinion of the participants was diverse, some were enthusiastic and some were very critical. The average score on the SUS was 55 (SD 20.2) indicating that the usability is “ok”, but also has a low acceptability range. Post-test the SUS score changed, the participants rate the GOAL application between 43 and 68 and an average score of 56 (SD 10.5, n=4). The scores on the end-user acceptance were very diverse. Overall, their opinion on the end-user acceptance was ambiguous.

Pre-test the subjects had problems with the executing the four basic tasks. Subjects had problems with finding the GOAL application in the Google Play store. After registration, the application did not provide any feedback on whether the registration was successful. Subjects also indicated that they were unaware of the term “stride length”. Overall, subjects thought the setting to update their profile were intuitive, although it was unclear how profile details were saved. When going to the web portal, participants noticed that it was not optimized for use on the mobile phone, although they indicated they would like to use the website on their phone. They would find it convenient to have a link to the website in the app, but in all cases be referred to the app when they are linked to the ‘GOAL Platform’ from an external application.

Post-test the subjects liked the potential to get a reward for being active. The interface of the app was easy and intuitive, despite many options being available. However, the subjects indicated that none of the options were functional. The step counter did not work, it was unclear if they needed an external activity monitor to count steps, the participants could not collect any coins or set goals/tasks, and the games were not available yet.

### 3.2 Phase 2

During the second phase, the base version of GOAL was enhanced in terms of visualisation of information, user profile collection and a help system. Two new games could be downloaded from the Google Play store: ‘Let’s Quiz!’ and ‘Pair Me!’. In total nine participants completed the second phase of the GOAL evaluation. Four of them also participated in the first phase. Of the participants, six were female and three were male. Their age was between 23 and 27 years old and all were students working on a bachelor or master assignment, or working as junior researcher at Roessingh Research and Development. Five participants completed both the pre- and post-test. Four participants, who participated in phase 1 as

well, only completed the post-test. Pre-test the SUS score was between 40 and 85 points (n=5). The opinion of the subjects was diverse, some were enthusiastic and some were very critical. The average score on the SUS was 61.5 (SD 21.8) indicating that the usability is “ok”, but also has a low acceptability range. Post-test the SUS score changes, the subjects rate GOAL between 32 and 80, with an average score of 58.2 (SD 12.8, n=9). The scores on the end-user acceptance were very diverse. Overall, their opinion on the user experience determinants was ambiguous.

At pre-test, the subjects (n=5) had problems with executing the four basic tasks. Participants still had problems with finding the GOAL application in the Google Play store. Setting-up the account was very intuitive, and participants found the explaining texts about stride length and other entries useful. However, participants still indicated that it was unclear whether and how they could save the entered profile details (n=4). The participants viewed the website on a laptop and found the design nice and clean, with clear headings (n=4 and n=3 respectively). Participants liked that they could find the games in the GOAL app (n=5), although they would like to receive a confirmation that they successfully connected the game to the GOAL app (n=3). It was suggested to integrate the games into one app package with the GOAL app, so no separate downloads would be necessary.

Nine subjects participated in the post-test of phase 2. During this post-test session various advantages, improvements and problems were discussed. The app was already improved compared to the first phase. Two games were now available to play and people enjoyed the way their activity level was represented; the graphs were informative and it was nice to have different representations of activity level. However, participants did not collect any coins nor understood how they could collect coins (n=7). Moreover, despite being able to set tasks, it was hard to understand what could be done with them (n=6). Some participants mentioned that the step counter did not work at all, others thought it only worked when opening the app, and a few stated that the step counter was not accurate. ‘Let’s Quiz!’ appeared to have some bugs; questions were repeated, too hard, or contained mistakes (n=4). Four participants, who had already participated in phase 1, mentioned that they forgot their password and would like a ‘password reset’ button.

### 3.3 Phase 3

During the third phase, the base version of GOAL with several updates was used. The app now supports the external activity tracker ‘Activity Coach’, and coins are awarded for reaching activity goals. Users can setup tasks or participate to them. Past activities are now summarized. Moreover, some technical problems with the step counter and ‘Let’s Quiz!’ were solved. By email, 104 older adults were asked to participate in this study. Fifteen were willing to participate. However, five subjects were not able to participate as two of them did not have a smartphone and three of them did not have a smartphone with an android operating system. Furthermore, two subjects were not able to participate due to motivation issues or health compliances. In total seven subjects participated in the pre-test of the third phase of the GOAL evaluation. One subject did not participate in the pre-test, but has downloaded the app at home and was included in the post-test. Of the subjects, two were female and six were male. Their age was between 69 and 76 years old. Pre-test the GOAL SUS score was between 55 and 80 points (n=7). The average score on the SUS was 70 (SD 8.5), indicating that the usability is “ok”, with a high acceptability range. Post-test, the SUS score decreased, the eight participants rated the GOAL application between 40 and 87.5, with an average score of 65.6 (SD 15.7, n=8). This is slightly lower than pre-test although still with a high marginal acceptability range. The scores on the end-user acceptance were very diverse. Notable was the high score of five participants on “intention to use”. Overall, their opinion on the user experience determinants was ambiguous.

At pre-test, the subjects (n=7) had problems with executing the four basic tasks. Three subjects indicated they had never used the play store before; one had problems with downloading the app. All managed to download and install the GOAL application (n=7). Registering required additional instructions, typing the password twice was problematic to some, because they could not see the letters (n=3). All subjects needed instructions to set-up profile, and some with entering the details such as name and date of birth (n=4). Some technical problems were also encountered (n=5). When going to the GOAL website on a laptop, four subjects had no problem finding the log-in page, but many indicated that the log-in page and dashboard were hard to read due to the low contrast of letters (n=5). The dashboard was perceived logical and simple (n=4), although questions were asked about the ‘applications’ and ‘social marketplace’ blocks (n=4).

Some explanation about altitude, MET-minutes, and the other physical activity graphs was needed. All completed the last task (installing the “PairMe!” game) although instructions about finding it in Google Play Store were needed. Some did not like the keyboard falling over the log-in screen when connecting to “PairMe!” (n=4), although almost everyone managed to connect the app to the GOAL platform (n=6).

Eight subjects participated in the post-test of phase 3. Post-test, five subjects indicated that the step counter did not work and did not count steps at all. Two participants indicated that they do not carry their phone all the time and one would prefer to have a wrist-worn step counter. Some participants did not understand MET minutes (n=3) or the red line in the activity graph (n=1), and two preferred more explanations about the menu and functions of the app (n=2). Three subjects indicated they would like to record cycling as well, and a Dutch app version is preferred (n=3). Half of the subjects enjoyed the games (n=4), and three subjects indicated they would like to use the app if it would actually count steps accurately. The dashboard was perceived as simple and basic, with a nice overview of everything (n=3). The subjects did not specifically like collecting coins; many did not collect coins at all, as their step counter did not work. None of them used coins in the games. Two subjects forgot their password and could not use the memory game.

### 3.3.1 Focus Groups

During phase 3 of the GOAL evaluation, we got the opportunity by means of two focus groups to assess the GOAL technology among a group of older adults of a local elderly association. These focus groups were planned on December 18, 2018. After an introduction of the GOAL technology, the older adults were asked to share with us their perceived advantages and disadvantages and their ideas concerning the concept of earning GOAL coins. In total 21 older adults participated during the two focus groups. The majority of the participants were male (62%). The average age of participants was 72 years old ( $SD \pm 3.7$  years; range 64 – 79 year old). As perceived advantage, the majority of the participants (52%) mentioned the aim of the technology to encourage a healthy lifestyle. Next to this, 33% of the participants claimed that the fact that the GOAL technology is free to use (no financial reimbursement) is an advantage. Also 24% mentioned that they liked the idea of learning something new and experiencing the GOAL technology as fun or a nice challenge. As

a disadvantage, participants mentioned the fact that the GOAL mobile application is only available for Android smartphones (43%) and that the GOAL mobile application is mainly in English (24%). Another disadvantage that was mentioned was the reluctance to playing mobile games (24%) by the target population. Most participants (62%) claimed that maintaining health was the biggest reward when using the GOAL technology. Another reward mentioned was “making progression visual”, this was mentioned by 33% of the participants. Next to this, 19% of the participants experienced being active in nature as a reward. Considering earning GOAL coins, the most of the participants (38%) claimed that they want to earn GOAL coins by being physically active. Finally, the participants were asked how they would like to spend the earned GOAL coins in the real world. Nine participants would like to receive a gift card for (digital) books / newspapers (n=3) or for things related to their hobby (n=5) or to buy new technology (n=1). Four participants would like to help others or charity, one participant would like to spend coins on activity with their grandchildren and one participant would like to receive a discount on their health insurance. Overall, 38% of the participant had no interest in spending earned GOAL coins in the real world.

## 4 CONCLUSIONS

The evaluation of the GOAL system is still running. The results of phase 1, 2 and 3 of the evaluation lead to several improvements of GOAL, facilitating the adoption of this technology by older adults. Over the phases, the level of usability increased and subjects become more and more enthusiastic about GOAL. However, the following recommendations based on the usability and user-acceptation of GOAL can be made:

- There should be a password reset button, in case one forgets the password;
- The app should have an help-function explaining for instance how coins can be collected and the concept of MET.
- The profile section can be more simplistic with a clear button to save entered details;
- The website should have a higher contrast so it will be more accessible for people with impaired vision;
- The activity tracker should also recognize other activities than walking, such as cycling;

- The app should be available in the local languages.

During the third evaluation phase, older adults needed instructions to download and install the app, to set-up the profile, to go to the website, and to connect to a game. The external help that is requested by the older adults will be provided by a motivational agent (Bickmore et al., 2009, Vardoulakis et al., 2012). This motivational agent is planned for the next version of GOAL. This feature of the Mobile application can increase the level of intuition and provide the needed instructions to the older adults, so external help is not necessary anymore. Moreover, the functionality of the social marketplace task-setting and activity tracking, and technical problems will be addressed in the phase 4 updates.

The adoption of technology is not a purely technical topic, since multiple aspects need to be taken into account. Following a paper of Lee & Coughlin, 2015 (Lee and Coughlin, 2014) there are ten factors of older adults' technology adoption; value, usability, affordability, accessibility, technical support, social support, emotion independence, experience and confidence. These ten factors address four aspects: individual aspects, technology aspects, social aspects and delivery aspects. During this evaluation, we focus mainly on technology factors (design and functional features that affect how older adults interact with technology) in phase 1 and 2 and individual factors (characteristics of older adults as individual users that affect their interactions with technology) in phase 3. During phase 4, subjects will be invited to use GOAL by sending out a mass email and advertisements in local newspapers to get older adults to sign up to GOAL for themselves. After three phases in a lab-setting GOAL will be evaluated in the real environment during this final phase. To get a broad overview of the adoption of GOAL by the target population it will be good to also focus on the social (expectations and needs that arise from the social and cultural contexts that older adults are in) and delivery (ways in which technology is communicated and distributed to older adults for purchase and use) factors.

A weakness of this study is the selection bias of the subjects, as using GOAL was voluntary. The majority of the older adults who were willing to participate, were technology minded and had basic skills to use a (smart) phone, tablet or laptop. Although it is in general desirable to develop technology and assistive tools for the target population of less-technologically skilled older adults and those less motivated in achieving a healthy lifestyle, this is not necessarily the main target for the

GOAL platform. However, to enhance the adoption of technology and assistive tools it is important to take into account the individual, technology, social and delivery aspects and invite the target group as co-designers.

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