Motivational Features in an Application for Presenting Dysfunctional Movement Patterns and for Providing Support in Conducting Exercises

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***Abstract*— This paper describes motivational features in a mobile application for physiotherapy related exercises. The features support goal setting, possibilities to follow progress, personalization and possibilities to compare own progress or performance with other users. During the iterative development of the application, an explorative study was conducted where the participants were interviewed about the motivational aspects described above. The respondents emphasized the importance of goal setting together with the physiotherapist and being able to follow progress. With respect to being able to compare performance or progress with other users, the outcome of our work is in line with previous research where comparisons have been rejected. However, people may be more positive if the comparison is disguised as a gamification element, for example, as a part of a competition or in terms of contributing to a group.**

Keywords-movement related disorders; mobile application for conduction exercises; motivational theories; social comparison; personalization.

I. INTRODUCTION

Movement related disorders is a common occupational disease in the European Union and workers in all sectors and occupations are affected [1]. This is an increasing problem and one of the most important causes of long-term sickness absences. Early detection and early intervention could reduce the number of serious movement related problems. By gathering and analyzing movement data from large groups of people over a long period of time, categorization of different movement related patterns can be made. Based on this categorization, one person's movement pattern can be placed into one cluster and early signs of problems and movement related disorders can be detected before it has started to cause problems or pain. Depending on this knowledge, relevant and individualized support and exercises can be suggested using smartphone applications. However, the challenge is to motivate the users to conduct the suggested exercises based on individual recommendations from the physiotherapist, and to comply with training programs aimed at solving possible future problems.

In this work motivational features were applied in a mobile application for physiotherapy related exercises. The features were related to goal setting, providing support in follow progress, personalization and possibilities to compare own performance with others. Interviews and gaining feed-back from users were conducted as a part of a larger work where the application was developed in an iterative way with different user groups. The aim with interviews was to gain a deeper understanding of how to apply motivational features and personalization when developing applications based on large amounts of aggregated movement related data. The work does not claim to investigate different motivational models in a systematic way. Instead, it was an explorative study highlighting the use of different social motivational aspects in developing an application providing support in conducting exercises. In the following text, section 2 describes the project and the concept that the developed application was a part of. Section 3 gives a short overview of motivational theories. The categories of motivational theories and the concepts that are described are central and discussed in terms of possibilities to be applied in the context of the developed application. Section 4 presents the outcome of the explorative study that was conducted as a part of the iterative development. Based on the study, Section 5 suggests design implications and also gives examples of how these features were implemented within the developed application. Finally, section 6 discusses the work conducted and suggests possible future work.

II. AN APPLICATION FOR SUPPORTING PHYSIOTHERAPY RELATED EXERCISES

The application, developed as a part of this work, was based on the company Qinematic's software service that record and analyze body movements using 3D digital video. The users are standing in front of a Kinect sensor and follow instructions about movements to conduct. Based on these sessions, 3D-data is gathered and stored. As an extension to this service a research project was conducted that had two aims. The first aim was to develop machine learning algorithms to analyze gathered movement data, and the second aim was to develop user applications to provide information about dysfunctional movement patterns, facilitate contact with healthcare providers, make it possible for physiotherapists to suggest exercises and for the users to set goals and follow their progress (Figure 1). Via the application, the healthcare provider also had the possibility to gather further information by asking health related questions to the users. This was done to offer a better and more personalized care. As mentioned, the entire concept/system consisted of several parts, including

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machine learning and categorization of dysfunctional movement patterns. The work presented here focuses on the development of motivational features in the application targeted towards users with possible dysfunctional movement patterns. However, the larger concept around the application placed other demands related to motivational features than when developing applications that only support users to be more physically active or conduct exercises.

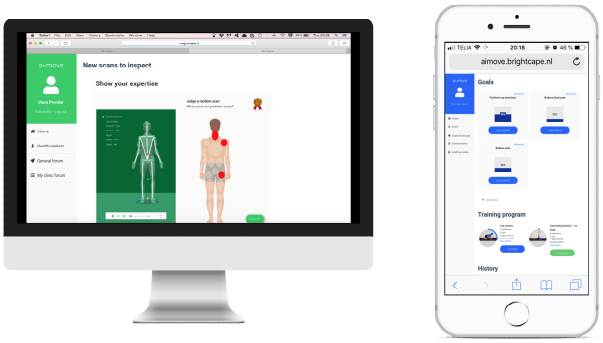

Figure 1. Application for health providers to the left and to their clients to the right.

III. MOTIVATIONAL THEORIES

This section describes central motivational theories and the choices that were made regarding applying some of them in the application developed. Theories not applied in the application are also described below since they are relevant to this domain when the presuppositions for developing are different.

A. General and Intrinsic Motivational Theories

Health Belief Model is a psychological model that attempts to provide an explanation of health behavior where the focus is the individual's beliefs and attitudes. It is based on the belief that the individual's perception determines his/her success in conducting a behavioral change [2][3]. In order for the health-promoting behavior to trigger, there must be a stimuli or cue action present. Important factors are: readiness to act, severity, barriers, and self-efficacy.

Self-Determination Theory (SDT) is a general motivational theory. With intrinsic user motivation, it is believed that humans by nature show positive qualities, effort and dedication. People's self-motivation and personal integrity are innate needs (psychological), but they do not happen automatically. There are three needs that have to be met for the intrinsic user motivation to be high: autonomy, competence and psychological relatedness [4].

There are also theories that categorize people in different stages, like *Transtheoretical model (TTM)* and *Precaution Adoption Process Model (PAM)*. These theories can be used to understand the readiness to change of a person. The TTM [5] has six stages of change based on how long the person sustained the new behavior. On the other hand, PAM [6] has seven stages of change based on the psychological state of the person.

B. Social Motivational Theories

Bandura's *social cognitive theory* refers to people learning from each other, for example through modelling, observation and imitation [7]. The theory has often been defined as a bridge between behaviorism (Behaviorism is a scientific psychological focus focusing on behavior and learning) and cognitive learning theories since it comprises motivation, memory and attention.

Social comparison theory supports that people, in lack of standard measurements, compare to others for self-evaluation [8], self-enhancement [9], self-projection [10], and coping [11][12]. However, the relation between comparison and competition is rarely studied [13]. Regardless the positive results from psychological studies on social comparison [11][12], often people refuse engaging in comparisons due to social norms [14] or due to different perception of the term ”comparison” [15].

C. Goal setting

Goal setting has proven to be an effective strategy for encouraging behavioral change [16]. Locke and Latham [17] identify three types of goals: (1) self-set, (2) assigned, and (3) participative set. In terms of self-set goals, the individual is expected to set goals that are realistic to achieve. These type of goals usually have personal significance for the individual since it is related to self-efficacy.

If an assigned goal (a goal set for the individual by someone else) is perceived as motivating, the level of achievement is comparable to a participatory set goal (a goal that the individual has contributed to define). If a goal assigned to the individual does not have a clear motivation, it leads to lower level of achievement.

D. Applying motivational features in a mobile application for physiotherapy

In this work motivational features were applied in a mobile application for physiotherapy related exercises. The overall aim with the project and the entire system was to gather, analyze and visualize large amounts of movement related user data. The analyses provided clusters of users with similar movement patterns, where the users could see which cluster they belonged to.

Motivational features were applied based on existing models of motivation. The intrinsic motivational theories described above were difficult to apply within this context since data providing information about internal drivers were not gathered within this framework. Models related to readiness to change could neither be applied in this context. These models demand long-term data related to the user's progress towards an actual behavior change.

Based on the analysis of possible theories to apply, the application developed is focused on features based on social cognitive theory and goal setting with possibilities to set short-term and long-term goals. Features based on social comparison theory were also applied, making it possible to

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relate own performance with performance of other users. The social comparison was used to see which cluster a user was categorized in, and how many other people that were in the same cluster. Social comparison can also be applied in terms of possibilities for users in the same clusters to exercise together and to support and motivate each other to follow the healthcare professional's exercise recommendations. However, this feature was not implemented in this first version of the application.

As described previously, the features selected and developed were based on practical aspects such as access to data and project duration.

IV. EXPLORATIVE USER STUDY

As a part of the iterative development, a number of user tests were conducted. One of these tests focused on motivational features and personalization. It was an explorative study where we wanted to get feedback from possible users about how we could integrate motivational features in a meaningful way.

There were seven participants in the test, five men and two women, in an age range between 33 and 52 years. All participants had an education from a university in terms of a Master of Science degree or higher.

The material used were a digital mock-up prototype designed in Figma [18] and a scenario description (Figure 2).

Scenario: You have done the scan and discussed your result with your physiotherapist. Imagine that a hip problem has been detected (or another problem that you want to choose). You have got a training program from the physiotherapist to improve the hip problem and to prevent from hip pain. In the web app you can see what exercises to do and how often as well as the number of repetitions. You can also see the results of the scans.

Figure 2. The scenario presented to the participants.

Semi-structured interviews were conducted, and during the interview questions were asked about motivational features and about personalization. The questions about motivation included questions about what kind of features that would motivate the participants to use the system and what they thought was needed to find motivation to follow the exercise plan. The interview also consisted of questions about getting feedback about progress and about being able to see the progress of other users. Further questions that were given to the participants were questions about personalization and to which extent they wanted the system to be adapted to their preferences and needs. Finally, the participants were asked how they expected the system to support the individualized treatment in physiotherapy. Each interview lasted about an hour. The interviews were recorded, and the data collected was transcribed and thematically analyzed.

A. General motivation

Being able to see progress: The participants described the possibility to be able to see improvement as the most motivating feature, for example by comparing their past scan data with the results from the latest scan or being able to see progress with respect to goals or in terms of reduced pain. Being able to follow the progress was described as one of the most important features, since the lack of progress could be demotivating. In that case, the user could get the feeling of doing something wrong and stop doing the exercises.

Feedback to the user from the physiotherapist: The users had full confidence in the physiotherapist when it came to planning/rehabilitation, but there was a desire to make the planning together with the physiotherapist. The participants thought that frequent interaction with the physiotherapist would increase motivation to continue doing exercises, answer questionnaires and report pain.

Sharing health related information: From a data sharing perspective it was described as important to understand how the system used information provided by the user, for example answers to health related questions. The participants pointed out the importance of a clear connection between questions asked by the system and the feedback that was given. The participants said that if they could not understand this connection, they would hesitate to answer health related questions. Being able to report pain and to get feedback based on pain level was a described as important. This, since one of the main goals for the users is to get rid of the pain.

Reminders: The possibility to get reminders was also described as important among the participants. Especially since it is easy to start to forget doing the exercises when starting to feel better. However, this feature needs to be optional and it has to be possible to enable/disable the reminders.

B. Goal setting

Goal setting was perceived as positive among the participants. However, they were hesitant towards setting their own goals. They perceived the physiotherapists as experts and were expecting them to set the goals.

C. Social comparison

Sharing progress with other users is a feature that some people like and others strongly dislike. For some, it might be too personal to share health related aspects, but for others it is a way of sharing experiences and motivate each other.

In this part, participants were asked to report how it would influence their motivation to see other people's data on their persistence in following the physiotherapist's advice (do the exercises regularly) and in terms of filling in personalized health related questionnaires. Most of the participants (6 out of 7) thought that we asked them to compare their health progress, but it was clarified that we were asking only about their persistence on sticking to the training program or to fill in the health related questionnaires. Their reply was generally that they were uninterested to know about how persistent other users were in following their training programs or filling in their health related questions. However, the participants pointed out that gamification features in the application could make it more interesting to relate to other people's data. An example would be the data used for contributing to a group target or used in competing about being the most persistent user.

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Table 1 shows some of the comments the participants shared about their persistence on sticking to the training program or to fill in the health related questionnaires.

TABLE I. COMMENTS FROM THE PARTICIPANTS ABOUT SOCIAL COMPAIRISON

Comments about comparing exercise persistence
A. "If I could see how much I contributed to the group, in a gamified group goal" B. "So as to get the feeling that you are in this together" C. "If we collect points together I would be more interested than competing. If other people are persistent then I would be more persistence" D. "I would be more motivated by competing against the others in the group and try to beat them" E. "Competition is sometimes good but not here, if you put it closer to collaboration" F. "It matters more to me if I am doing it than if other people doing it"
Comments about comparing questionnaire completion persistence
G. "If I was the only one did not fill them in, it would have motivated me to fill them in"
Other insights
H. One participant would be compared only to a standard value or a value close to a standard based on a statistical average I. One participant compared the results of the scan to a colleague to understand how their bodies were crooked, but this was perceived as a comparison promoting awareness, and the participant perceived their reaction to be influenced by the novelty effect with no value to continue comparing future data.

D. *Personalization*

For the participants, personalization was mainly the same as individualized treatment and not related to interaction with application. The interpretation of personalization in this case was an application that generates data to be used to make care related decisions based on the individual's condition and preferences. The users expected the data generation to support the physiotherapist in prescribing the most optimal exercises or treatment for each specific user, and to monitor the rehabilitation progress. In the study, some of the users expected an application like this to enable advanced forms of personalized feedback from the physiotherapist in terms of care progress and potential improvement in condition. Other participants expected that an application like this would generate data in a way that could trigger a personalized intervention based on an input from the user. For example, if the user reports increased pain level, the physiotherapist was expected to react with a personalized intervention in terms of an adjusted treatment plan or with supportive exercise guidance.

V. INSIGHTS AND SUGGESTIONS FOR DEVELOPMENT

Below we present insights from the work in terms of suggestions for development of motivational features for applications in the domain. We also give examples of how we implemented some of the features.

Support communication with the physiotherapist: It is important that the users get individualized feedback based on his/her particular situation. The physiotherapist should monitor progress and make the user aware of that his/her efforts are seen and contribute to the progress. For this application it was considered important to be able to report pain so that the physiotherapist could provide feedback based on the pain level. The implementation of the pain reporting was conducted using a representation of a body and of a pain scale (Figure 3).

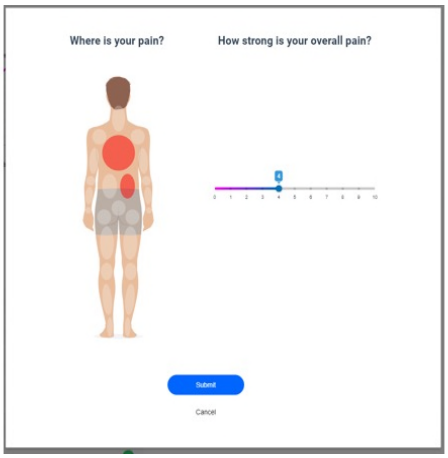

Figure 3. Possibilities to provide the physiotherapist with information about pain level.

Provide feedback about progress: Information about progress is one of the most important features. This can be done by showing improvements in terms of comparing past data with present performance, or in relationship to the goals that have been set. In this application we implemented and visualized the progress of the pain scores (Figure 4). For this user group it was important to follow their progress, and also hopefully be able to see that the pain decreased.

Figure 4. History of the user's pain score.

Support in setting the goals: Goal setting theory has been taken into account in different levels of the application. The goals need to be realistic and have to be based on domain knowledge. Therefore, the goals should be set together with the physiotherapist. Besides being realistic, goals need to be concreate and measurable, and the users could benefit from

having explanations to the goals. Finally, it could be motivating to be able to see goals that have been reached. In our application we applied the goal setting features at a high level in terms of self-defined long-term goals (Figure 5), and in terms of possibilities to follow progress in relationship to the goals that have been set (Figure 6). We also applied gamification for short-term goal setting using medals based on the user's compliance in terms of consistency in following the physiotherapist's advices and in doing the exercises (Figure 7).

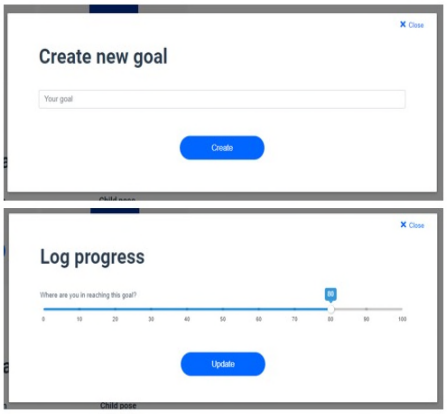

Figure 5. Possibilities to set own goals.

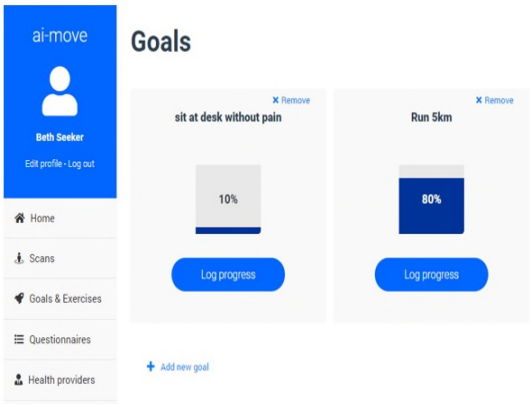

Figure 6. Possibilities to see progress in relationship to the goals that have been set.

Figure 7. Reward for conduction the exercises every day for a week.

Support from other users: Some users could benefit from sharing experiences with people in the same situation and being able to hear information about other's progress. Users who are unable to keep up with their new exercise routines could benefit from having the possibility to ask for support from people that have managed to engage in new routines [19]. This without triggering competition if that is unwanted. On the other hand, competition might be considered as positive in this case.

Feedback based on data from other users: If the users are categorized into different groups, it could be shown which group the user belongs to and how many people that are in the same cluster. This could provide support in understanding that there are other people struggling with similar issues. *P*rogress could also be based on reported data from other users. For example, it could be shown how successful the suggested exercises are in terms of fast progress.

Comparison in compliance: Comparison can be used for compliance in conducting exercise and in answering health related questions. This can be done regardless of progress and without users sharing sensitive information about their health. For example, rewards for conducting exercises can be given and compared. Another comparable measurement is "number of days after each other that the exercises have been conducted", this shows the user's compliance on a daily basis. Compliance is also a usable motivation aspect when there has been no progress, since it will still be possible to give rewards [20].

Reminders: Motivational messages and reminders can reduce the risk of that exercises will be forgotten when the health improves and the pain has vanished. The motivational messages should be based on the user's actions, for example when reporting that they had conducted an exercise.

VI. CONCLUSION AND FUTURE WORK

Due to the nature of the application, motivational aspects related to goal setting and social motivational theories were the most relevant ones to apply in the development of the application. Goal setting and being able to follow progress were important features to include. It was also shown that the goals for the user's exercises needed to be realistic and set together with the physiotherapist. This was explained in terms of that the physiotherapists were experts in the physiotherapy domain and therefore could estimate true progress. However, it was important that the goals were meaningful and motivating for the user, otherwise it could affect compliance and performance [17].

With respect to being able to compare performance or progress with other users, our results were in line with the research done in the psychological field regarding the rejection of comparison [14][15]. However, if the comparison is disguised as a gamification element, the participants thought that people would be more willing to compare to others for competing, for feeling a part of a group or for contributing to a team. Due to the rejection of

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comparison in this work, it was impossible to get detailed user specification about design of social comparison features. For example, if they would like to compare to specific individuals, random users of the application or with statistics created by all the users. More research is needed to understand how we can make the users comfortable to talk about comparisons they engage in.

The need for personalization was mainly related to getting qualified feedback from the physiotherapist in terms of him/her following care progress and providing an updated exercise plan. The frequent communication and interaction with the physiotherapist and the individualized exercise plan based on input from the users was described as an import aspect for sharing health related data with the system. The users in our study were willing to provide a variety of personal information, as long as it was used in a meaningful way that supported their progress and their care related decision-making. Other studies have also shown the importance of social interaction and of being seen by the physiotherapist. For some users this social aspect might be the most important motivational feature [20].

Finally, one motivational feature that was not initially discussed with the participants but came up during the interviews was awareness of body posture, and that the visualization of the body in itself could be a motivating feature. This could provide the user with feedback about existing posture and goals showing what to strive for [20].

To summarize, this work conveys insights and suggestions for developing motivational features in applications that supports conducting exercises based on recommendations from a physiotherapist. We have not investigated the use of different motivational theories in a systematic way and do not suggest which motivational theories are most successful to apply in this context. In an exploratory way and for this particular application, practical combinations of different theories were applied. Future work needs to be conducted, both in terms of applying other motivational theories and in terms of evaluating the applied motivational features.

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