Applying Motivational Theories and Personalization in a Mobile Application within the Domain of Physiotherapy-Related Exercises

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***Abstract*—This paper describes motivational features and personalization in a mobile application for physiotherapy-related exercises. Motivational and personalization theories are discussed in terms of being relevant for the developed application. The motivational features that were applied supported goal setting, possibilities to follow progress, personalization and possibilities to compare one's own progress or performance with other users. During the iterative development of the application, an explorative study was conducted in which the participants were interviewed about the aspects related to motivation and personalization. In the study, the participants emphasized the importance of goal setting together with the physiotherapist and of being able to track 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 in which comparisons have been rejected. Based on the outcome of the study and on insights with respect to applying motivational theories, the implications and usefulness of the applied theories are presented and discussed.**

Keywords - movement-related disorders; mobile application for performing exercises; motivational theories; goal setting; social comparison; personalization

I. INTRODUCTION

This paper is an extension of the work described in Sjölinder et al. [1], where the development of a mobile application for physiotherapy-related exercises was described. This extended paper focuses on the usefulness and applicability of different motivational theories.

Movement-related disorders is one of the most common occupational hazards in the European Union, and workers in all sectors and occupations are affected [2]. This is an increasing problem and one of the key causes of long-term sickness leave. 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, different movement-related patterns can be categorized. Based on this categorization, a person's movement pattern can be placed into one cluster and early signs of problems and movement-related disorders can be detected before they have started to cause problems or pain. Based on this knowledge, personalized support and exercises can be suggested using a smartphone application. However, the challenge is to motivate the users to perform the suggested exercises based on personalized recommendations from the physiotherapist, and to comply with training programs aimed at solving possible future problems.

In this study, motivational features and personalization were applied in a mobile application for physiotherapy-related exercises. The features were related to goal setting, providing support in tracking progress, personalization and possibilities to compare one's own performance with others. Conducting interviews and gathering feedback from users was a part of a larger process in which the application was developed in an iterative way with different user groups. The aim of the 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. Based on the outcome of the study and on previous work, the implications and usefulness of the applied theories are discussed. In the following text, Section 2 describes the project and the concept that the developed application was part of. Section 3 to Section 5 present previous research and the background to this work. Section 3 gives an overview of motivational theories, and Section 4 gives an overview of personalization theories and approaches. In Section 5, the theories and the central concepts are discussed in terms of possibilities to be applied in the context of the developed application. Section 6 describes the explorative study that was conducted, and it

presents the outcome of the study, which was a part of the iterative development. Based on the study, Section 7 discusses implications and usefulness of the applied theories. Finally, Section 8 discusses the work conducted and suggests possible future work.

II. An Application for Supporting Physiotherapy-Related Exercises

Physiotherapy is a profession in healthcare that aims at improving the functional ability and health of the healthcare user [3]. The core of physiotherapy is to involve the healthcare user in such a way that the user can participate in the physiotherapy process and the decisions that are made regarding their own health [4]. Although physiotherapists are positive towards technological applications, the adoption of technological applications in physiotherapy has remained low [5]. One of the major challenges in physiotherapy is that the healthcare users are not provided with information that allows them to actively participate in the care process. Because of this, there is a continuous need for technological applications that could provide both the physiotherapist and the healthcare user with easily interpretable personalized data [6].

As there is a niche in the market for such technological interventions, Qinematic, a small Swedish startup, developed a software service that records and analyzes body movements using 3D digital video. The users stand in front of a Kinect sensor and follow instructions about which movements to conduct. Based on these sessions, 3D data is gathered and stored. As an extension to this service, a research project with two aims was formulated. 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 allow the users to set goals and track their progress (Figure 1).

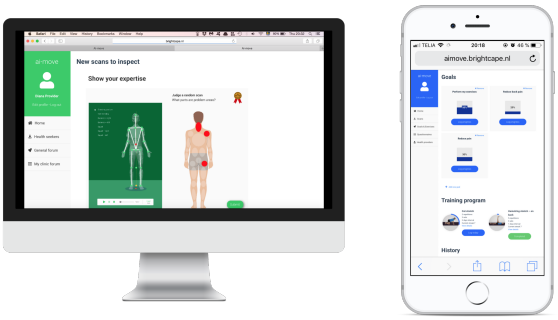

Figure 1. Application for health providers to the left, and for their clients to the right

Via the application, the healthcare provider had the possibility to gather further information by asking the healthcare users health-related questions, with the aim of providing better and more personalized care. The entire system consisted of several parts, including machine learning and categorization of dysfunctional movement patterns. The work presented in this paper focuses on the development of motivational features in the application targeted towards healthcare users with possible dysfunctional movement patterns. However, the larger concept surrounding the application, with a machine-learning module and a healthcare provider application, placed other demands related to how to apply motivational features than what are faced when developing applications that only support users to be more physically active or to perform exercises.

III. Motivation and Behavior Change Theories

This section describes some of the most important motivational and behavior change theories and their relation to the design of technological applications. These theories shaped the starting point of our design discussions and some of them played a central role in the final design of the application presented in this paper.

A. Models and theories focusing on the individual

The **Health Belief Model (HBM)** is one of the most used behavior change models [7]. The aim of the model is to provide explanations of behaviors related to health prevention [8]. The focus of the model is on the individual's beliefs and attitudes. It suggests that the individual's perception determines success in terms of behavior change [7]. For the health behavior to trigger, there must be an external stimulus or a cue prompting the appropriate action [7]. Basic individual variables are (1) perceived susceptibility, i.e., how possible it is to have the condition; (2) perceived seriousness, i.e., how severe the impact of the condition will be on the person's life; and (3) perceived benefits of and barriers to taking action (an example of a benefit is the belief that taking a preventive action will have a positive health outcome, and a barrier could be that the action the individual has to take is expensive). A fourth individual factor was added in 1982 [9]: self-efficacy from social cognitive theory (a social behavior change theory described below). Perceived self-efficacy is one's own belief in their ability to perform a task [10]. The figure below (Figure 2) visualizes the main components of the HBM.

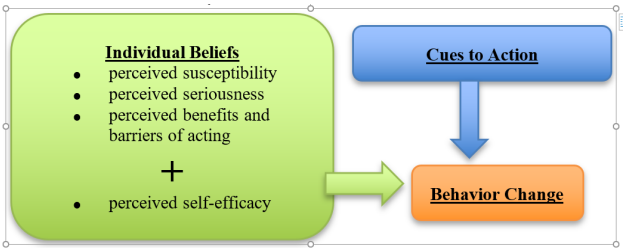

Figure 2. Main components of the Health Belief Model

In the field of technology and health, the HBM is used in combination with other behavior change and motivation theories to design technology for physical activity/wellbeing [11], and for more (medical) condition-focused applications [12][13]. The field of technology and health – apart from using the HBM – has extended it and combined it with other theories to better suit the technological context [14][15].

Self-determination theory (SDT) is a motivational theory focused on the types of motivation a person has towards different behaviors. It consists of concepts such as intrinsic motivation (motivation that comes from within) and extrinsic motivation (external driver). Further, the theory focuses on individual differences with respect to intrinsic and external motivation, basic needs, goals, and relatedness to others [16]. SDT has two important characteristics. First, it is more focused on the type of motivation than the amount of motivation. Second, it underlines the importance of three components: autonomy, competence, and relatedness [17]. Autonomy is related to the feeling of being in control of our own self and our actions. Competence is related to the ability to perform a task. Relatedness is related to our will to interact with others. SDT is a complex theory, and its detailed description is beyond the scope of this work.

In the field of technology and health/wellbeing, SDT has been used in the evaluation and design of technologies. Some examples of where it has been applied are to serve as a basis for the creation of heuristics for healthcare wearables [19], to get integrated in the evaluation process of wearable technology for physical activity [20], and to enrich commonly used design tools such as personas [21].

Stage models are different models that focus on people's readiness to change and categorize them based on that. These models have a clear definition of each stage, and clearly defined factors one must fulfill to move to the next stage [22]. One must pass through all the stages before reaching the final behavior. However, relapsing to previous stages is expected and this is not necessarily sequential [22]. Moreover, one can stay in a stage eternally [22]. The most well-known stage model is the Transtheoretical Model (TTM) first used for smoking cessation and addictions, and later expanded to physical activity and eating habits [23]. The TTM has six time-based stages, each of these including ten factors [23]. Table 1 presents the different stages of the TTM.

TABLE I. DESCRIPTION OF THE TTM STAGES

TTM Stages	Description
Pre-contemplation	The person is not intended to act soon (usually in the next 6 months)
Contemplation	The person is intended to act soon (usually in the next 6 months)
Preparation	The person intends to act in the next 30 days and may have taken actions in the past
Action	The person changed behavior but kept it for less than 6 months
Maintenance	The person changed behavior but kept it for less than a year
Termination	The person changed behavior and kept it for more than a year

The Precaution Adoption Process Model (PAPM) is another stage model [24][25] that takes a different approach than the TTM. The PAPM has seven stages of change that are based on the psychological state of the person rather than the time duration the person practices the new behavior; see Table 2 [26]. It has clearly defined and stage-specific factors for each transition between the stages [27]. The PAPM was created to meet the need for a qualitative approach to adopting new complex behaviors that cannot be fully described by cost-benefit individual models such as the HBM [26].

TABLE II. DESCRIPTION OF THE PAPM STAGES

PAPM Stages	Description
Stage 1	Unaware of an issue
Stage 2	Unengaged by the issue
Stage 3	Undecided about acting
Stage 4	Decided not to act
Stage 5	Decided to act
Stage 6	Acting
Stage 7	Maintenance

In the field of technology and health/wellbeing, the stage models have been used mainly to evaluate the effect of the technology on users' behavior change. An illustrative example of such usage is the well-cited study involving the Fish'n'Steps interactive computer game, in which users could track their own progress as visualized by the growth of a virtual character [28]. The stage models are used today in similar ways [29].

B. Motivational and behavior change theories focusing on social aspects

Social cognitive theory (SCT) focuses on the interplay between individual factors, behaviors, and the environment [30]. It is based on Bandura's social learning theory [31], which supports learning within a social context, i.e., that people bring with them knowledge and experience and that learning happens by imitating others. In SCT, concepts from cognitive psychology and social learning are merged [22] into five categories: psychological determinants of behavior (which include self-efficacy, goals, and outcome expectations) [30], observational learning, environmental determinants of behavior, self-regulation, and moral disengagement. Goals that people set for themselves can be both short-term and long-term goals [30]. Self-efficacy – the belief in one's own ability to conduct a task or take action – is a vital component of the theory [10].

In the field of technology, SCT has been used to support the design of applications related to health and wellbeing, such as physical activity [11][32]. Moreover, it has been used to develop applications that target behaviors by involving multiple actors, such as patients and caregivers. An example of such a case is the development of an application supporting children with asthma and their parents [33]. Another example is a breastfeeding application that was aimed at motivating fathers to support their partners in continuing to breastfeed [34].

Social comparison theory (SCT) suggests that people, in the lack of standard measurements, compare themselves to others for self-evaluation [35], self-enhancement [36], self-projection [37], and coping [38][29]. People often confuse comparison with competition due to the close relationship between these words; however, this relationship is rarely studied [40]. Regardless of the positive results from psychological studies on social comparison [38][39], people often refuse to engage in comparisons due to social norms [41], different perceptions of the term "comparison" [42], or a confusion of "comparison" with "competition" [1]. Social comparison has shown potential in the field of psychology, and it is often used in the field of technology.

In the field of technology, social comparison is often applied as a gamification feature for behavior change [1][43]. Its design is challenging as it needs special care if the designer wants to avoid promoting competition while still promoting one or more of the other aspects, such as social learning [44]. In general, the design field has designed comparison features without specifically referring to the theory, such as in the well-cited Fish'n'Steps study we referred to in the TTM model [23], involving a computer game in which the users can compare the states of their avatars and draw conclusions about each other's physical activities.

C. Goal setting

Goal-setting theory (GST) has proven to have a positive effect on behavior change [45] and has also been used in healthcare in relation to physical activity [46]. Moreover, goal setting is part of other behavior change theories such as SDT and SCT. GST focuses on the goals, as the name implies, which can be divided into sub-goals and into different levels of difficulty [47]. Locke and Latham [48] identified three types of goals assignment: (1) self-set, (2) assigned, and (3) participative-set. Self-set goals are those the individual sets and usually have personal significance. An assigned goal is set for the individual by someone else and a participatory-set goal is a goal that the individual has contributed to define. The GST has evolved since it was first defined, and the goals can now be defined as learning and performance goals [46], with the first being more relevant to people who are new in the particular behavior change as they learn the new behavior.

In the field of technology, GST has been the second most popular theory after the TTM stage model [49]. Goals have also been used in combination with gamification [50]. One example of goal-setting theory in persuasive technology is CALFIT, which shows the results of daily progress between users who have personalized goals and those who do not [51]. Another example is the design of applications that target physical activity for people with chronic obstructive pulmonary disease by implementing goals in different ways [52]. GST can be combined with other theories and applied in design, such as in the MS application where the user, a multiple sclerosis patient, learns to estimate the energy they will consume by doing various activities [53].

IV. PERSONALIZATION THEORIES AND APPROACHES

This section describes some of the most important personalization theories and approaches that can be considered in the design of technological applications. Personalization theories and approaches have their roots in service marketing [54], but information technology has increasingly become the main enabler for personalization [55]. Personalization approaches and theories introduced in this section provided a starting point for our design as they helped us to consider the design at the different levels.

Personalization at the level of the technological application. The first personalization approach focuses on the design of personalization at the level of the technological application itself. At this level, personalization can be defined as a process that changes the functionality, interface, information content, or distinctiveness of a technological application to increase its personal relevance to an individual [56]. Personalization theories and approaches at this level have often focused on classifying and describing personalization in different dimensions.

One of the most well-known and comprehensive classifications for personalization was provided by Fan and Poole [57], who classify personalization into three main dimensions: The dimensions are: 1) "What to personalize?," which refers to the aspect of the technological application that is adjusted to provide personalization, for instance, user interface (UI); 2) "To whom to personalize?", which refers to the target of personalization – whether the personalization is targeted at a single individual or a group of users; and 3) "Who personalizes?", which refers to the party that is providing personalization, meaning whether personalization is done by the system/service provider or by the user [57]. These dimensions and the aspects in these dimensions are intended to support the design of personalization at the level of the technological applications. When it comes to personalization, developers have often lacked the theoretical frameworks for personalization [58]. These dimensions have also been considered in the design of technological applications in the domain of healthcare [59].

Personalization through technological application. The second personalization approach considers personalization more broadly than in terms of just the technological application itself, focusing instead on personalization that can be mediated through the technological application. Personalization through technological application is referred to as technology-mediated personalization (TMP) [60]. Shen and Ball [60] classify personalization through technological application into three main categories: 1) "Interaction personalization", which refers to the use of technological applications to

address the user by name, for example, through personalized emails or greetings; 2) "Transaction outcome personalization", which refers to the use of technological applications to allow the user to personalize certain aspects of the product of service, for instance, in the form of a webpage layout in which the user is allowed to make adjustments based on his/her preferences; and 3) "Continuity personalization", which refers to continuous personalization based on the learning and knowledge of the user and where the gained expertise is used to provide even more personalized products and services to this individual user [60]. The TMP approach connects to personalization literature in the field of service marketing, where personalization takes place in the service interaction between the customer and the service provider [61][62], and where the role of the service provider is emphasized in personalization [63].

Role of the technological application(s) in personalization. The third personalization approach considers personalization even more holistically, at the level of the entire service process, where instead of a single technological application, several different technologies can support the service process to make the service pathway more personalized for the individual user. The focus at this level is on the role technological applications can play in the personalization of the entire service pathway. According to Korhonen and Isomursu [64], the role of technological applications in the personalization of the entire service pathway can be classified into three categories: 1) "Coercive personalization" in which personalization is provided automatically by technological applications without the involvement of the human actor (for instance, based on predefined personalization parameters); 2) "Data display personalization" in which personalization is provided automatically by technological applications, but is interpreted manually by the human actor; and 3) "Collaboration-based personalization" in which personalization is supported by technological applications, but the focus is on the interpretation and co-creation of personalized services between the human actors.

V. APPLYING MOTIVATIONAL FEATURES AND PERSONALIZATION IN A MOBILE APPLICATION FOR PHYSIOTHERAPY

This section describes how different motivational and personalization theories were applied as features in the developed application.

A. Applying motivation and behavior change theories

GST influenced the design of the application in relation to creating goals and different types of rewards (see Figures 3 and 4). Goals could be set by the physiotherapist or by the user him/herself. In the design, the goals were closely related to each exercise. Both proximal (short-term) and distal (long-term) goals could be set within the application. Although originating from GST, the distinction between short-term and long-term goals can also be found in the autonomy part of SDT. Short-term goals were set by the physiotherapist and were related to the exercises, and the long-term goals were set by the user. The users self-evaluated their progress on their long-term goals in terms of reduced pain (Figure 3). One social outcome was the evaluation that was conducted by the physiotherapist, which could be seen from the perspective of SDT's relatedness.

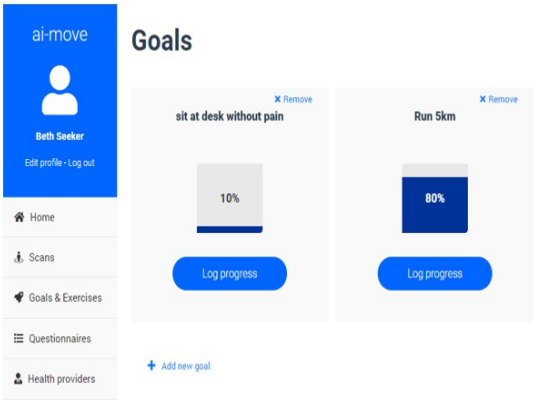

Figure 3. Possibilities to see progress in relation to the set goals

Figure 4. Reward for doing the exercises every day for a week

SDT consists of different types of motivation, and the external motivational aspects were relevant for the design of the application. The concept of autonomy – the freedom of choices a user has – was applied through GST and particularly by implementing self-set goals. The concept of competence – the person's belief in the extent to which they can conduct a task – was applied through personalization of services, in this case through discussion with the physiotherapist in which they together set exercises, repetitions and goals in a way that made the healthcare user feel competent and capable. This was also covered in the concept of self-efficacy – the belief in one's own ability to conduct a task – which is part of SCT.

To cover the relatedness part of SDT and the social aspect of SCT, social comparison theory was applied. Due to the tight timeframe of the project, it was a challenge to apply social comparison theory fully since a number of different users are needed for comparisons. However, potential users

of the application were asked during the interviews about what types of comparisons they would like to be engaged in. The phrasing was altered in order to avoid the word comparison due to its challenging nature (i.e., people often reject comparisons). In the application, comparisons were implemented in relation to the physiotherapist's advice and the healthcare user's adherence to it. Such comparisons between the healthcare users could be related to performing the exercises suggested by the physiotherapist in a consistent manner, or in relation to the completion of the medical questionnaires that had been made available by the physiotherapist.

The HBM was applied in relation to the visualizations of the scans. For example, perceived severity and susceptibility could be influenced through the 3D scan visualizations. The idea behind this was that people are unaware of how their body moves, but by looking at the visualizations they could be able to better understand harmful movement patterns that on a long-term basis could lead to problems and chronic pain.

Stage theories such as PAPM and TTM were found to be difficult to apply. The TTM is time-based and at least one month to one year of interaction with a functional prototype of the application is needed in order to be able to see any changes in the user's behavior. However, we used the PAPM to understand the users' initial intentions and readiness to change.

B. Applying personalization approaches

Personalization approaches can provide support at different levels. Personalization approaches at the technological application level [57] can help in understanding what can be personalized, for instance, in the training program. On the other hand, personalization through technological applications [60] can provide insights to consider, for instance, how the physiotherapist can adjust the training program based on the feedback. Finally, the role of technological applications in personalization [64] can help in considering the role of technology, whether it can provide data-display support for the physiotherapist only, or whether it is intended more as a tool for collaborative decision-making between the user and physiotherapist for personalization. Personalization approaches in the developed application were connected to the use of the technological application in order to understand the user needs, but also to the use of the technological application in order to personalize the physiotherapy services for these needs.

VI. Explorative user study

As a part of the iterative development, a set of user tests were conducted. One of these tests focused on motivational features and personalization. This was an explorative study in which the aim was to gather feedback from possible users about how motivational features could be integrated into the application in a meaningful way.

A. Method

There were seven participants in the test, five men and two women, in an age range between 33 and 52 years. All participants had university educations and held a Master of Science degree or higher. The materials used were a digital mock-up prototype designed in Figma [65] and a scenario description (Figure 5).

> **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 received a training program from the physiotherapist to improve the hip problem and to prevent 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 5. The scenario presented to the participants

Semi-structured interviews were conducted based on an interview guide. The guide was formulated to collect information about motivational features and personalization, for example, types of features that would motivate the participants to use the system and follow the exercise plan, how they would like to receive feedback on their progress, if they would like to be able to see the progress of other users, or to which extent they wanted the system to be adapted to their preferences and needs or 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.

B. Results

Motivational profile. The participants' general profile, based on the interviews, was that they were extrinsically motivated to follow their physiotherapist's advice based on progress improvement and pain reduction. All the participants were aware and engaged with the matters related to physical posture, physical activity, and pain issues due to bad posture or sedentary life. All participants had at some point been instructed to act to reduce the risk of posture issues. However, they had been acting on this on different levels, e.g., they were exercising but often had to skip it because daily life got in the way. Finally, all described issues with maintenance, e.g., when the pain stopped, they started to neglect their physiotherapist's advice.

Being able to see progress. One of the most motivating factors was being able to see progress. The participants described the possibility of being 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 track the progress was described as one of the most important features, because the lack of progress could be demotivating. This showed that the participants were extrinsically motivated to adhere to the physiotherapist's instructions. However, if the outcome was negative or stable, there was risk of getting the feeling of doing something wrong, which could lead to reduced motivation to continue exercising. The lack of pain (external motivator) could also lead to forgetting to do exercises prescribed by the physiotherapist.

Goal setting and feedback from the physiotherapist. Goal setting and feedback from the physiotherapist was described as vital. The participants thought that frequent

personalized interaction with and feedback from the physiotherapist would increase their motivation to continue to do exercises, answer questionnaires and report pain. In general, 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. Even though the users had full confidence in the physiotherapist when it came to planning/rehabilitation, there was a desire to do the planning and set the goals together with the physiotherapist.

Reminders. Adherence to the exercises could be externally motivated by discomfort induced by pain. The participants also pointed out that it is easy to forget to do exercises when the pain is no longer present. The possibility to get reminders was described as important by the participants, regardless of the existence of pain. However, they pointed out that the reminders should be adjustable and optional.

Sharing health-related information. To be able to connect with others, there is a need to share information and be able to see other people's information. In practice, this raised a lot of questions in relation to data handling, security, and reasons for collecting the data. Data handling and sharing were described as important aspects for using this kind of feature.

Sharing progress with other users. Sharing progress with other users was a feature that some participants liked, and others strongly disliked. For some, it might be too personal to share health-related aspects, but for others it is a way of sharing experiences and motivating each other. To apply relatedness, we used social comparison theory. We asked the users to report how it would influence their motivation to see other people's data on their persistence in following the physiotherapist's advice (doing 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 in sticking to the training program or filling in the health-related questionnaires. Their reply was generally that they were uninterested in knowing about how persistent other users were in following their training programs or filling in their health-related questionnaires. However, the participants pointed out that gamification features in the application could make it more interesting to relate to other people's data if, for example, the data was used for contributing to a group target or used in competing about being the most persistent user. Table 3 shows some of the comments the participants shared about their persistence in sticking to the training program or filling in the health-related questionnaires.

Personalization as a motivating factor. It was important for the users to understand how the technology used the information they provided in the health-related questionnaires. The participants pointed out the importance of a clear connection between questionnaires and the feedback that was given by the physiotherapist. They stated that if they could not understand this connection, they would hesitate to answer health-related questions because the value of answering the questions would not be clear. Being able to report pain and to get personalized feedback specifically based on pain level were described as important aspects. This was understandable, because one of the primary goals for a healthcare user is to get rid of the pain. The importance of personalized feedback can also be seen by the need to have direct contact with the physiotherapist.

For the participants, personalization was connected primarily to being treated as individuals, rather than to interaction with the technological application. In this case, the technology generated additional data points through user reporting that could be used in personalization. The participants expected that the generated data would not only support the physiotherapist in prescribing the most optimal exercises or treatment for them, but also help the physiotherapist to track their progress. In the study, some of the participants expected that the technology would enable advanced forms of personalized feedback from the physiotherapist in terms of care progress and potential improvement in condition. Other participants expected that the technology would generate data in a way that could trigger a personalized intervention based on input from the user. That is, if the user were to report an increased level of pain, the physiotherapist could use the data and contact the user with a personalized intervention.

TABLE III. COMMENTS FROM THE PARTICIPANTS ABOUT SOCIAL COMPARISON

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 collected points together, I would be more interested than if competing. If other people were persistent, then I would be more persistent" 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 make it more like collaboration" F. "It matters more to me if I am doing it than if other people are doing it"
Comments about comparing questionnaire completion persistence
G. "If I was the only one who didn't fill them in, it would have motivated me to fill them in"
Other insights
H. One participant would have liked to be compared only to a standard value or to a value close to a standard based on a statistical average. I. One participant compared their scan results with those of a colleague to understand how their bodies were crooked. This was perceived by the researchers as a comparison that promoted awareness. However, the participant thought that this was a novelty effect and could not see any value in continuing to compare future data.

VII. IMPLICATIONS AND USEFULNESS OF THE APPLIED THEORIES

A good understanding of the most common behavior change and motivation theories is an advantage when

designing applications within this area. It increases the understanding of users' attitudes to performing exercises, their behavior, and their motivation. For example, we expected users to be reluctant when it came to comparison since theory supports that many people will refuse to engage in comparisons for sociocultural reasons [41][42]. Therefore, alternative ways to apply comparison were considered. The design presented in this work was strongly based on theories of motivation, behavior, and personalization. However, the design process of an artifact is complex since it seeks to solve "wicked problems" in the real world [66]. According to Buchanan, a "wicked problem" is a complex problem that has many dependencies, contradictory or incomplete information and changing conditions. Buchanan furthermore links this to the need to understand the problem in its context in order to be able to develop solutions that are valuable from the user's point of view. Therefore, a combination of theories was applied in the development of the application.

A. Goal-setting theory

Goal-setting theory (GST) is a commonly applied theory for health-related behavior change [67]. In the health-related area, the goal setting should be designed with care as it may harm the healthcare users, e.g., if the goal is too difficult to reach and the healthcare users strive to reach it. Locke and Latham [67] define a goal as "*the object or aim of an action, for example, to attain a specific standard of proficiency, usually within a specified time limit*" [48]. Four principles specified in the theory of goal setting – ability, commitment, feedback and situation resources [68] – can be taken into account when setting performance goals.

Individuals need the *ability* to achieve a specific, challenging performance goal: "People cannot attain goals if they do not know how to do so" [68]. Studies have shown that difficult and specific performance goals can be detrimental to performance when people have not acquired the abilities or skills for a particular task [69]. Performance goals should not be set if the necessary ability is lacking [46]. To meet the ability of the health care user, support in setting the goals could be provided. The need for this was also shown in the conducted interviews, where the participants descried a desire to have goals set either by the physiotherapist or in cooperation with a physiotherapist. Goals should also be realistic and appropriate for each participant's situation. Otherwise they may be too hard or too easy to achieve, and this can cause the user to become demotivated [45]. This was also something that was mentioned during the interviews. Besides being realistic, goals need to be concrete and measurable, and it could also be beneficial to have explanations of the goals. Motivation can be further supported by making it possible for the user to track progress towards the goals, and to see goals that have been reached.

Being *committed* to the goals is an important prerequisite for success. The individual him/herself needs to be involved in the goals. They must be seen as important if people are to be committed to achieving the goals. *"A goal that one is not committed to attain will not affect that person's actions"* [68]. The participants in the study described themselves as more committed to and more confident about goals that had been set together with a physiotherapist.

Feedback should be given regularly throughout the treatment or process to provide support in achieving the goals. If the healthcare users set goals that are difficult to achieve, they must be able to get feedback about their performance in relation to their goals [70]. In the absence of feedback, the healthcare users have no information that could support whether they should change their strategies to achieve the goals or whether they should just continue in the same way as previously [46]. Therefore, it is important to understand and receive feedback regarding goals in order to be able to track progress towards the goals or see if you are moving away from them. It should be noted [46] that it may not only be enough to set performance goals; other strategies such as self-monitoring may also be needed to make it easier to achieve the goal. Self-monitoring is a personality trait that involves the capacity to regulate and monitor behaviors and emotions in different situations. Here, an individual focuses on skills that lead to the achievement of the goals. The individual can complement this with their own checklists and/or take notes about their own development of the performance of the exercises. A user should also be able to understand the connection between the goals and the overall objective. This should be done by the physiotherapist, and it could be beneficial to have explanations of the goals in the app.

According to Latham [68], the *resources* that are necessary must be available (such as equipment needed for the exercises), as the lack of these may otherwise influence the individual's ability to achieve the goals.

Goal-setting theory is consistent with the results obtained from the conducted study (see Section 6) in terms of need for feedback. The participants pointed out that it is significant to gain feedback about progress, and that information about progress is one of the most important features to include in an application like this. This can be achieved, for example, by showing improvements in terms of comparing past and present performance, or in relation to the goals that have been set.

B. Theories that include social aspects

To apply the relatedness aspect of self-determination theory, social comparison theory was applied. Social comparison theory suggests that people evaluate their abilities and that they have a willingness to improve. When people feel insecure about their abilities, they usually compare themselves with others. If an individual has several people to compare themselves with, it is likely that he/she will choose someone with abilities at a similar level (e.g., in terms of fitness) for comparison [35]. The more different one individual is from others, the less he or she tends to compare him/herself with them. Other studies, on the other hand, show that some people compare themselves with people they are different from [71].

Sharing health-related data is related to the relatedness aspect of SDT and our will to interact with others. The participants in this study pointed out that they were reluctant to share health data since they perceived their situation and

their health data as unique. They therefore did not wish to have any comparisons, and they were also uninterested in seeing other people's health-related data. However, they were positive to sharing data in relation to the adherence to their physiotherapist's advice and with respect to questionnaire completion, particularly if the comparison was applied in the shape of gamification [1]. One thing that is important to note for the comparison to be meaningful is that the people compared should perceive each other as similar [35]. One solution to this is to categorize users into different groups based on their condition and/or exercises they have to do. This would enable the healthcare users to see the group they belong to and recognize that there are several other people in the same cluster. Being in contact with people who are struggling with similar issues could provide psychological support for negative feelings such as feelings of deviance or isolation [38].

In the study, some of the participants were positive towards sharing advice to help others or asking for advice from those who had managed to follow the physiotherapist's advice better than they had. Healthcare users who are unable to keep up with new exercise routines could thus benefit from having the possibility to ask for advice from people who have managed to engage in new routines [44]. It is recommended that this be designed in a way so as to not trigger competition if that is unwanted. However, not everyone in the study disliked competition related to adherence to the physiotherapist's advice, and several also thought that gamified competition could support motivation [43].

C. External motivation and rewards

Extrinsic or external motivation is behavior driven by external rewards. Extrinsic motivation is a concept that applies every time an activity is performed in order to achieve a desirable outcome. Extrinsic motivation thus contrasts with intrinsic motivation, which refers to doing an activity simply for the enjoyment of the activity itself, rather than its contributing value [72]. SDT suggests that extrinsic motivation can vary greatly in the extent to which it is autonomous (related to the feeling of having control over our own selves and our actions). This can be exemplified by comparing two students doing their homework [72]. One does the homework only so as to not be "punished with sanctions" by his parents, and the other student does the homework because he personally thinks it is good for his future career. Neither is doing it because they find it interesting to learn. Both cases are extrinsically motivated, but the latter example has a sense of personal feeling and approval while the former example is only about external control. Both represent conscious behavior, but the two examples of extrinsic motivation differ in their relative autonomy.

Feedback that is based on data from other users could also serve as external motivation. Progress may be shown based on reported data from another group of users. For example, it can be shown how successful the proposed exercises have been in terms of rapid progress.

The participants in the study pointed out that they were motivated to follow the physiotherapist's advice based on situation and existence of pain, which could be described as external aspects for motivation. Even if exercises are forgotten, their value was understood. Therefore, the participants expressed the need for reminders. Reminders are related to the HBM and its cues to action. Reminders in combination with motivational messages can support the users in remembering to do the exercises, especially when health improves and pain has vanished. Within an application, motivational messages could be based on the user's actions, for example referring to a situation in which the healthcare user had performed the exercises. However, it is important that reminders are adjustable, that they are based on the users' needs, and that the user can deactivate them if desired since they can be overwhelming.

Another feature that might be motivating for some users is to add gamification. This feature is based on external motivation in terms of different kinds of rewards, such as being rewarded for performance in comparison with other users. Comparison, in this case, can be used for compliance in performing exercises and in answering health-related questionnaires. This can be done regardless of progress and without users sharing sensitive information about their health. Another comparable measurement is the streak (the number of days in a row the user did the exercises). This shows the user's compliance on a daily basis. Compliance is also a usable motivational aspect when there has been no progress since it will still be possible to give rewards [73].

VIII. Conclusions and Future Work

Due to the nature of the application, motivational aspects related to goal setting and social motivational theories were the most relevant aspects 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 could therefore estimate true progress. However, it was important that the goals were meaningful and motivating for the user as otherwise compliance and performance could be affected [48].

With respect to being able to compare performance or progress with other users, our results were in line with the research conducted in the psychological field regarding the rejection of comparison [41][42]. However, if the comparison was disguised as a gamification element, the participants thought that people would be more willing to compare with others for competing, for feeling a part of a group or for contributing to a team. Due to the rejection of comparison in this study, it was impossible to get detailed user specifications about the design of social comparison features. For example, if they would like to compare specific individuals, compare random users of the application, or compare with statistics created by all the users. More research is needed to understand how we can make the users feel comfortable talking about comparisons they engage in.

The need for personalization was mainly related to receiving personalized feedback from the physiotherapist in a way that takes into consideration the user's condition. Users described that the frequent interaction with the physiotherapist and the individualized exercise plan based on input from the users was an important 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. 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 [73].

Finally, one motivational feature that was not initially discussed with the participants but which came up during the interviews was awareness of body posture and that the visualization of the body could be a motivating feature. This could provide the user with feedback about their existing posture and goals showing what to strive for [73].

To summarize, this study conveys insights about applying motivational theories and provides suggestions for developing motivational features in applications that support performing exercises based on recommendations from a physiotherapist. We have not systematically investigated the use of different motivational theories and are not suggesting which motivational theories can be most successfully applied in this context. In an exploratory manner, 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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