Transforming Rehabilitation to Virtually Supported Care - The vCare project

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ABSTRACT

vCare is designing personalized rehabilitation programs that will lead to better continuity of care and a better quality of life for patients with stroke, heart failure, Parkinson's disease or ischemic heart disease. It's goal is to provide a holistic approach for transferring rehabilitation pathways from stationary rehabilitation to the patient's home. VCare persues two novel approaches in the field. First, it combines persuasive system design (PSD) with a health psychological model (IMB) which are implemented into a software system to motivate the user. Second, it integrates personalized rehabilitation paths and a virtual coach with graphical representation to support the rehabilitation process. The coach is based on patients' personalized care pathways. It engages with patients so that they meet their individual care plans. This encourages compliance with the patients' rehabilitation programs.

KEYWORDS

virtual coaching, clinical pathways, ontologies, avatar

1 INTRODUCTION

Virtual Coaching in healthcare is a rather new approach with the main purpose of engaging patients towards a healthier lifestyle. Hence, Virtual Coaching is closely related to the research topic of persuasive computing [12], [13]. Persuasive computing is a field of computer science with the aim to use technology to influence

appraisal and decision of humans and has a wide range of applications like human-computer interaction, advertisement or even the method how knowledge is indexed by a search engine. The efficacy in terms of the effect of methods in persuasive computing is related to a persons personality, gender, social status and other traits. New ICT based concepts for empowering and motivating people can help them to proceed with a personalized rehabilitation that complies to age related physical, cognitive, mental, and social conditions. Actually, the major disadvantages of home-based rehabilitation solutions are the lack of specialized equipment and insufficient alignment and adaptability of the technical possibilities to the individual care needs and abilities. In this context, the so-called "Virtual Coaches" are seen as a key driver for health promotion in home care settings, not least because the technological possibilities have massively evolved over the last decades. In the literature, several studies have analyzed the positive impact of Virtual Coaching on users in various clinical settings. In the project those studies were analyzed that are dominant and remain reference points in this field throughout the years. E.g., in [1], it has been highlighted that one of the greatest areas of innovation for Virtual Coaching was to support preventative health management and self-care. The authors believed a new class of intelligent devices and applications is capable of facilitating self-management, users' compliance and prevention of secondary conditions in the field of rehabilitation. Hence, and based on the experience of the clinicians involved in the project, vCare was started aiming for a holistic approach for transferring rehabilitation pathways from stationary rehabilitation to the patient's home using modern ICT and in an engaging way. VCAre provides a clear contribution to the field, by combining persuasive strategies with a health psychological model and using this combination to make a virtual companion with graphical representation more persuasive while supporting the rehabilitation process.

1.1 Related Work

In the literature, a number of applications of Virtual Coaching can be found for general prevention and self-care [1] or specific indications like weight control [17], diabetes [14] or chronic obstructive pulmonary disease [15]. Efficacy of advanced AI based systems with appropriate user interfaces has been shown also in [9] using concepts such as motivation and supporting behavior changes. A proper way of communication has shown to be an important aspect

of effective digital communication. However, high quality e-health communication programs depend more on the appropriateness and dynamism of the messages exchanged than merely on the digital channels used for communicating. Although the literature on Virtual Coaching reports a limited number of subjects in its studies, the existing publications indicate an effect of digital interventions on health in general and rehabilitation in particular. Hence, further work on this topic is encouraged and the vCare project is based on these results aiming for Virtual Coaching in rehabilitation for patients with one out of four diseases (stroke, heart failure, Parkinson's disease, ischemic heart disease).

2 THE VCARE APPROACH

Virtual Coaching can be understood as an application of persuasive computing using a virtual companion or adviser. Although in the broadest sense a virtual coaching can be done without graphical representation (e.g. through a chatbot) a humanized (or characterized) graphical representation offers a much more persuasive potential. Such a companion can be represented via an avatar (human-like, but also comic style) or even by using a physical embodied device or a mobile robot. The approach within vCare combines a virtual avatar with persuasive computing technologies (see Figure 1) and makes extensive use also of ubiquitous computing [18], the computer science paradigm where computing is made to appear anytime and everywhere. In vCare, this means the patient is using multiple devices which are connected to each other via a central computing infrastructure to interact with the overall system. These devices measure interaction parameters and/or environmental parameters which are further used in a feedback loop to adapt the coaching services in terms of the way of interaction (How? When?) but also the content (What?). In vCare, this feedback loop is closely related to the pathways defining the means of rehabilitation for the patient at home. A pathway is derived from the disease-induced treatment and then adapted to the personal needs of the patient. Hence, the coaching services will be highly personalized not only in terms of the patient's disease but also in terms of individual disease-related parameters and co-morbidities, preferences, behavior and context. The patient can interact with the coaching interface via an tablet app. The virtual coach itself has not only a graphical representation, but it is possible to interact verbally with him.

3 THE MOTIVATIONAL MODEL

Due to the fact that the adherence to treatment of chronic medical conditions (CMC) is low in general (up to 63% do not adhere as observed e.g. [2]), health psychologists have started to observe the reasons and investigate possible interventions to increase it. These findings have also a major impact on the efficiency of digital interventions for therapy support like those developed in this project. One of the few models which is readily translatable to targeted intervention approaches is the "Information, Motivation, Behavioral Skill model" (IMB) [16]. It consists of three dimensions (Information, Motivation, Behavior) and offers a unique characterization of the core determinants of one's care initiation and subsequent maintenance in care over time that can be efficiently translated to comprehensive, feasible and actionable intervention strategies. According to the IMB model, the performance of health promotion
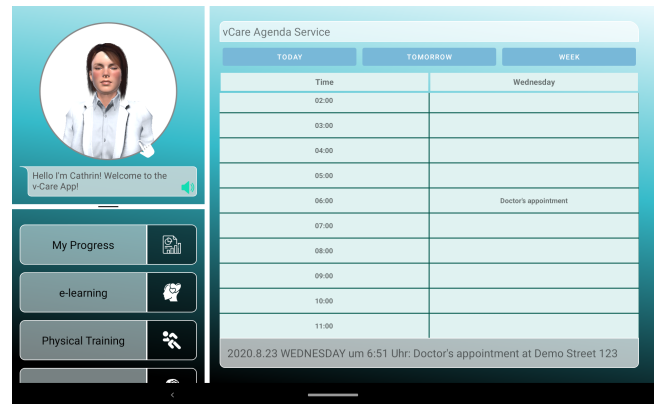

Figure 1: Screenshot of the avatar-based UI.

behavior is supported by being well-informed about the behavior, highly motivated to perform the behavior in both personal and social aspects and having the appropriate skills to perform the behavior. Among others, the IMB model has also been successfully used recently in a digital application for self-management of diabetes patients [6].

The Information dimension includes behavior-relevant accurate information (e.g. benefits of treatment, condition when left untreated). The Motivation dimension includes attitudes and beliefs about positive and negative consequences of negotiating the care task both on the intra- and interpersonal level (e.g. involvement of important others, prioritizing self-care). Both Informational and Motivational Dimensions have an impact on Behavioral skills as well as the position on the continuum of care (see Figure 2). Behavior skills include system navigation skills (SNS), functional skills (FS) and activation skills (AS). SNS refer to skills needed to successfully secure access to available resources and coverage for treatments. FS refer to skills which are needed to attend in care (e.g. remember appointment dates). AS refer to skills which help to motivate, engage and activate the user (e.g. minimize negative and maximize experienced/perceived benefits of care).

Within vCare, the "Information, Motivation, Behavioral Skill model" provides a general framework for structuring intervention strategies, but it does not provide information about how these strategies should be realized. The framework of persuasive system design (PSD) [12] provides several principles of how to realize such strategies. The PSD is based on Fogg's behavior model [4] and was developed to positively change health behavior. It consists of four main categories each including 7 strategies (see Table 1). For each
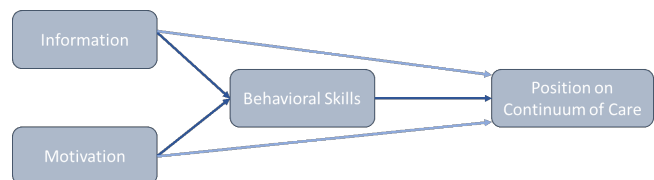

Figure 2: Structure of the Information, Motivation, Behavioural Skill model.
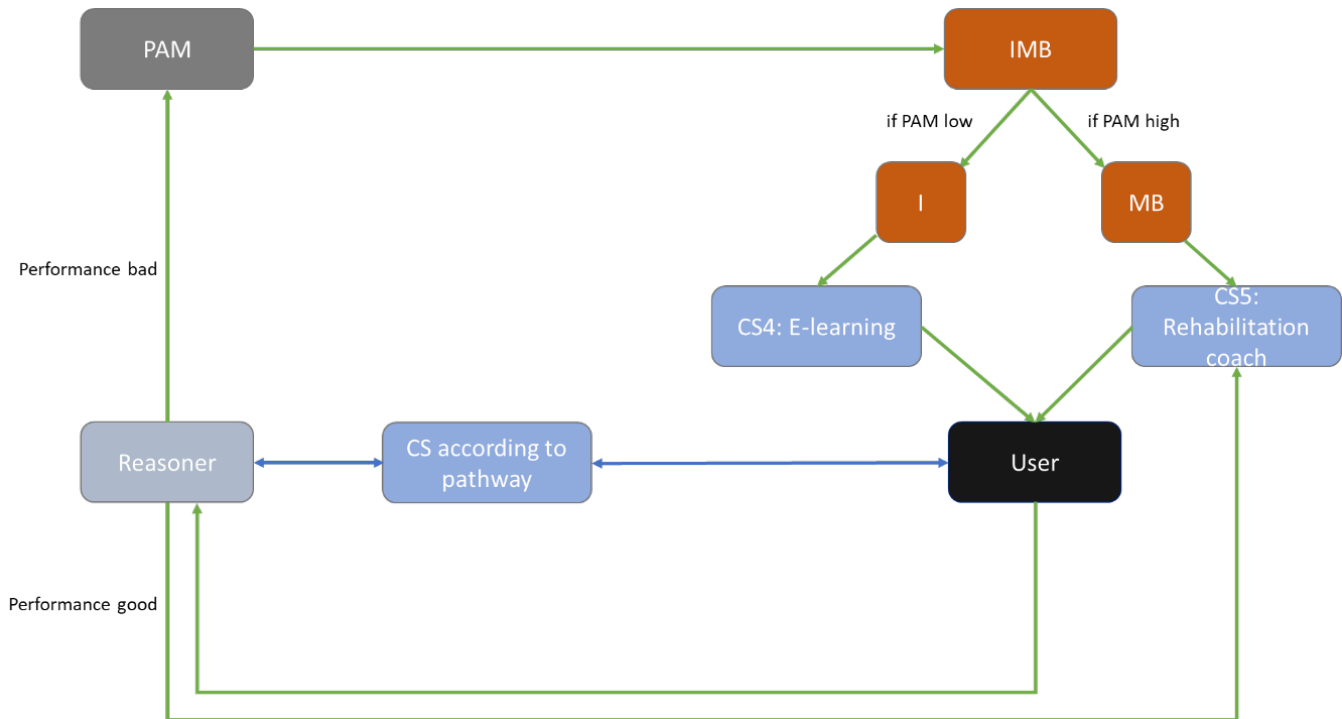
Figure 3: Integration of the IMB model into the coaching services concept. (CS stands for coaching service and is a component for a specific purpose, e.g. e-learning)

Table 1: Dimensions and strategies of the Persuasive Design Principles.

Primary Task Support	Dialogue Support	System Credibility Support	Social Support
Reduction	Praise	Trustworthiness	Social learning
Tunnelling	Rewards	Expertise	Social comparison
Tailoring	Reminders	Surface credibility	Normative influence
Personalization	Suggestion	Real-world feel	Social facilitation
Self-monitoring	Similarity	Authority	Cooperation
Simulation	Liking	Third-party endorsements	Competition
Rehearsal	Social role	Verifiability	Recognition

strategy, the authors provide a definition, an example requirement and an example implementation.

In a recent review study performed by Lentferink [10], 32 studies on eHealth interventions combing self-tracking and persuasive eCoaching have been analyzed in terms of identifying the key components with significant impact on the efficacy of the solutions. In detail, the PSD strategies reduction, personalization, praise and reminders had a significant positive effect on health outcomes. Yet, in another study the strategies self-monitoring, reminders and tunneling were perceived as especially beneficial for prevention of metabolic syndrome [8]. More recently, another review showed that the strategies tunneling, personalization, and self-monitoring were most often used in e-health intervention which were highly effective [3].

In the vCare project, we combine the two concepts IMB model and PSD which is a novel approach, since reviewed studies did not use the PSD based on a specific model. Therefore, other PSD strategies than the ones mentioned above could have a positive impact on health outcomes. In detail, the dimensions Motivation and Behavior are combined with the PSD while the Information dimension has no application for PSD. In the literature, the IMB model has been applied for various health issues (e.g. [19], [7]) giving examples for (non-digital) interventions related to the model. This example was taken as blueprint to integrate the care method consistently into the coaching services by distributing the coaching services among the dimensions of the IMB model. Specific interventions realized in vCare for the two IMB model dimensions and its related coaching services are given in Table 2. In order to determine from which dimension of the IMB the user benefits the most at a specific time, the Patient Activation Measure (PAM) is used. The PAM assesses patients' willingness to manage their health and health care, with a 13 item questionnaire about skills in reducing effects of disease

Table 2: Specific interventions realized in vCare.

IMB Dimension	Sub-category	PSD
Motivation	Interpersonal	Social learning
		Social comparison
		Normative influence
	Intrapersonal	Self-monitoring
Behaviour	System Navigation	Expertise
	Functional	Reminders
	Activation	Praise
		Suggestion

symptoms, making lifestyle changes, and maintaining them[5]. The complete integration of the motivational model is depicted in Figure 3. In a first step, the reasoner chooses a coaching service according to the pathway of the patient. After finishing, the performance is reported back to the reasoner. If the performance was good, the Rehabilitation coach is triggered and the user receives an appropriate PSD (e.g.praise). However, if performance was bad the PAM is used to determine if the user needs either more information on the topic or a motivation/behavior strategy. In the first case, the E-learning service is triggered providing the user information about the benefits of performing well in the specific coaching service. In the second case, the user receives an appropriate PSD (e.g. normative influence).

4 DISCUSSION & OUTLOOK

The vCare application just passed the Tech Labs phase for functional validation of the overall system and is currently in the Living Lab phase for testing the application in a real world settings at the facilities of the clinical partners of the project in Italy, Romania, Spain and Denmark. While at the beginning it will be used by professionals, at a later stage rehabilitation patients will be involved in a clinical setting. Within the Living Lab phase, the vCare Virtual Coaching system will be evaluated in terms of usability and likability of the patients. The ability of using the systems for patients who have passed a stroke or suffer from Parkinson's disease is under special consideration since some user interaction modalities like speech input or via touch display may cause difficulties for these individuals. Guidelines are applied which overcome those restrictions [11]. The Living Lab phase will be followed by field trials in the above mentioned countries for clinical validation of vCare in terms of efficacy.

5 ACKNOWLEDGMENTS

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