Designing an E-coaching System for Older People to Increase Adherence to Exergame-based Physical Activity

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Abstract: E-coaching technologies constitute an emerging trend because they differ from the ordinary methods that tend to patronize user's behavior. E-coaching focuses on co-organization and personalisation of the intervention by the user and the system. The current work describes some important features that must be studied in the design process of an e-coaching system that promotes the adherence of physical activity in older adults. The proposed system will be based upon already existing exergame platform for elderly, the webFitForAll. Firstly, the significance of physical activity in elder's everyday life and how the physical activity guidelines are implemented in webFitForAll are discussed. Furthermore, the behavior change techniques, that are an important part of e-coaching systems, are presented as well as the design plans for the e-coaching environment.

1 INTRODUCTION

For the last few years it has become notable a constant shift from instructing and patronizing a person during her daily exercise to coaching and helping towards making own choices. It is now well known that it is crucial to encourage patient involvement, motivation, and empowerment in adapting to lifelong changes. The key term of co-design with seniors their everyday exercise plan has been dropped in the scene. To this extent, coaching has been defined as an ongoing process of self-enhancement and effective goal striving with the observation, aid and collaborative conversation with an expert, referred as coach(Ives, 2008).

Another emerging necessity both in industry and academia is the digitalization of various functions in a wide variety of domains, including coaching practices. An automatic, digital coaching system could be ubiquitous, individualized, constantly adapting and gathering information while providing the necessary feedback. Human-to-human interaction is irreplaceable but the financial cost and the human resources needed may be dissuasive. The rapid advances in technology along with its broader penetration in our everyday life may increase the acceptance and necessity of non-human coaches that may also cover the inclusion of human coaches.

At this point, it needs to be highlighted that most articles use the term e-coaching for systems that are used to enable communication with human coaches (Boratto *et al.*, 2017)(Allen *et al.*, 2008). However, the terms should not refer to systems that facilitate or conceptualize the coaching but to systems that do the coaching (nonhuman coaches).

It is also important to accept an explicit definition of what an e-coaching system is and what are the key-points that must include, in order to effectively develop the e-coaching environment. As B. A. Kamphorst (Kamphorst, 2017) states, the e-coaching system must have a sufficient level of sophistication and independence and he defines it as "a set of computerized components that constitutes an artificial entity that can observe, reason about, learn from and predict a user's behaviours, in context and over time […]" (Kamphorst, 2017, p. 5). This definition underlines some key-points in e-coaching systems:

- must be *context-aware* (Ives, 2008)(Pecora *et al.*, 2012)
- must be personalized
- must collect information from the user (direct or other measurements)
- needs to have the ability to forecast and plan future steps

This paper presents a proposed e-coaching system for promoting physical activity for elderly population,

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expanding an already existing exergaming platform. Three major points are covered, including the importance of physical activity for older people, what are the behavior change techniques (BCTs) that have been developed for physical activity enhancement and the designing goals for the proposed system.

2 PHYSICAL ACTIVITY IN ELDERLY POPULATION

As the aging population is rapidly increasing in size and is estimated to keep increasing, the concept of active and healthy aging has become a significant socioeconomic phenomenon. According to the World Health Organization (WHO) physical activity plays a decisive role in maintaining or achieving a good quality of life (QoL) (World Health Organization, 2010). Regular physical activity has been associated with reduced risks of developing Alzheimer disease (Laurin *et al.*, 2001), osteoporosis (Nguyen, Center and Eisman, 2000) and cardiovascular disease (Geffken *et al.*, 2001). Furthermore, a great cohort of studies has exhibited the positive impact physical exercise has on psychology, functional capacity, autonomy and general QoL(Taguchi *et al.*, 2010)(Vagetti *et al.*, 2014)(Konstantinidis *et al.*, 2016)(Chodzko-Zajko *et al.*, 2009).

Although the positive effects of physical activity in health are well established, activity levels are decreasing with age. Elderly face cessation of physical activity as an inevitable consequence of aging. They believe exercise to be a time consuming task that often perceived as having negative effects on their body (sweating, muscle soreness, etc.)(Schutzer and Graves, 2004) while 50% of exercise intervention participants tend to drop out before realizing any health benefits (Bennett and Winters-Stone, 2011). Another deterrent factor is the abstract guidelines given by the healthcare specialists. All the above indicate the need for an e-coaching system.

Furthermore, environmental factors may restrain elderly's devotion to physical activity more than younger people. For example, most elderly will avoid walking outside when it is raining or snowing. Social or economic barriers are also reported (Brawley, Rejeski and King, 2003). Apparently, e-coaching system could and should facilitate the personalization and adaptability on each individual's needs.

2.1 Physical Activity Guidelines

In accordance with the key-points mentioned above for e-coaching systems, the context and the target group have to be carefully studied in order to elucidate specific needs and barriers. For this reason, we present the recommended levels of physical activity for elderly as reported by the academic community. The Center for Disease Control and Prevention (CDC) propose that every adult should be as active as their abilities allow, avoiding inactivity (CDC, 2015). The minimum suggested activity by CDC for achieving health benefits is 150 minutes of moderate-intensity aerobic activity or 75 minutes of vigorous-intensity aerobic activity and muscle strengthening activities for all muscle groups on at least two days of the week. The American College of Sports Medicine (ACSM) also suggests at least two days per week strength exercises to improve flexibility and balance(Chodzko-Zajko *et al.*, 2009).

Aerobic activities may include bicycle, dancing, walking or jogging, swimming, tennis etc. (U.S. Department of Health and Human Services, 2008). Muscle strengthening activities are carrying groceries, pilates, washing windows or the floor, some activities of gardening, etc.

2.2 The webFitForAll Exergaming Platform

There are also exergame platforms that encapsulate the necessary amount of exercise in an attractive way for the elderly (Konstantinidis *et al.*, 2016)(Brox and Hernandez, 2011). Since the physical activity solutions for an older adult are of great amount, the need and potentiality of developing a personalized plan is even greater.

In our approach the basic exercise plan will be based on the webFitForAll (wFFA) game platform (Konstantinidis, Bamparopoulos and Bamidis, 2017). The wFFA is a web based serious game platform specially designed for elderly. It consists of physical exercises and games that promote physical activity and contribute in advance and maintenance of wellbeing and QoL. A wFFA session constitutes of aerobic, strength, balance and flexibility exercises designed in a playful, simple and understandable way, lasting for 60 minutes. A participant can complete the proposed physical activity per week if engaged for a minimum of 3 times per week with wFFA.

Its predecessor, FitForAll (FFA) has been widely tested and exhibited significant results in improvement of QoL and physical condition(Konstantinidis *et al.*, 2016). The wFFA has shown high acceptability rates between elderly and increased the ease of use of FFA (Konstantinidis, Bamparopoulos and Bamidis, 2017) while as well

displayed effective differences in participants' fitness (Zilidou *et al.*, 2016).

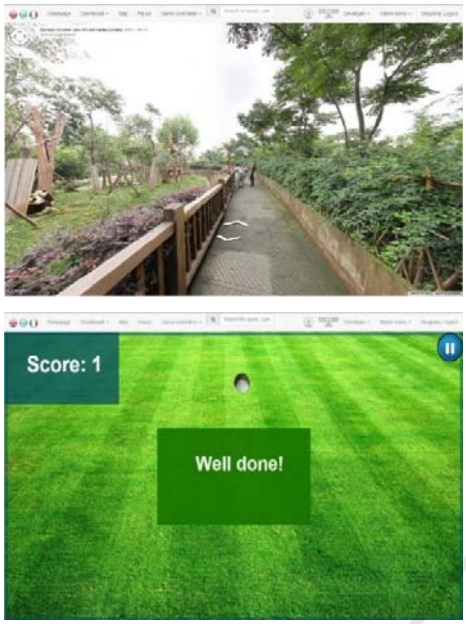

Figure 1 Example of two wFFA games. In the hiking game (above), the user walks in a Google Street View environment according to his/her body posture and steps. In the golf game the user moves a ball according to his/her body movement, trying to put it in the hole.

3 BEHAVIOR CHANGE TECHNIQUES IMPLEMENTATION IN THE E-COACHING SYSTEM

As mentioned above, e-coaching systems support an ongoing process and effort to achieve a goal, improve or change a situation. Consequently, it is critical for the design of these systems to focus on the inclusion of BCTs that can be associated with effectiveness. The use of persuasive strategies have demonstrate positive influence on the outcome of the interventions in physical activity.(Orji and Moffatt, 2016) Although the importance of inclusion of BCTs is undeniable, the majority of e-coaching systems lack examination and adjustment of that techniques (Orji and Moffatt, 2016)(Mollee *et al.*, 2017).

3.1 Proposed Taxonomy of Behavior Change Techniques

Michie et al. have defined a taxonomy including 40 BCTs that should be implemented when developing an intervention for physical activity behaviors, the CALO-RE (Michie *et al.*, 2011). However, it should be carefully considered how these BCTs are altered in accordance with the corresponding target group. Elderly are more susceptible in quitting and it is often more complex for them to make long-lasting changes in their lifestyle and behavior.

The BCTs of the proposed e-coaching system will be designed in 3 phases: the *starting*, the *design and adaptation* and the *intervention* phase. The design and intervention phases are not strictly segregated as the design phase could re-implemented through the intervention.

In the *starting* phase, the readiness for change and motivation should be assessed and enhanced. Firstly, it is critical to recognize which adults are at risk of developing adherence issues by determining the willingness to change and improve self-regulatory skills (Culos-Reed *et al.*, 2000). The main challenge is to adequately answer the question "Why changing my physical activity routine if I currently function satisfactorily?". For this reason, the system has to provide information about the consequences that the upcoming intervention will have in the individual and in general, based on existing studies. Information about the general approval of the system, the behaviour of other groups and the reliability must also be reported.

Consequently, the behavior goal and overall outcome goal would be clarified in the *design* phase. In this section the main effort should be to personalize the intervention. The system and the participant must co-organize the actions that have to be taken. Asking the right questions to the elderly is crucial in order to engage him in the process. The general plan is constructed, giving special attention to the environmental, socioeconomic and individual barriers each participant may face. These information is stored for possible readjustment of the behavior plan. The participant is encouraged to participate actively in the problem solving procedure. Depending on these information, the tasks must be realistic and avoid overestimating each person's abilities. The coachee, in our case the elderly, will make a behavioral "contract" that they accept the designed plan and will commit to it. This may be in form of formal consent with the system or a selected familiar person (Michie *et al.*, 2009).

The most significant phase is the *intervention* phase, when the behavior change happens. It consists of the tasks that were agreed in the previous phase. To retain adherence, the system must reward the participant for achieving goals or for making progress. That can be in terms of collecting points that are shared among a groups' members that go through similar intervention, using the same e-coaching system. In elderly population a common practice for maintaining dedication to a goal, is to inform their

family, friends, spouse or a special selected person for their progress. The e-coaching system facilitates and plan this social support based on the participant's desire and encourage social comparison. However, the reward must be proportionate to the progress and each time an anticipation must be created for future rewards. Feedback is provided in each separate task, on general performance as well as demonstration and suggestion to achieve better results. Especially in elderly the instruction must be simple, supported with audiovisual content and do not assume that the directions are clearly remembered every time.

Throughout the whole process, the system must take into consideration to prevent new physical activities to be abandoned. Stress and time management is also crucial for the participant's health and must be taken into account (Abraham and Michie, 2008).

3.2 BCTs Implementation

The wFFA exrgames are a well-established solution that has been widely tested and the results are scientifically documented and supported. In the *starting* phase the system should exhibit the benefits that people in the pilots of wFFA had related to physical condition and overall QoL. More precisely, the system compares the user's profile and presents charts and images of the progress of people with similar profiles in the database. The presentation of real statements will empower the reliability of the system. Also, statistics for the value of physical exercise in the elderly population must be presented in a comprehensive way e.g. charts and images.

Our exergame platform incorporates a default protocol of four difficulty levels but it also provides the option to manually modify the intervention. The *design* phase aims at individualizing the sessions of wFFA based on the overall goal and participant's preferences. However, the e-coaching system can also motivate the user to do other physical activities besides wFFA, if her/his character and environment allow. For example, the user can agree to take a walk outside instead of the hiking game of wFFA (Figure 1) once a week. The agreed plan will be forwarded in a familiar person, given the participant's consent.

Before each game in the wFFA platform there are audiovisual instructions accompanied by a simple text (Figure 2). In the current form, the user collects points e.g. number of balls in the hole (Figure 1). In addition a scoring functionality has been designed and is under development. The score for every game will be calculated depending on the in-game metrics that the system collects during the intervention and will reflect the actual improvement in physical and cognitive cognition. To do so, wFFA correlates in-game metrics (users' gaming performance measurements) with neurophysiological assessment test of previous users and compares them with the current users. wFFA is a web-based application which can easily support social interaction between users. The achievement of a goal or the augment of a score will be shared among desired users to promote competition. Concluding, the system can provide additional instructions, when an exercise is being executed, correcting possible mistakes.

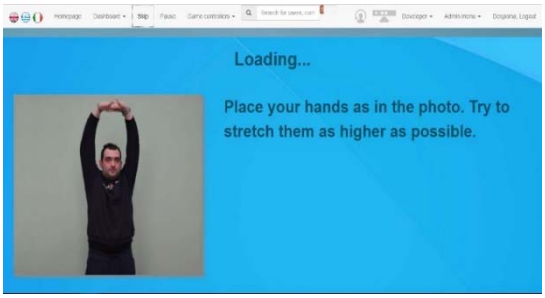

Figure 2 Visual and text instructions before an exercise.

4 DESINING THE E-COACHING ENVIRONMENT

There are two aspects that should be considered when designing the framework of an e-coaching environment: *what* are the suggestions that the system would do and *how* these should be addressed to the user. The former is based on option generation techniques and effective counseling dialogue system development, while the latter is about defining the most appropriate interface and information gathering technique, taking into consideration the target group.

The options that the system proposes to the user can have two possible implications. Firstly, they can affect the decision making process and influence the final decision (Fogg, 2003). As mentioned previously, coaching is an ongoing process that encapsulates BCTs so, in fact it intervenes with people's decision. Consequently, the suggestions must be carefully studied. Secondly, if the system repeatedly make suggestions and indications that a person rejects, because they are not contingent on his character, may harm the system's reliability. The proposals must in general agree with what a person consider as an option (Kamphorst and Kalis, 2014). If a suggestion is rejected or not followed by the coachee, the system must produce a dialogue explaining its importance and making questions to identify the reasons of its rejection. The new

information provided by the user will help the system learn more about his character. In case of an option is accepted and successfully carried out, the system encourages and praises the participant. Obviously, an holistic dialogue ontology must be created to support counseling and enhancement of physical activity, taking into consideration the specific needs of older adults.

Vision impairment and reduction of precision in motor skills are frequently encountered as normal consequences of aging. These difficulties can prevent elderly from using conventional computer interfaces like mouse, keyboard, small buttons or gestures requiring slick movements. The user interface must be clean, friendly and not include redundant material. From our point of view, three points that a user interface for elderly must have are: usability, acceptability and reliability. That means that the elderly can easily interact with the technology, accept it in their everyday life and last but not least be sure that the system effectively interacts with them.

A proposed technology, which has not yet been used in e-coaching, is augmented reality through projections. This means that the system could project contextualized information, wherever needed, without the use of devices like mobile phones or tablets. The user could interact with the system by touching or moving actual objects, without the need of a specific skills and preexisting knowledge. This way the e-coaching environment will blend in the real life environment, making it easier for older people to accept it. Furthermore, the absence of buttons or touch screens will reduce the stress of touching or pushing the "wrong" button as the interaction will be done by real life movements (Steele *et al.*, 2009).

The wFFA games are controlled by the user's movement using information from a 3D sensor camera that detects human body joints. Projection technology can be exploited in order to replace computer screen. It can also be used for direct instruction when using technical equipment like blood pressure meter. Audiovisual direction on how to place the device and take the measurement would be projected near the device.

It is also of vital importance for the system to gather behavioral, physiological as well as emotional information about the user. This can be done unobtrusively with the use of 3D sensing systems. The potential uses are of great amount, including facial image technologies to capture emotional state, gait analysis, communication with traditional devices like blood pressure meter and pulse oximeter and physical and cognitive state indicators through serious games in-game metrics.

5 DISCUSSION

The current work presents the main issues that have to be studied during the design process of an e-coaching system aiming to promote physical activity in older adults. This system will be based upon wFFA exergame platform which is an effective way to improve physical condition, specially designed for older people and already widely tested. This work tries to indicate the basic components of an e-coaching system and address the necessities in its outline.

Although the e-coaching systems are, fairly, an emerging trend, questions have been raised on the exclusion of the human specialists. The current system aims at the inclusion of human therapists/doctors or a familiar person chosen by the user who can have access to the stored data and involve or interfere in the coaching process (Geissler, H. Hasenbein, M., Kontouri, S., Wegener, 2014).

In conclusion, the construction of an e-coaching system must not be confronted with naivety. It is a complicated process that demands careful planning and cooperation of many scientific domains like psychology, computer science, and medical science.

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