PhySeEar

Moving Yourself to Shine and Sound in Geriatric Physiotherapy Interventions

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***Abstract*—For useful feedback in physiotherapy interventions for geriatric rehabilitation, we have designed and tested two prototypes, based on commercially available radio frequency tags. The prototypes were designed to be suitable for a population with limited proprioceptive skills, high dependency rate, and limited cognitive skills. Focus for design was on designing feedback that would allow the inpatients to self-monitor their rehabilitation process, and would make for increasing their proprioceptive skills. The system is also intended to mean a source of motivation for rehabilitation practice. We have performed a first explorative study in a real setting. In this paper we will be commenting on initial observations of the use of one of the prototypes.**

Keywords-physiotherapy; movement-based interaction; design; geriatric; elderly; health; rehabilitation; HCI; prototypes.

I. INTRODUCTION

Population aging is becoming an issue in Europe, with an estimated 70% increase of the number of people aged over 65 in 2050, and 170% for people aged over 80 [1]. There are many socio-economic and health related consequences of this [3], like the increase of personal dependency ratio [2], which is expected to double to 54% by 2050.

There is a need to optimize resources in assisted living facilities that host elderly with disabilities, reducing the costs but increasing effectiveness in geriatric rehabilitation. In these facilities it is normal to deal with geriatric interventions planned by a group of therapists, which is usually comprised of an occupational therapist, a psychologist, and a physiotherapist. We believe this depend very much on new ad hoc practices, methods, and tools appropriated to the peculiarities of each assisted living facility and that should ideally be designed by interaction designers/engineers together with therapists in the facility.

In the following, we are presenting a case study in progress, performed in the "Nuestra Señora de la Soledad" assisted living facility in Tocina (Sevilla), Spain. A group composed of an interaction designer/engineer, the physiotherapist of the center, and a psychologist, devised and tested two systems that would to make rehabilitation more fun and efficient. These systems were designed to be wearable and provide clear feedback on the user's movements without distracting them from their movements.

In this paper we are describing some observations of the first contact of the inpatients with one first low-tech prototype of one of such systems. At this stage, the prototype is not yet autonomous, but remotely controlled by the physiotherapist.

II. BACKGROUND

In the last years, there have been many attempts to make rehabilitation more engaging and fun, so that it has an impact on the motivation of the patients to practice more, which in turn should improve their rehabilitation [4][5][6][7]. Motivation is very important for the rather repetitive nature of physical rehabilitation therapy, with series of prescribed movements that have to be repeated, which sometimes is boring for patients [7].

Progression and physical improvement seems to be affected not only by the quantity of movements (repetition), but also by the quality of them, as indicated in [7]. MacLean and Pound highlight the patient's level of motivation as key for the success of the rehabilitation's interventions [8], which can be assessed by the level of participation of the patient [9]. On enhancing motivation, many systems have been conceived for physiotherapy rehabilitation focusing on the use of video game platforms, the use of commercial video games [6] [4], or a certain technology, like Virtual Reality (VR) [5].

PervasiveHealth 2012, May 21-24, San Diego, United States
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DOI 10.4108/icst.pervasivehealth.2012.248629

Focus seems to have been paid to two things: i) the creation of an immersive experience, and ii) accurately sensing the inpatients movements.

For the latter (ii)), some of the above mentioned systems have used commercial available technology or game platform (like the wii) for their purpose. The reason may lie in that these system count with developed sensing mechanisms. However, with them come other disadvantages, like the lack of adaptation of the form and function of their controllers to the physical limitations and capabilities of the elderly people in our assisted living facility, e.g. some of them suffer from the Parkinson's disease which makes button pressing or holding the control rather difficult.

As highlighted in [10], for bodily interaction, there can be alternative approaches to further develop sensing mechanisms. Like in [10] we move away from the approach of "the more you sense, the better". We do not think there is necessarily a direct relationship between more sensing and a more effective rehabilitation. There are other elements that should be considered, like the role of the people involved, i.e. the physiotherapist and the inpatient, or the role of the technology.

In our project we intend to focus on different prototype designs that could enhance and improve the physiotherapy interventions. For these prototypes, immersive experience (i)) is important in the way the inpatient is deeply involved in the practice. However, we move away from the kind of immersive experiences some of the above mentioned systems have exploited, many of them screen-based, in which movements are the mean to achieve a goal in the game. For us, the movement should be instead an end itself. Also, we would not like to have immersive experiences tied to a virtual reality that could divert the attention of the inpatient from the performance of their movements to the result that movements have has in that virtual world. In our case, we moved away from screen-based interaction to focus the attention to the item of movement itself, be it the upper of lower limbs. We explored the interaction with two wearable design prototypes.

III. Inpatient Care in Assisted Living Facilities

This project is born to the light of limitations of conventional physiotherapeutic practices in a particular assisted living facility. Most of the inpatients in this facility are illiterate people and are not able to keep track of their personal achievements in terms of physical therapy.

There are two main motivations these inpatients have in attending to the therapy: first, they trust their physiotherapist's judgment in that there is a relationship between their exercises, and their physical improvement. Although some of them corroborate this with their personal daily experience over time, there is no immediate feedback whilst exercising that allows them to keep track of daily improvements. Second, from our observation seems quite clear that their main motivation for doing the interventions might be an emotional bond with the physiotherapist, whom they do not want to disappoint.

With our designs, we would like to present the inpatients a system that provides them with immediate feedback that is easily understood by them, and easy to retain. This, we believe, will lead to their having more control over their rehabilitation, i.e. they would be able remember their performance and set goals for next interventions. All this, together with the appeal that introducing an interactive device in their rehabilitation session brings in, will provide them with another source of motivation.

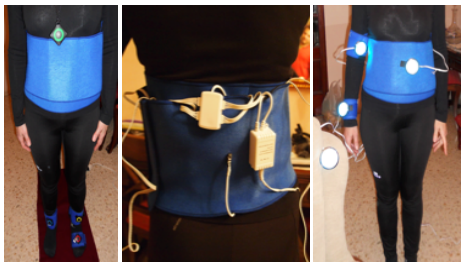

Figure 1. Sound system, Radio receiver for light sytem, and light system.

Overall, the goals we would like to fulfill with our designs are: 1) increasing the inpatients proprioceptive skills when doing the physiotherapy sessions, 2) increasing their awareness of their physical improvement, 3) improving their monitoring over rehabilitation process, and finally 4) providing them with a source of motivation for doing physiotherapy interventions.

IV. Designing The System

In this phase of our project we are exploring different designs that could serve our goals. Before going one step further in the design process, we needed to see some possible design options in use in the real setting. At this stage of the design process, we were more interested in what kind of interactions, reactions, and movements these systems would trigger, more than how much they would sense. We decided to build low-tech mock-ups with the basic intended functionality, and try them in the real setting using *Wizard of Oz* techniques to control feedback. The systems we tested did not actually measure anything, but were remotely controlled by the physiotherapist, who triggered the output of the systems during two rehabilitation exercises: one practicing mobilization of lower limbs (walking), and another one practicing mobilization of upper limbs. Focus was paid in the embodied social practice of the rehabilitation process.

Light for your ams

This system is designed in the form of a commercial equipment of LED lights that can be lighted in different colors and with different intensities with a remote control equipped with infrared (See *Figure 1*). Three lights are to be attached to wristbands and armbands, adjustable in size with Velcro; a fourth light is to be positioned in front of the inpatient. All the lights are lit at once with the same color and intensity. They were designed to assess whether or not different limb exercises were performed correctly. Three colors were used: red indicating the wrong movement, orange indicating right movement, but not performed correctly, and green indicating the right movement that had been performed correctly.

Sound for your steps

This system is designed in the form of a set of small commercial available radio tags, each producing a different sound beep when activated via radio with a remote control (See *Figure 1 left*). Like with the lights, the sound tags were to be attached to bands with Velcro. There were four different tags, one attached to a foot band, two attached to two ankle bands, one to a leg band, and the last hang in string, to be put as a collar. The tags on the ankles were to measure the symmetry of the steps and the length of them. The tag on the foot measures the elevation of the step. The tag on the collar measures the deviation of trajectory while walking.

V. The Study

The assisted living facility. Participants

"Nuestra Señora de la Soledad" facility is comprised of 40 inpatients, most of them aged 72-96 years old. Twenty-six of them are participating in our project. Of those 26, there are 11 men, 15 women, 6 use a wheelchair, 5 use walking frames, 5 use canes. Five of them suffer from the Parkinson disease, 3 from Alzheimer, and 2 have suffered a stroke. In terms of independency, 2 of them are completely independent, 5 are scarcely dependent, 6 are moderately dependent, 10 are severely dependent, and 2 are totally dependent (according to Barthel independency test [11]). Fourteen of them have normal (or slight) cognitive impairment, whilst 6 of them suffer severe or very severe cognitive impairment according to Pfeiffer test [12]. From those who have not very severe cognitive impairment, 12 of them are possibly or very likely to be depressed or very depressed, according to the Yesavage test [13]. None of them have ever played video games, and all of them are very new to computers (when we started the testing, some of them had just started basic computer lessons). They regularly attend to group physiotherapy interventions, as well as personal interventions to exercise their upper and lower limbs.

Methodology

Twenty five inpatients were divided in three groups: Eight of them formed the Control Group (CG), and were not using any device; Nine went to the Light Group (LG), using the visual device (See Figure 2); and Eight formed the Sound Group (SG), using the audio device. The groups were made accordingly to their score in the Pfeiffer test, so that the groups were leveled, and also regarding physical limitations, like not considering inpatients using wheelchairs to form the SG, for this group would work with lower limb exercises.

The study of this project will continue over time for approximately 5 months, focusing on physical, psychological, and emotional differences between the groups. However, in this paper we are focusing on the very first use of these devices, specifically in the use of the light device.

There were two different kinds of exercises, decided by the physiotherapist: upper limb exercises, done in the LG and in the CG; and lower limb exercises, done in the SG, and the CG. The sessions lasted about 10-15minutes. In the upper limb sessions, there were two sets of 5 exercises of flexion, extension, abduction and horizontal abduction of shoulders, and flexo-extension of elbows; each session consisting of 15-20 repetitions. The physiotherapist walked around the room with the control remote, triggering the different colors depending on the inpatient's performance.

Figure 2. Working with upper limb movements, and fixing the system

In the lower limb sessions, inpatients walked back and forth the room, assisted if needed by physiotherapy parallel bars. These sessions were divided in five parts; each of them was dedicated to one walking parameter. There were two cameras, recording the scene from two different angles.

Currently, we are in the process of analyzing the videos from this first interaction. So far, we have gone though half of the material, corresponding to half of the CG and the whole LG.

VI. First Observations

In the following, we are commenting on some recurrent observations from the video analysis done so far:

Good cop (the physiotherapist), bad cop (the device)

The role of the physiotherapist seemed to have changed in the eyes of the inpatients. In the CG, we have observed some of them complaining to the physiotherapist about the number of exercises, or repetitions, or when receiving corrections from the therapist on their movements.

In the LG, it seems like the physiotherapist is seen as if he was more on "their side". The device was in charge of providing the feedback on the accuracy of the movements, whilst the therapist limited himself to comment on possible reasons why the device was in orange or red, and explained or demonstrated how to make the movements to turn the lights green: "*This one (pointing to the light in the front), this one is a tattletale!*"- said one of the inpatients laughing. "*It knows too much*"- replied the physiotherapist laughing too.

The physiotherapist used the device to help in giving negative feedback and reinforcing the corrections he had just said: "*Be careful (the lights turn orange). See? I was about to tell you […]* "

Focus

Except for cases of severe cognitive impairment, the lights attracted the inpatient's attention during their exercises. They either stared at the light in front of them, or peaked at it when they perceived a change in color. The location of the lights

seemed adequate for these exercises, and although the most looked light is the one positioned in front of them, some inpatients looked at their limbs when doing the exercises, and were able to perceive changes in color.

It seems there was less chatter unrelated to the exercises in the LG. However, some inpatients tended to stop the exercise when the light turned orange or red, waiting for the therapist's explanation or correction. This may have been because they wanted to get the movements right, but this may however also disrupt the dynamics of the exercise.

Self-monitoring and awareness

Many of the inpatients in the LG referred at the end of the sessions the colors they had received, some of them highlighting the red ones: "*It got red the two first times*" – said one inpatient. The physiotherapist played down the importance of negative results, highlighting the exercises with better performance (green lights), and usually establishing goals (in terms of color) for the next session.

We have perceived so far slower and what seems to be more cautious movements in patients in the LG. Also, when inpatients were repeatedly told to correct one same mistake, the lights served as a reminder, with no need for the physiotherapist to remind them again, i.e. when such inpatients perceived orange light, they would immediately try to correct what they had previously told was wrong.

Motivation

The use of a new artifact that provides visual feedback seems to be a source of motivation. Many reacted positively to the system the very moment of switching it on: "*Good heavens!*" – said one of the inpatients. Also, at the end of the exercises, some stayed practicing more on their own, which was not seen in the CG. One inpatient, who had received some red colors and kept doing the exercise at the end of the session replied, when asked why was continuing with the exercise: "*This one (laughing and pointing to the light in the front), this one does not punish me, I punish him!*"

Some of the inpatients seem eager to start doing the exercise, even when the physiotherapist is still explaining the movements, which made the latter one have to call for attention some time. Last, but not least, many of those in the LG offered themselves to be called to repeat the exercise when needed.

VII. WRAPPING UP

For feedback on physiotherapy interventions for geriatric rehabilitation, we have designed and tested two prototypes, based on commercially available radio frequency tags. They were designed to be suitable for a population with low proprioceptive skills. Focus for design was on the movement itself as an end, rather than on the movement as a vehicle. Although the prototypes are designed to suit the inpatients in a specific assisted living facility, it can be extrapolated to the elderly population of the same age range nowadays.

The designs intend to increase the inpatients proprioceptive skills and their awareness in their physical improvement. Also, allow them to self-monitor their rehabilitation process, and present a source of motivation. Initial analysis is showing interesting findings in line with our design goals, like feedback easily understood and memorized by the inpatients, or an increased motivation of many of those using the system.

Our next steps will be to finish analyzing the data to complete our observations. Also, another evaluation is planned in about two months to see whether the novelty effect of the devices have influenced our observations and whether there is a psychological or physical improvement in the inpatients.

ACKNOWLEDGMENTS

Thanks to "Nuestra Señora de la Soledad" (owned by Tocina's town council, and Fonserrana S.C.A de interés social). Special thanks to the elderly participating in this project, to the staff, especially Inés Gallego and Francisca Peña, to Annika Waern for her valuable feedback, to Dolo Segura for modeling, to Sophie Dowler for her translations, to Luis Maqueda for his feedback, and to Michaela Munitzk for designing the poster.

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