Towards Social Robots that Support Exercise Therapies for Persons with Dementia

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Abstract

Exercise therapy for dementia care helps patients improve balance, muscle strength, endurance, flexibility, and posture. Usually, a therapist develops a physical training program to help patients retain their locomotor abilities, but in many cases, the challenge is to motivate and engage participants. To assist the therapist to engage participants we introduced the anthropomorphic social robot Kiro. Aiming to support the therapist along with a predefined routine, Kiro follows the instructions of the therapist to perform several exercises moving its arms and legs while motivating patients with personalized and motivational phrases. In this work, we report a preliminary user study consisting of two sessions with seven persons with dementia in which the robot successfully engaged with the patients and kept them motivated. Finally, we discuss the intervention design, adoption, and user interaction.

Author Keywords

Socially assistive robots, persons with dementia, exercise therapy

Introduction

Regular physical exercise programs have proved to be effective to maintain and improve the overall health of elderly individuals [1]. Particularly, physical activity is an effective non-pharmacological intervention for behavioral problems for persons with dementia (PwDs) [5]. An exercise program may yield benefits in the management of falls, malnutrition, behavioral disturbances, and depression - critical problems for PwDs [7]. A PwD does not need to remember having engaged in an exercise program to reap its benefits. However, it has been found that lack of motivating among older adults is one of the main challenges preventing their participation in physical therapy sessions [4].

Nowadays, a subset of healthcare services for the elderly such as exercise therapy, social interaction, and companionship can be supported by a socially assistive robot (SAR). Using speech, facial expressions, and communicative gestures, a SAR assists in accordance with a particular healthcare context [8]. Previous studies have used SARs to address physical therapy. For instance, Bandit 2.0 is a robot coach that engages with elderly users in a physical exercise aimed at achieving health benefits and improve quality of life [4]. ROCARE - A Robotic Coach Architecture for Elder Care [3] - deployed in a Nao robot, established a one-to-one interaction to conduct an exercise therapy. Results of a feasibility studies using ROCARE give evidence of its potential usefulness and acceptance by older adults. On the other hand, Lofti et al. developed a SAR to engage, coach, assess, and motivate older adults in physical exercises [6]. Using an observational evaluation, they reported that participants are generally happy with the robot as a mean of encouraging them to do an exercise correctly.

The studies presented above show the feasibility of using a SAR to support exercise therapies for the elderly. However, these initiatives were focused on healthy older adults. Due to the differences between persons with and without dementia, the strategies to engage PwDs in an exercise therapy must be different. In this work, we conducted a feasibility study about the use of a SAR to support an exercise therapy for PwDs. Our study focuses on the intervention design, adoption, and interaction.

Contextual Study

We conducted a contextual study to design the intervention to envision how a SAR could support an exercise therapy for PwDs. Our approach was based on qualitative methods, including interviews and observation. Thus, we conducted semi-structured interviews with 7 participants - 4 caregivers, 1 therapist, 1 specialist in behavior and cognition, and 1 geriatrician. Besides, we conducted two non-participative, non-structured and direct observation studies with 6 PwDs (men=2, women=4) during an exercise therapy conducted by the therapist. We coded all interview transcripts and detailed notes from observations. We used an emergent open coding through interpretation sessions to identify recurring themes and application opportunities. A set of relevant findings emerged from the analysis such as most frequently problematic behaviors from PwDs, interventions to deal with these behaviors, effects of non-pharmacological interventions, and physical and social characteristics of PwDs. The following two concepts derived from the above findings are directly related to our proposal for the use of SAR in exercise therapy.

Social interaction. Most PwDs are in need of social stimulation. Thus, a good strategy to make a bond with them is verbal communication and the use ofaffective cues. *"Social interaction is one of the most important issues for a PwD, and it has many benefits because the affective system is altered, this has cognitive benefits. I recommend caregivers to engage PwD in social interaction."* [Specialist in B&C]

Engagement. Engaging PwDs in specific activities is challenging for caregivers and therapists. Due to the disease,

Figure 1: Kiro robot

PwDs require constant feedback and motivation to maintain them focused on an activity.
"Some residents do not perform the activities. However they stay to observe and enjoy the interaction. Their facial expression says a lot about the effects of the therapy. However, sometimes it is hard to keep them motivated and engaged, they get easily distracted." [Therapist]

We envisioned an application scenario following the findings obtained from the study.

Scenario. *Olga is a therapist who has worked with older adults for the last 10 years. As she does everyday morning, she conducts a physical therapy at the geriatric residence. She brings with her "Bob", her robot assistant, and explains to the 6 elders participating in the session that they should also follow Bob's movements. In the middle of the session, Olga instructs the robot to continue with the next phase of the therapy, and Bob responds by reproducing the movements and playing the appropriate music along with motivational phrases. While the residents follow Bob's movements, Olga assists one of the residents who has limited mobility and has difficulties following the therapy. She helps him perform relaxation movements while massaging his arms and shoulders.*

Feasibility Study

We designed a user study to asses the feasibility of the application scenario. This study aimed to explore the role of SAR during an exercise therapy regarding adoption and interaction. As a feasibility study, we used a Wizard-of-Oz approach to maintain control over robot features to enact particular behaviors to promote an initial bond with participants. In this study, the therapist has control of the session using the SAR as support to engage participants. Furthermore, we used strategies to facilitate the acceptance of a social robot by PwD [2]. Mainly, we applied the strategy related to the use of intermediaries to get comfortable with the robot in our case a caregiver (the therapist) assumed this role. Another strategy is the use of standard guidelines to promote and improve verbal communication with PwDs. The study was conducted in the facilities of a geriatric residence in Ensenada, Mexico.

As an initial step of our study, we conducted a pilot session to asses the initial settings for the intervention. Seven PwDs participated in this pilot. Drawing from findings of the pilot, we modified elements related to the setup, Kiro's features, procedure, and sequence of exercises.

Setup
Every day a caregiver (who assumed the role of therapist) of the geriatric residence conducted a group exercise therapy. Thus, the setup of the study was designed based on the original configuration of the therapy. The robot was placed next-to of the caregiver and in-front of participants. Finally, the operator was placed outside of participants eyesight.

Robot
To address the role of the SAR, we used Kiro, a robot provided by Mirai Innovation. Kiro is a small humanoid robot (20 cm tall) with 18 DOF that allow the robot to move its arms and legs (see Figure 1). An operator application was developed to send preprogrammed movement commands to the robot. The interface also has Text-to-Speech (TTS) capability that allows the robot to speak out predefined speech phrases or phrases that are instantaneously typed by the operator.

Before the therapy, the names of participants were registered in the operator application. Thus, during the session - where the operator manipulated the robot, Kiro enacted personalized speeches for each participant. A personalized utterance is a strategy to make a social bond between PwDs and the robot. Besides, a set of motivational utterances such as "Let's do it!" and "[Name], you are doing it excellently!" were used to motivate and engage participants to keep doing exercise.

Figure 2: Non-verbal interaction. Participants imitate Kiro when it performs hug and reverence gestures.

We deployed sequences of movements in Kiro to replicate the exercises used in traditional exercise therapy. In addition, body gestures of thanks, greetings, farewell, and affection (reverence, hugs) were programmed. Thus, supplementary to the speech features, Kiro's movements were used as visual stimulation to motivate and engage PwDs to participate in the therapy.

Exercises
The exercise therapy conducted in the geriatric residence is composed of 25 simple exercises - including neck, shoulders, arm, hip,and leg exercises. Often 5-7 PwDs participated in a group session and all of them are seated during the therapy. Kiro, it can only perform those which include movements of the arms and legs (leaving aside those related to neck, shoulders, and hip). The exercise program was adapted to the limitations and physical characteristics of each participant.

Figure 3: Participants follow instructions from Kiro to perform an arm exercise.

Procedure
Before starting the therapy session, the caregiver introduces the robot to the participants. The caregiver instructs Kiro to greet the participants. Then, the caregiver makes a short demonstration about the first movement and performs the exercise. During the exercise, Kiro executes the exercise and motivates the participant using motivational and personalized phrases. This process is repeated for each exercise of the therapy. For those exercises that Kiro cannot perform, it only uses speech features. At the end of the therapy, Kiro performs a farewell using speech and body gestures (hug and reverence).

Results
We conducted a feasibility study using the robot Kiro to support the exercise therapy. The study was conducted in the facilities of a geriatric residence. A total of 7 (female=6, male=1) persons, all of them diagnosed with dementia and aged between 72 and 87 years (M= 77.22, SD=6.53), participated in the study. The study was composed of 2 sessions which lasted an average of 23.70 minutes. A group of 4 PwDs (P1-4) participated in session 1, while 3 PwDs (P5-7) participated in the second session. All sessions were video recorded for later analysis.

The following describes the results obtained from the feasibility study. We analyzed the video recordings from two sessions. This observation based analysis focused on the interaction between PwDs and the robot during the therapy. Moreover, we gathered comments from participants about their experience in the session. Finally, we interviewed the caregiver to gather information about his experience and expectations of an exercise therapy assisted by the robot Kiro.

Interaction
In this first study, the therapist lead the session, while Kiro followed his instructions to support the therapy. However, there were periods of direct interaction between participants and Kiro. The main interaction was by verbal communication. Using personalized utterances, participants often responded to Kiro. Motivational phrases and feedback utterances from Kiro were kindly received by the participants who responded either verbally or with expressions of enjoyment (smiling, laughing, surprising, clapping hands). Another interaction channel was through body gestures. Participants perceived the body gestures of Kiro, movements

sequences for hugs, reverence, and clapping its hands. Participants imitated Kiro's movements as a non-verbal interaction (see Figure 2).

Engagement
When Kiro performed an exercise, participants usually focused on the robot. For example, in session 2, P5 and P7 were gazed at Kiro for prolonged periods. They followed and imitated Kiro and even adapted the speed of their movements to synchronize with Kiro's movements (see Figure 3). In session 1, P1 was gazing at Kiro most of the time. She was surprised by how Kiro made some movements and said out loud positive comments about this. In both sessions, Kiro counted out loud the repetitions of the exercises, this motivated to participants to do the same. Moreover, participants followed instructions from Kiro. For example, when Kiro instructed them to clap their hands - using its speech and gesture features, participants followed its instructions. Besides, verbal communication was another cue for engagement during the sessions. During the sessions, Kiro asked participants about the therapy, and they responded directly to the robot.

Adoption
During the session, participants made positive comments about Kiro such as:
"Ooh, I want that puppet [Kiro]. It is really cute. Don't you sell it? [smiling]" [P1]

Once the session concluded, one of the authors asked participants what they thought about the session and Kiro. We obtained the following responses:
"I would like to tell it [Kiro] that I like it very much and I would like to take it with me, but it depends on the boss [caregiver]." [P1]
"I had a great time because I like so much the exercise." [P3]
"Very nice, the little robot is very nice."[P5]
"It is formidable. This is the best one I have seen." [P7]

Also, we asked them if they would like to repeat the session with Kiro next week.
"Yes of course, I would be charmed. Yes, I would like it" [P3]
"Yes, of course, come next week. Well, on Thursday" [P7]

These answers provide preliminary evidence of the adoption of Kiro by the participants. In addition, we interviewed the caregiver regarding his expectations of an exercise therapy assisted by the robot Kiro.
"I think that a therapy [using Kiro] is feasible because it is not complex. It is a simple therapy, and the robot can do it. However, it [Kiro] has to be aware that everyone is doing the exercises such as I do it. Also, I think that it would be better if it were bigger and had more flexibility as us [humans] then it would be excellent to support the therapy. " [Caregiver=C]

Conclusions
We conducted a feasibility study as a first step towards the use of a social robot to support an exercise program in a residence for people with dementia. Results from this study show an initial rapport between participants and the robot. Although not all participants interacted directly with the robot, those who did it interacted with the robot using verbal communication and body gestures. They followed the instructions and imitated the movements of the robot. Furthermore, the caregiver and participants considered the therapy supported by Kiro as a good initial experience, and they expressed their interest in repeating it. Drawing from these findings, the use of a social robot to support an exercise therapy seems feasible. However, it is necessary to conduct more sessions and involve more participants to

understand better the issues related to the adoption of this kind of therapy by PwDs. Moreover, an in-depth analysis is necessary to explore different ways of interaction between PwDs and the robot and to define how a fully-autonomous interaction could be achieved.

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