Robot personality for cognitive training

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Abstract
Robots are becoming more present in our daily activities and in particular in the health context. To improve the human-robot interaction in a training session it is important to design and develop social behavior and personality in robots. Recent studies found that personality is an essential feature for creating socially assistive robots. For this purpose, I want to investigate if the robot personality (extrovert or introvert) can improve the user's cognitive performances in elders with Mild Cognitive Impairments during one-o-one cognitive training.

Keywords
Human-Robot Interaction, Socially Assistive Robots, Personality,

1. Introduction

In the last decade, the aging of society is occurring worldwide. By 2050, the number of individuals over the age of 85 is projected to be three times more than today [1]. Aging has a considerable impact on the health of older adults, and most of them need physical, social, and cognitive assistance. At the same time robots have become more common in our daily life and they are no longer only supplementary tools for laboratories. Recently, robots, called socially assistive robots (SAR) are employed to assist older adults. SAR can aid users through social interaction to enhance the quality of life and reach optimal results in terms of training tasks. In my Ph.D. project, I want to use a SAR with older adults affected by Mild Cognitive Impairments (MCI), which is a progressive cognitive decline between normal aging and dementia [2]. It affects the completion of complex tasks usually performed with simplicity in normal health conditions, such as cooking and managing the home. Moreover, every year 10% of elders with MCI have a high risk to degenerate into dementia. Existing studies on robot personality are limited because they are based on the assumption that robots are tools to be used rather than social companions to interact with. For this reason, in my Ph.D. project, I want to investigate the effects of different robot personalities on elders during cognitive training. In fact, personality can be a key element for creating SAR that can facilitate human-robot interaction(HRI) and provide better engagement in the users.

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2. Related work

The benefits of SAR in heath context with elderly are investigated in the research by Tanaka et al.[3]. The researchers compared a speaking humanoid Kabochan Nodding ROBOT with the same robot but without the communication elements. In the 8-week trials with MCI patients, the researchers found improvements in cognitive functions. Pino et al. [4] evaluate the effectiveness of human-robot interaction(HRI) to reinforce therapeutic behavior. In the experiment with MCI patients, they found improvements in differents cognitive domains and that HRI can reinforce therapeutic behavior. In literature for social robots performing assistive tasks with personality, Tapus et al. [5] investigate the role of the robot's personality in a therapy process for rehabilitation of post-stroke users. In the study, they used an ActiveMedia Pioneer 2-DX mobile robot designed to assist, encourage, and socially interact with post-stroke users engaged in rehabilitation exercises. As result, they found the first evidence for the preference of personality in the assistive domains.

3. Proposal

In 2019 the HIIS laboratory of CNR-ISTI in conjunction with the Neuroscience Institute of CNR of Pisa collaborated to investigated how seniors with MCI perceived cognitive training with a humanoid robot [6]. As result, we found that the robot seems to improve the engagement in the user, in fact, the older adults considered the humanoid robot as if it had human traits. Taking into account this experience, my Ph.D. research addresses the limitation in prior work: personality. The idea behind this project is to design and implement an extrovert and introvert personality in a robotic system. Research question: Can a social robot showing a personality improve cognitive performance and engagement in the user?

Robot system The humanoid robot I will use is called Pepper Robot, which is developed by Softbank Robotics. Pepper is a 1.2-m-tall wheeled humanoid robot, with 17 joints for expressive body language. Pepper has multimodal interfaces for interaction: touchscreen, speech, tactile head, hands, bumper, LEDs, and 20 degrees of freedom for motion in the whole body. It hears thanks to four directional microphones on his head, which allow it to detect the provenance of sounds and voices and turn its face in the direction of those who are talking. The robot speaks or reproduces sounds thanks to two speakers in the ears, and it is also equipped with 4 microphones on the head. For the vision, it is equipped with two identical 2D cameras, a 3D camera, and a stereo camera. To develop personality in the robot I will use the QiSDK for android, a Java library that offers a set of modules to program the robot.

Behaviour and personality In literature, different personality models are proposed. I consider the Five-factor model[7] because a considerable amount of research indicates that extroversion and introversion are the most observable personalities. For this reason, I want to implement extrovert and introvert personalities in a humanoid robot during cognitive training with three serious games. After a preliminary interview with the psychologies and therapist of the clinic the two personalities have been identified and, before the user test, they will be validated

Table 1
Personality Parameters

	Extrovert	Introvert
Verbal		
Intonation:	Joyful	Neutral
Pitch variation:	pitch set at 150 [50-200]	pitch set as default 100
Volume:	set 90 % maximum [0-100%]	set 50% maximum
Speak rate:	170 words per minute	150 words per minute
Rythms variation:	Variation rhythm set 2 [0-2]	Variation rhythm set 0
Feedbacks:	reinforcement feedback	neutral feedbacks
Non-verbal		
LEDs light:	shiny colours, flashing light	neutral colors or light colors no flashing
Gesture:	both arms, head, torso movements with big angles, faster responses	one arm with small angles, slower response
Set of animations:	animations that convey different emotions	neutral animations
Moving speed:	40% faster than introvert movements	slower movements
Sounds:	movement associated with sounds and melody	no sounds or melody
Autonomous movements:	autonomous movements	few autonomous movements

by psychologists and therapists. Table 1 summarizes the verbal and non-verbal cues used to modulate the robot's behavior. For the verbal parameters, I identify: modulation in the robot's intonation between neutral, joyful, and didactic; variation in the pitch and rhythm; changes in the volume and speech rate; different set of feedbacks. For the non-verbal cues, I identify: LEDs with different colors and intensities(e.g flashing light), customized set of animation that can convey different emotions; creation of complex gesture with different angles; association of movements with sounds; modulation of the movement's speed; addition of autonomous movements (e.g. natural movements of the arms). For each interaction with the users, Pepper will provide a different combination of verbal and non-verbal cues according to the personality performed.

Scenarios In this paragraph, I describe two scenarios in which I propose a possible use of the robot personality during cognitive training with older adults. Mario is a 75 years old teacher and since he has a diagnosis of MCI, he regularly attends cognitive training in a cognitive center near his house. Recently a one-o-one cognitive training with a humanoid robot was integrated into his program by the clinic. Monday morning, as usual, he prepares and goes to the clinics. The psychologists welcome and take him to the training room. After the introduction phase in which the robot introduces the cooking game and the ingredients of the first level:
Extrovert scenario.

1. Pepper says with a joyful intonation and a high-pitched voice "Which is the first ingredient to cook the chicken curry: chicken, curry, salt or yogurt?" highlighting its LEDs with a bright blue and moving both its arms over its head.

2. When Mario answers right to the question, immediately Pepper says "Good job Mario, you are doing a great job!". At the same time, it raises both arms two times and nods its head, the eyes LEDs become bright green and flashing, and it produces a sound that expresses joy.
3. Pepper says "How many grams of flour are needed for the recipe: 10, 150, 200, 400 gr?". Pepper highlights its LEDs with a bright blue and opens both arms at 40 degrees outwards as to encourage the user.
4. For the first wrong answer, Pepper says with a loud voice and an enthusiastic intonation "You made a mistake, but you can try again!". When Mario answers wrong more than one time Pepper says, " Mario, stay focus! You know the answer, try again!". At the same time, it shakes the head and moves the arms up and down, an "oh" sound is vocally provided, and all the LEDs become bright red and flashing.
5. Before the game end, Pepper combines different gestures to simulate a victory animation accompanied by sounds of applause, while all the LEDs are flashing and become green and blue. In the end, Pepper salutes Mario saying "Really good job Mario, it was fun to play with you! Hope to see you again next time!". During the cognitive session, Pepper performs autonomous movements (e.g simulate breathing movements).

Introvert scenario.

1. Pepper says with neutral intonation and a low volume "Which is the first ingredient to cook the chicken curry: chicken, curry, salt or yogurt?". After a few seconds, it slowly undulates the torso twice to the right and left while the shoulders LEDs become light gray.
2. When Mario answers right, Pepper says with a neutral intonation and a slow speech rate "Good". It waits two seconds and slowly it nods its head, while the eye LEDs become light green without flashing.
3. Pepper says "How many grams of flour are needed for the recipe: 10, 150, 200, 400 gr?" It gently opens its right arm to 20 degrees outwards right while the eyes LEDs become a light yellow.
4. When Mario answers wrong, Pepper says "Wrong, try again." It lightly shakes the head one time, while the eyes and shoulders LEDs become light red.
5. In the end, Pepper moves backward and forwards one arm and it salutes Mario saying "Good job Mario, see you next time". During the cognitive session, Pepper performs a restricted set of autonomous movements.

Methods and evaluation I want to insert the adaptation of personality in a robot system for supporting cognitive training according to the users' personalities. For the evaluation study, I define two experimental conditions: an extrovert condition in which the robot performs an extrovert behavior during the training and an introvert condition in which the robot performs an introvert personality. Before and after the test, the users will be subjected to the UES questionnaire [8] for evaluating the engagement of the users, the Big Five Inventory test for evaluating the users' personalities [9] and the Godspeed Questionnaire Series [10]. During the cognitive training, I will collect data to evaluate the improvement in the memory domains stimulated: reaction time, number of the wrong/right answers, time session, number of attempts, etc. Learning which robot's personality better fits the user is important to evaluate the improvements in attention, and also to improve the HRI. Creating a robotic system capable of adapting its personality to the users could be a useful tool to stimulate the elders to continue the therapy, and moreover to achieve progress in their rehabilitation. In conclusion, I want to evaluate if different robot personalities adapting to the user can create an enjoyable interaction; engage more the user during the tasks; increase the user's attention, and consequentially if can improve the user's task performance and cognitive functions.

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