Interacting with dementia: The MARIO approach

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Quick Overview:

This paper presents the results from trials of MARIO interacting with people with dementia (PWD). MARIO aims to help PWD to battle isolation and loneliness by enabling them to stay socially active. In this paper, results from the first trials are presented in terms of acceptability and user interaction with the robot.

Introduction/Background

Robotics is an emerging technology to be used in many different domains in the near future. Assisting people with disabilities on their daily needs is one of the areas that many applications of robotics are being tested in research worldwide. This paper focuses on the use of robotics as a technology to facilitate older people with dementia to stay socially connected and active in a means to help mitigate the effects of isolation and loneliness.

The number of people with dementia is expected to double every 20 years reaching to 66 million by 2030 and 115 million by 2050 [1]. More than a third of people with dementia have reported loneliness [2]. Robots have the potential to combat the devastating impact of loneliness in people with dementia by improving their mood, quality of life [3], and reduce social isolation by facilitating people with dementia (PWD) to maintain social contacts.

The quality of the interaction which takes place between the robot and the PWD is crucial in determining the acceptability of the robot as a companion and the impact of its applications to potentially promote social connectedness and reduce loneliness. This paper reports the trials under taken with MARIO with regard to the interactions between it and PWD. Research has shown that ease of use and customization and adaptation to users' needs is very important. One approach being used in some cases is the use of zoomorphic robots that are responding to touch and sound recognizing a limited set of words (usually their name). Paro is one such example. Paro has a seal-like form and has been successfully used to facilitate therapeutic work with PWD, to enhance social interactions and reduce social isolation [4,5,6]. Paro has been the most

widely studied zoomorphic robot adopted into practice, however, other zoomorphic robots include Pleo, a dinosaur, and Aido, a robotic dog. Studies have revealed positive attitudes towards robotic dogs [7]. In one small short term study in an American residential home, Aido was found to stimulate more social interaction than a real dog [8].

Robotic dolls are an alternative to zoomorphic robots for use with PWD who may have negative feelings towards animal robots. Studies comparing robotic dolls, such as Babyloid, with zoomorphic ones, such as Paro, with older people (n=29) living in a Japanese nursing home have demonstrated high acceptability of both robots but a stronger preference to Paro [9].

Other studies have examined the effect of a humanoid robot using verbal and non-verbal feedback demonstrated that people with cognitive impairment responded positively to music as a stimulus on the music based game provided by the robot. Those with more severe dementia responded for relatively less time and one responded after 6 months [10]. Two people with mild dementia enjoyed the game, but six with severe dementia did not respond to it. Therefore the use of music in the interaction can also have a positive effect in some cases.

Another approach is the use of telepresence robots, which removes the need of interacting directly with a robot. These robots, such as Girraf, are recognized by PWD as representations of their family members, facilitating the interactions with them [11]. These robots demonstrated an improvement in the participants' emotional response and engagement and Giraff was found enjoyable to use while it improved their social connectedness.

In more complex interactions, involving verbal communication accompanied with visual cues, studies have revealed that PWDs with more severe dementia find it more difficult to interact and follow robots instructions. However, in most cases, participants feel that they can trust the robot [12] and enjoy simple interactions with it like having fun conversations [13]. In the case of Paldro, where the robot (a humanoid) could walk, play music, games, dance, take photos, and connect to the internet, it was found that users with advanced dementia had greater difficulty interacting with Paldro compared with those participants with mild dementia [14].

In the case of MARIO, the interaction is based on a multimodal interaction combining touch and verbal input with visual cues on a screen on the chest of the robot and a Text-To-Speech (TTS) system that speaks to the user. This idea enables MARIO to have a dialogue interaction with users while assisting them by providing accompanying visual cues on the screen. However, since MARIO aspires to provide users with a variety of functionalities and also aims to help developers develop applications for PWD, a choice was made to isolate the user interaction elements of MARIO from application developers by following a different approach than what is usually met in such systems. The applications running on MARIO use a User Interaction (UI) component that provides developers with an API that allows them to present a set of specific UI patterns accompanied by a screen shown in the touch screen of MARIO. The information sent to the UI component is limited to a minimal amount of information; all other features, such as speech rate, voice, colors, prompts, etc., are handled by the UI component. For example, either a user is presented a set of genres to select in the music application, or a set of topics to read about in the news application, the interaction pattern employed is the same in both cases and developers don't need to care about details mentioned before. This choice of architecture limits the freedom of application developers to create their own unique designs, and interaction patterns but

this reduced choice helps to maintain a common look and feel between all different applications of MARIO. This consistency benefits the experience of the end users.

This paper describes trials conducted at nursing homes in Ireland and a hospital in Italy and discusses the resulting successes and challenges. It concludes by providing potential solutions and suggesting improvements for MARIO which can be tested in the next cycle of trials This discussion particularly highlights how the choices made regarding the architecture can benefit the further development and improve the user interaction.

Methods

This section describes the aims of the trials, the participant inclusion criteria, the recruitment process, the trial protocol, and the data collection process for both trial experiments.

This first stage pilot trial was focused on two primary outcomes: i) how PWD, who are residing in long term care nursing homes and in hospitals, react to the presence of a companion robot, and ii) whether PWD can interact with the companion robot using simple apps to accomplish tasks, such as listening to music, playing games, and reading news headlines. These outcomes were assessed by carrying out interactions with the MARIO robot and PWD residing in dementia specific wards at several different nursing homes in Ireland and in the Geriatric Unit of the IRCCS "Casa Sollievo della Sofferenza" (San Giovanni Rotondo, Italy). These interactions were led by a researcher, sometimes with the assistance of the nursing staff or family members, in either the participant's bedroom or in a quiet area of a common room

As this study involved the use of human participants, ethical approval was required prior to recruitment. Ethical approval for this study was obtained from NUI Galway Research Ethics Committee for the trials in Ireland. For the trials in Italy, approval of the study using human subjects was obtained from the local ethics committees on human experimentation. Written informed consent for research was obtained from each PWD and or from relatives or next of kin

Furthermore, as this study involved working with a vulnerable population, several steps were taken prior to seeking consent for participation in the trial. In the case of nursing homes in Ireland, these steps can be summarised as follows: firstly, the Nursing Director of the Nursing Home was contacted to discuss the project details to determine whether the residents and staff would be willing to participate in the study. Secondly, the Director of Nursing or her nominee identified those residents that met the inclusion criteria (Table 1) and who they believed would be able to participate. The inclusion and exclusion criteria for participants in the Italian pilot are summarised in Table 2.

Table 1. The participant inclusion and exclusion criteria for the trial in Ireland.

Inclusion Criteria	Exclusion Criteria
Resident at the nursing home for at least one-month prior and for the duration of the study	Diagnosed with sever dementia or memory loss
Formal diagnosis of dementia	Significant sensory impairment
Any diagnosis of dementia by a medical clinician	Acute physical illness that impairs ability to participate
Is prescribed anti-Alzheimer's medication	
Nurses' judgement advise that the person has dementia	

Table 2. The participant inclusion and exclusion criteria for the trial in Italy.

Inclusion Criteria	Exclusion Criteria
Age ≥ 65 years patients with diagnosis of mild dementia according to the criteria of the National Institute on Aging-Alzheimer's Association (NIAAA) The ability to provide an informed consent or availability of a proxy for informed consent	Patients with serious comorbidity, tumors and other diseases that could be causally related to cognitive impairment (ascertained blood infections, vitamin B12 deficiency, anaemia, disorders of the thyroid, kidneys or liver), history of alcohol or drug abuse, head trauma, psychoactive substance use and other causes of memory impairment.

In the case of nursing homes in Ireland the following process was followed: if the PWD fulfilled the inclusion criteria, Care staff asked the potential participant whether they would be interested in meeting the study researcher. If the participant agreed, care staff introduced the researcher who spent time building a rapport with each potential participant, explaining the study in simple language, and explored whether person was interested in being included. Where a potential participant was willing to engage in the study and expressed an understanding of the purpose of the study and its voluntary nature, as well as expressing a choice to participate, the researcher finalised the consent process directly with the person. In instances where it was not possible to gain consent directly, consent by proxy was used, where the person's next of kin was asked to give formal written consent on behalf of their relative.. Process consent was utilised whereby the researcher continually checked with the PWD on each occasion if they were happy to continue to be involved in the MARIO project and reminded that participation was voluntary and they could withdraw from the study at any time without consequence. .

In IRCCS, five patients (M=3; F=2) were screened for eligibility according to the inclusion/exclusion criteria, shown in Table 2. In Ireland, PWD (n=5) were recruited. Of these, four were residents of two different nursing homes in rural Ireland, currently diagnosed with moderate dementia. These four participants required a great deal of assistance to complete everyday tasks and struggled with short term memory. The fifth participant lived at home with his wife receiving assisted care from her.

In Ireland, the pilot protocol was divided into an acceptability phase and a testing phase, with each phase lasting four weeks in the case of Ireland. In IRCCS due to shorter time of stay in the hospital the protocol was adjusted so that PWD were invited to use MARIO during their stay in the hospital therefore merging the acceptability and testing phase in one.

The acceptability phase was focused on obtaining feedback from participants based on the physical appearance of the robot. The testing phase was focused on obtaining data in regards to how the PWD would use the MARIO robot. In each phase, feedback was obtained from interactions between MARIO and the PWD. These interactions were highly guided and supervised by the researcher. The frequency of these interactions were partially dictated on the participant's wellbeing and general health at the time of testing; on average, two interactions, per person, were carried out each week. During the acceptability phase, these interactions lasted only several minutes, but averaged close to 30 minutes during the testing phase. During the testing phase, the researcher first demonstrated the functionality of the different applications available (games, music, news) on MARIO. The PWD was then asked to navigate through the different applications and was asked to try to use, voluntarily, the apps they were most interested in.

The cognitive problems and communication difficulties of the PWD meant we were unable to used standardized scales and we needed to design and use questionnaires suitable for this PWD. These enabled us to capture observational qualitative and quantitative data in addition to their verbal responses to questions. This enabled researchers to gain insights and record the participants' experiences with MARIO. During the acceptability and testing phase, data was collected using these questionnaires which were divided to capture the observational data of the researcher and a questionnaire for the participant. The participant questionnaire focused on simple questions that would be easily understood by the PWD (e.g.. Do you like how MARIO looks? Can you hear MARIO? Which application is your favourite?). The observational questionnaire obtained quantifiable data, based on the researcher's observations of the interactions between MARIO and the PWD. This questionnaire used a rating scale to measure how involved the participant was in the interactions, how they seemed to enjoy the experience, how long the participant spend with MARIO, how many times and how long they used each application,. The same questionnaires were used in both Ireland and Italy.

Results

In this section, an overview of the results from the two completed questionnaires, as well as some of the challenges encountered when attempting to collect data, are presented. A brief summary of the participant questionnaire is summarized in Table 3, while the results from the observational questionnaire are presented in Table 4. In Table 3, the questions from the questionnaire are included with a summary of the participants' answers and comments. Where applicable, a numerical score between 1 and 5 is used to represent an average rating from the participants. On this scale, a rating of 5 is representative of a positive response where a rating of 1 is representative of a negative response (the participant did not respond positively to the appearance of MARIO or to the use of a specific app). In Table 4, questions from the observational questionnaire are included. The same rating scale is used to quantify how the participants responded to MARIO's physical appearance, the UI, and the use of the different apps. The average score for all participants, based on the researcher's observation, is recorded and included in table.

Table 3. Summary of participant questionnaire responses.

Question	Participants' Response
Was MARIO good company?	5.0
What do you think about MARIO's appearance?	He looks lovely, very nice and clean. He looks grand.
Would you like to use MARIO again?	5.0
Can you easily read the text on the screen?	5.0
Do you have any kind of problem using MARIO?	Difficulty using the touch screen. Not intuitive for the participants, as they would use whole had or multi-finger touch. Required several reminders each day to 'tap' the screen with a single finger
What was it about MARIO that you liked the most?	Enjoyed listening to Irish music. Liked to play the 'Simon' game.

Table 4. Summary of the observational questionnaire, with the average score based on the researcher's observations**.**

Question	Participants' Response
Does it seem as if the PWD likes MARIO's appearance?	4.2
How easy did the PWD find MARIO to use?	3.0

Did the PWD like having MARIO around them?	3.8
Do you think the PWD would be happy to work directly with MARIO again?	4.6
Can the PWD easily read the text on the touch screen?	4.6
Is MARIO at the right height for the PWD to operate the touch screen?	4.6
Does the PWD understand MARIO's verbal instructions?	2.2
How often does the PWD use the voice command aspects of MARIO?	1.0
How many times did the PWD select the music app per interaction? (Score indicates number of times not rating)	2.2
How many times did the PWD select the games app per interaction? (Score indicates number of times not rating)	2.4
How many times did the PWD select the news app per interaction? (Score indicates number of times not rating)	0.4
Was MARIO positively accepted by the staff at the nursing home?	4.0

From the acceptability phase, it was noted that the participants in both trial sites liked MARIO's appearance (as well as color, size, shape, icons, and eyes), but in Italy they commented about voice interaction declaring that the voice was too robotic and they would like the male voice.

One of the primary challenges in the data collection process was related to the engagement capacity of the PWD and their limitation in interacting with MARIO. From a technical stand-point, MARIO presents the PWD with options on a screen, via verbal communication and with visual text representation. This was seen to sometimes overwhelm the PWD, as too much information was being vocalized (making a choice between three options, and having to remember the options) to them at one time. As such, in the majority of cases, the PWD would re-read the text on the screen that MARIO had just spoken. This caused all the PWD tested to focus on solely using the touch screen as a means to interact with MARIO. None of the PWD felt comfortable interacting with MARIO via speech.

This unfortunately lead to several issues, mainly: i) During the time the participant spent reading and considering their options MARIO would prompt the participant for a choice, this would cause more confusion and indecisiveness, and ii) the operation of MARIO relied heavily on the participant's skill with using a touch screen, and, as many of these older participants in Ireland had limited exposure to touch screen technology, they struggled at time using the touch screen (multi-finger touch, holding their finger on the screen).

This second issue was mitigated by spending time at the beginning of each session helping the participant understand how to use the touch screen. The first issue, in regards to engagement posed a more significant problem. In many cases, the participant was more interested in speaking with and interacting with the researcher instead of MARIO.

A second set of challenges stemmed from the questionnaires themselves. Despite the best efforts in developing questionnaires with simple language and simple questions, in some cases the questions were too complex for the participants. This would lead to the participant either ignoring the question or simply agreeing with the question, future work needs to focus on developing dementia friendly questionnaires so that more meaningful data can be obtained

Discussion

The results show that users are accepting MARIO and like his appearance but the multimodal interaction combining verbal and visual cues is in some cases challenging. MARIO is trying to employ a conversational mode of interaction with the user and through these dialogues help them to identify and use it as they like (play music, games

etc.). The interaction is designed based on a question spoken by Mario accompanied with a set of options to select from. Although the number of options has been reduced to 4, the fact that Mario presents verbally all options in a series of questions seems to confuse and overwhelm PWD, especially in more advanced stages of the disease.

Moreover, MARIO prompts for a choice after a specific time of inactivity and this seems to sometimes confuse users, who might be reading the options from the screen and trying to make a choice. However, this is not the case with all participants Therefore, the timing of prompts to the user should be carefully examined and should be adjustable by the robot itself or the caregiver. If the robot is able to understand through body posture recognition that the user is still trying to read the screen then the prompt can be further delayed. The current technical architecture allows for that to be adjusted easily and in a common way between all applications taking the burden from application developers and maintaining a common experience for the user no matter what application they are using.

Another problem in the verbal interaction with end-users is also posed by the capacity of speech recognition software to interpret correctly phrases and commands for PWD. In many cases, PWD in particular those with advanced dementia take long pauses, confuse words and in general speak in a difficult to comprehend way. These special attributes of speech pose significant problems for the Dragon Nuance speech recognition software used in MARIO. These problems make it difficult to figure out the sentences, or even the keywords spoken by the user, leading to issues when trying to direct the interaction thereafter. However, although users feel overwhelmed by the presentation of multiple choices, listening to a voice form the robot was not perceived negatively. Therefore, speech can still be used from the robot to trigger response from users using longer pauses and shorter sentences in some cases. It is the speech as input mechanism from the user that poses the biggest problem in particular for participants with more severe dementia and one suggestion from pilot sites was to include the ability to turn off in total the speech recognition and make MARIO accept commands only from the touch screen. Again the technical architecture isolating the user interaction component from application developers makes it easy to implement such a facility for all apps in a common way by profiling users and their preference in using the robot through voice & touch or touch only.

Conclusions

The findings of the trials and their discussion reveals some key positive and negative issues in the approach MARIO is taking.

- The idea of combining verbal and visual communication needs careful adjustment and customization options are required for different users taking into account their stage of dementia. A one-size-fits-all solution is probably going to fail for some users.
- Both interaction modalities were used depending on the user, however the speech recognition and speech input poses significant challenges due to the speech difficulties associated with dementia
- Developing applications independent of the UI and providing developers with specific patterns to use enables customization of the UI for all apps at the same time by configuring appropriately the UI component parameters.
- Moreover, the abilities provided by the robot infrastructure can enable even more dynamic adjustments of the roots UI which will be consistent across all applications.

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