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Investigating the effect of social robot embodiment

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Abstract: The experiment described in this paper is an early assessment to identify if the embodiment of a verbal and visual user interaction system in a robot is more effective in people with dementia than when using the same system in a simple laptop. This study provides input for the robot's design.

Keywords: Robotics, Dementia, Loneliness, Isolation, Acceptability, Embodiment, MARIO

Introduction and Background

This paper reports the results of tests conducted during the development of applications (apps) for a social robot called MARIO. This robot's purpose is to support the care given by human care givers to People Living with Dementia (PLWD). It aims to assist them to connect socially with other people, to increase independence, and reduce problems of loneliness and isolation, which affects over one third of PLWD [1]. This issue is significant, as dementia will affect 66 million people worldwide by 2030 [2].

MARIO's apps suite includes access to music entertainment, to support reminiscence through photographs and life stories, read the news, reminders of events or activities and a facility contact friends, family and carers, through social networks and possibly phone calls. This paper focuses on the impact of robot embodiment and how the interactions of PLWD with the music app are impacted when they are delivered through the robot in comparison to being available on a laptop. The music app was selected when the whole set of apps was still under development because it is relatively simple to use and PLWD often respond to music.

The Almere model of technology acceptance suggests that a robot's social presence and its perceived sociability impacts a user's willingness to interact with a robot [3]. A robot's social presence relates to a user's need to believe the robot has social abilities and a robot's perceived sociability concerns a user's perception of the robot's sociability [3]. These constructs are related and have been found to have a positive correlation (beta 0.540, t 3.399, p<0.005) [3]. They are likely to be important as robots which are physically embodied, sharing a physical space with users rather than being virtually present, are more likely to engage PLWD [4]. In addition, PLWD

are known to engage longer with stimuli which possess social attributes than those which are unsociable [5].

Based on these theoretical assumptions and empirical evidence, PLWD should be more positively engaged with Mario's apps when they are presented in an embodied robot than if they are presented in a touch screen laptop format. To test this hypothesis the following experiment was carried out.

1. Methods

Researchers gained informed consent from nursing home residents (n=2) with moderately severe dementia; a lady aged 90 (P1) and a man aged 85 (P2) (MMSE scores of 19; 15). They agreed to be observed when the apps designed for MARIO were presented in two conditions. In the first condition (L, as for Laptop), participants were invited to use the application presented on a laptop, which acted as a touchscreen from their perspective. This was operated by the researcher who unobtrusively changed the screen using a mouse in response to their verbal and touch commands. Their responses were rated and the researcher also recorded their qualitative observations. These results were compared with those obtained during the second condition (M, as for MARIO). This occurred a few months later when the same researcher, and another, who operated MARIO, presented the apps on the touch screen via the robot platform.

Ethical approval for this study was obtained from the Research Ethics Committee at the National University of Ireland, Galway.

2. Results

Little difference was found between the participants' ability to use the apps. In both conditions, they required high levels of support and were unable to use them independently. P2M often made unprompted comments and P1M was able to activate MARIO when prompted. However, researchers recorded participants did not understand that the robot was for them to use at their will and they are very hesitant at the start of every session. In neither condition were they able to use key words including MARIO's name. There was also little difference in their ability to discover and travel through the apps. P2M was able to return to the home screen without help whereas in all other participant conditions this did not happen. Researchers recorded that both participants always had difficulty using the touchscreen and often needed guidance and reassurance to do so. However, despite this difficulty, participants always preferred to interact with the apps using touch rather than voice commands.

There was a clear difference between conditions in the amount of time users engaged with the apps but this may be because apps were more fully developed in the robot than in the laptop condition.

Slightly higher levels of fun were reported in the robot condition (P1M) and engagement in all conditions was rated as high or neutral. However, the engagement in the robot condition activity, which was rated over a much longer period of time, was recorded as slightly lower.

There was also a clear difference between the conditions regarding participants' degree of happiness to work with the apps again. P2M stated they would like MARIO to come back again another time. However, there was no difference in reaction to the

sessions finishing, which recorded no reaction and P1M was happy for the robot to go knowing it would be back.

Table 1. Participant responses to the Application Presentations

Questions	P1L	P2L	P1M	P2M
1. Does the user address the apps by their name: Mario	No	No	No	No
2. Was the user able to Select the music app?	P1 did not want to try this app	Yes	Yes	Yes
3. Did the user successfully use the touch screen to return to the home screen?	No	No	No	Yes
4.Type of commands used by user: verbal and touch	Never used voice. Used touch three times	Used touch more than voice	Never used voice; always used touch	Never used voice; always used touch
5.Number of minutes User used the apps	10	5	20	45
Score for User Reaction: 1- very low; 2- low; 3- neutral; 4- high; 5- very high; UR- Unable to rate				
6.The user seemed to have fun using the application	3	3	5	3
7. Did the user seem engaged with performing the activity and concentrate on it most of the time?	4	4	4	3
8.Overall enjoyment of the User to the apps	3	2	3	5
9. How happy the Users would be to work with the apps again?	3	2	4	5
10.Amount Users needed the support to use the apps	4	4	4	4
Scoring When the session finished: 1- no reaction; 2:-they seemed sad (not smiling, said they wanted it back, got visibly upset); 3- they seemed happy for it to leave as long as it was coming back again; 4- seemed happy for it to leave without knowing if it was coming back or not				
11. How well did the user react at the end of each test session.	1	1	1	3
12. Rate the User's level of emotional engagement i.e. how much they smiled; chatted or laughed	n/a	n/a	3	5

More enjoyment was gained through using the apps in the robot condition. P2M smiled often and particularly enjoyed the music application and having Mario around. However, the researchers recognized that the participants' reactions in both conditions was impacted by their presence.

There was a high and neutral (P1M) and a high (P2M) degree of positive emotional engagement observed with the robot presentation but not the laptop.

3. Discussion

The results indicate that the participants' responses to the apps were more notable for similarities than differences but slightly more enjoyment, happiness and fun was recorded from the robot presentation. However, the hypothesis that PLWD should engage more positively with apps presented in an embodied robot cannot be supported nor denied because the test design was problematic in the following ways: 1) Variability of the participants' responses may be impacted by their conditions changing in intervening months (although no differences were reported by carers); 2) Responses were impacted by the researchers' presence; 3) The testing involved only two participants in each presentation condition; 4) The apps varied in what they afforded the users.

Despite these research design weaknesses, there was a neutral and high rated response to the robot does suggest social robots have the potential to provide emotional engagement. Additionally, the neutral response of PIM may have under represented the degree of his emotional engagement, as he did interact with the application willingly for 20 minutes. This result may reflect the complexities of conducting research with PLWD [6] as their responses to stimuli can occur with emotional blunting of expressions [7]. Future investigation into the impact of robot embodiment will be conducted as MARIO's development continues. This should be conducted testing identical apps in autonomously functioning robots, with larger samples of people who have mild to moderate dementia. It is unlikely people with moderately severe dementia will be able to operate a touchscreen iPad without assistance [8].

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