Technology Acceptance, Sociocultural Influence and Gender Perception of Robots: A Human Robot Interaction Study with Naive Users in Rural India

Amol Deshmukh[1], Sooraj Krishna[2], Nagarajan Akshay[2],
Vennila Vilvanathan[2], Sivaprasad J. V.[2] and Rao R. Bhavani[2]

Abstract— **This work was conducted to investigate the technological acceptance and social perception of a robot helper in a rural context. A feasibility study was carried out in a rural village in India with 11 participants for a water carrying task using the robot. A strong cultural influence was found in terms of gender perception of the robot, most participants perceived the robot's gender as female despite of the robot having a male voice. The overall social perception and usefulness of the robot was observed to be positive. Also repeated interaction with three participants showed reduced anxiety and increased acceptability of the robot. The paper reports results from the questionnaires and also some practical challenges and sociocultural considerations to be taken in to account while running such studies "in the wild" with rural subjects.**

I. INTRODUCTION

As we look into a future where humans and robots work together and robots act as helping hands to carry out complex routine tasks, that as there is an increasing need to deploy robots in the real world environments where people can experience these systems in their daily lives. Such real world experiments can further inform the design, usability and user experience aspects of robots. Human-robot interaction "in the wild" in real environments has always been challenging [1], [2]. There has been a lack of experiments with social robots in the wild, lately as per Baxter et al. nearly 75% of experiments were conducted in the lab recently over 2013-2015 in HRI conference publications [3]. Moreover, human-robot interaction research is traditionally carried out in urban environments in the developed world [4], [5]. And most of HRI studies typically have participants recruited from university populations which does not tend to be a good representative sample of the rest of the world.

People from an urban background who have not interacted with robots, often independently build mental models and expectations about robots based on their exposure to media and their interaction with technology. However, people from rural communities who have limited exposure to different technologies owing to their geographically remote or reduced economic background may perceive robots very differently. To the best of our knowledge no HRI study has been performed in a rural context with subjects who have rudimentary access to technology or education. We believe it is important in making an effort to understand the challenges of introducing robotic solutions in a real life rural setting. This is an essential step towards informing design decisions for robotic products that seek to address the underserved populations of the world. In this work we carried out a feasibility study to understand the user acceptance and challenges of deploying a robot in-the-wild in a rural village in India. We have reported some of the findings in this paper.

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[1]University of Glasgow, School of Computing Science, Glasgow, UK amol.deshmukh@glasgow.ac.uk

[2]AMMACHI Labs, Amrita University, Kerala, India akshay.nagarajan@ammachilabs.org

II. BACKGROUND

The United Nations sustainable development goals relate to bridging the digital divide making technology more accessible to all users rather than a privileged few in developed countries [6]. Identifying a valuable, and yet viable use case for social robots in rural populations is challenging. So we looked at the various basic requirements of rural subjects; one such important requirement is water transport. Statistics state that more than 50% of population in India, and a similar number the world over, does not have access to tap water at home and people have to walk large distances daily to fetch and carry drinking water [7]. This task is mostly performed by women who spend roughly 2-3 hours daily fetching water in rural India carrying pots or jars on their heads that weigh upto 20kgs when filled with water. This activity can lead to back, feet and postural problems [8]. It also takes away a lot of time from their daily routine which can be used to perform other duties, to make an income, for child care, or in a younger girl's circumstance, to be able to get a proper education. There have been other projects like the Wellowater[1], a water barrel with a handle, to reduce the burden of carrying water but it does not entirely eliminate the physical drudgery involved in the water fetching task.

These circumstances provide a research opportunity to investigate if a technological intervention can help. In this work we studied the technological acceptance and investigated the social perception of a mobile robot helper carrying water for inhabitants in a rural village. The goal of this research was to explore if robots can be used in potentially useful scenarios to aid rural populations "in the wild" and how people perceive the use of such technology.

[1]http://wellowater.org/

III. STUDY

The study was conducted in a rural village called Ayyampathy near Coimbatore in the southern Indian state of Tamil Nadu (figure 1). The village consisted of 25 houses with approximately 200 inhabitants. The study was conducted in November 2017 when the water availability from the nearby water tank (which is the main source of water supply in the village) is moderate during this time of the year. The water tank was at a distance of roughly 100 to 500 meters from the houses depending on how far the house was located.

Fig. 1. Satellite image of Ayyampathy Village in India

A. Questionnaires

The questionnaires consisted of a pre-questionnaire about the demographics, water requirements and level of exposure to technology and education and a post-questionnaire to collect user perceptions. The pre-questionnaire was created with the inclusion of questions from Unicef/WHO [9], used comprehensively in household surveys that include questions on drinking-water and sanitation. Post-questionnaires included some questions from the technology acceptance model (TAM) [10], [11] used to study the effects of external factors on users' attitude, behavioural intention and actual use of technology. All questions were translated in the local language (Tamil). We also audio recorded the participant responses for the post-questionnaire and utilised it to obtain detailed insights into their perceptions.

B. Participants

The study consisted of 11 participants, 10 females and 1 male, mean age 37, the youngest being 15 and the oldest 70. The participants were predominantly females as they are most likely to carry water for the house. None of them had ever seen a robot before, 2 of them had seen a robot only on television. Only 5 of them had received some level of formal education. For all the participants it was their first time experience with a robot. The pre-questionnaire indicated that participants made an average of 15 trips daily carrying water jars (15-20 liters capacity) weighing upto 15-20kgs each from the water tank in their normal daily routine. The participants also expressed their discomfort while carrying water during the high heat of summer when the water availability is also limited. Thereby making our study a suitable use-case in this village's context.

C. Setup

It was essential for our research that we use a robotic platform that can carry water in outdoor terrains. We used a mobile robot, the Husky UGV robot from Clearpath robotics [12]. Husky A200 (UGV) is a medium sized robotic development platform which can carry a payload upto 75 kg. A crate was attached on top of the robot to place water cans in it, refer figure 2. At a time, 3 water cans can be loaded on the robot and each can has a water holding capacity of 20 litres. This enabled the robot to carry upto 60 litres in one trip. The robot was also equipped with a bluetooth speaker and text-to-speech (TTS) capability [13] which was used to give instructions to users in their local language (Tamil) using a synthetic male voice. The robot was tele-operated by a researcher during the study for navigating it around and also to trigger the TTS. The participants were made aware that the robot is tele-operated. The tele-operator was placed roughly 10 meters behind the robot. We also added eyes to the robot which were round in shape with an iris that is comparatively large with respect to the whole eye region. This type of eye design seemed to convey a degree of friendliness according to Tomomi et al. [14]. In order not to elicit any appearance bias we did not put a mouth, nose, ears, cheeks or eyebrows on the robot [15].

Fig. 2. Husky UGV robot fitted with a crate, loaded with cans

D. Methodology

The participants were given a briefing about the study. They were told *"We have a system from overseas and we would like to see if it can be put to some good use in villages. We would like to see if it can be used to carry water to your homes and help you. We would like to get your honest feedback about this and see if it is useful to you or not. We would like to conduct a testing session for this and have your consent to record the session for our reference."* After the briefing the participant was asked questions from the pre-questionnaire [9]. The participant was then taken to the water tank where the robot was kept ready to carry water.

The robot gave instructions to the participants step-by-step as follows:

- Robot: *"I have come here to help you in carrying water. Please fill the cans and place it on top of me"*- The participant would then take out the empty cans from the crate and fill them and load them back on the robot.
- Robot: *"Can you show me the way to your home so that I can bring water to your home"*- The robot would follow the participant to their house and stop when they reached.
- Robot: *"Please take the water cans to fill your vessel and place back the empty cans on my top"*- Participant then would take out the cans and empty it into jars/containers at their house.
- Robot: *"I hope I was helpful to you. Please remember to wash your hands before you eat"*- The robot would end the task with a hygiene awareness message for the participant.

The participant was interviewed after the task and their response recorded using the post-questionnaire [10], [11] and also in form of audio recordings. Each participant took about 45 minutes to complete the study including questionnaires.

Fig. 3. Husky robot helping the participants

Question	Yes %	No %	NA %	Scale
Did you feel like talking to the robot?	55	45	0	SP
Did you like when the robot helped you?	100	0	0	SP
Do you think the robot was alive?	100	0	0	SP
Did the robot made you feel scared?	18	82	0	RA
Will you feel uneasy if you were to operate this robot?	82	18	0	RA
Do you find the robot to be useful?	91	0	9	PU
Does using a robot make it easier to do the task?	100	0	0	PU
Do you feel safe while using the robot?	91	9	0	PS
Do you find using the robot to be enjoyable/ pleasant?	91	9	0	PE
Did you understand what the robot said to you?	82	18	0	UN
Does using a robot to carry the water save your time?	91	9	0	PRU
Would you prefer to use the robot rather than carrying water yourself?	82	18	0	PRU
Would you like to use the robot in the future for water carrying?	82	9	9	PRU
Would you like if the robot brings water on its own?	100	0	0	AU

TABLE I

QUESTIONNAIRE RESULTS SUMMARY, SP: SOCIAL PERCEPTION, RA: ROBOT ANXIETY, PU: PERCEIVED USEFULNESS, PS: PERCEIVED SAFETY, PE: PERCEIVED ENJOYMENT, UN: UNDERSTANDING, PRU: PRACTICAL USE, AU: AUTONOMY

IV. RESULTS

In this section we present results related to the technology acceptance and social perception of the robot. We could not use Likert scales for the questionnaires as the participants did not have any understanding of scales to rate their opinions. The responses were recorded as Yes, No or NA (No answer). Results are summarised in Table I:

A. Social Perception

In terms of social perception (SP, refer Table I), more than half (54.44%) felt like talking to the robot, the others told during the interview they were a bit reluctant as they did not know what to expect from the robot. One participant stating *"I don't feel brave enough to talk to it."*. 100% of the participants perceived the robot as being alive, attributing aliveness to the movement [16] and speech of the robot, for example 2 of them they said *"Without being alive, how can it talk?"*, *"Only because it has life, it is following us, right?"*.

Some participants were a bit anxious (RA) initially when asked did the robot made them scared one participant saying *"Yes, I haven't seen anything like this before"*. Also 80% answered they will feel uneasy to operate this robot as they are not used to operating it, however most said if taught they can operate it. This anxiety could be associated with SOC (sense of control) which can be defined as the perception that a person has that she or he is the author of a given action of the robot [17] especially during first interactions with a robot.

B. Technology acceptance

In terms of Perceived Usefulness (PU), all the participants found the robot to be useful and most (91%) of them answered that using the robot did make them doing their job of carrying water easier, one participant quoting *"We can finish the work easily. For older people, it is difficult to carry water. More than us, this robot is useful for old people."* Another one saying *"It is helping us. During the times that I am tired, if this robot carries water, we will not be tired."* Also in terms of perceived safety (PS), perceived enjoyment (PE) and understanding of the speech (UN) the responses was generally positive.

C. Practical Use

In terms of practical use of the robot, the participants were positive about using it for carrying water also keen to use the robot in the future. Some examples of their comments are provided here, *"It saved time. Nothing is wrong with it. We are happy that it got water for us. I feel that it made our life comfortable by reducing the difficult work. But we cant use it because we don't know how to operate it."; "It is difficult to carry water on my hips. With the robot, I can carry water easily."; "Robot is comfortable, rather than doing it by myself."* In terms of autonomy all participants would like the robot to be fully autonomous and not remotely controlled.

D. Gender perception and cultural Influence

From the post-survey, we asked the participants *"Did you think robot had a gender? if yes what was the gender"* refer figure 4. We found that only one participant said it was a male robot stating because it had a male's voice she heard on the robot. Three participants did not know, 2 said they thought the robot did not have any gender and one participant did not have an answer. However, more than a third participants (4/11, 36%) participants (P1-P4) said it was female and the reasons they quoted; *P1 (male):"because it is a woman's job to carry water", P2:"It is helping us right! Males aren't helpful.", P3:"Only a lady will fetch water. Will a man ever do it?", P4:"It is like a girl because it is carrying water"*.

Three of them were women themselves and one was male. A strong cultural and gender bias was observed in terms of the gender perception of the robot in context with the nature of the task it carried out [18]. In previous HRI work based on voice perception, researchers have found perception differences between male/female subjects [19], robot voices (male/female) [20] and type of task [21]. To the best of our knowledge it is perhaps for the first time in HRI that we observed the gender perception of the robot to be strongly biased based on cultural influences associated with the type of task the robot is carrying out.

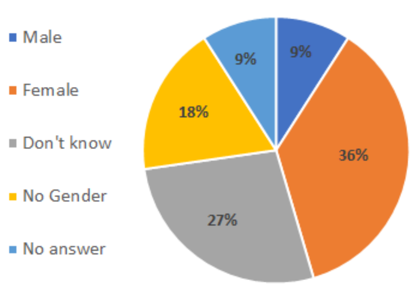

Fig. 4. Gender Perception (%) Pie chart

E. Second Interaction

Preferences and attitudes towards robots at first impressions (or encounters at 'zero acquaintance' as it is termed in psychology) are likely to change, and novelty effects will wear out [22]. Hence we wanted to investigate if opinions of the participants change after a second interaction with this robot. We had 3 participants who interacted with the robot for the second time the following day. We asked them some of questions as summarised in Table I. As mentioned before we could not use Likert scales with these subjects, they were asked to answer the question in comparison with their experience during first interaction (options provided were: More than before, less than before or Same as before). Answers, More than before was assigned a score of +1, less than before: -1 and same as before: 0. Results are averaged for 3 participants and summarised in Table II.

Question	Δ	**Scale**
Did you feel like talking to the robot?	↓	SP
Did you like when the robot helped you?	↑	SP
Did the robot made you feel scared?	↓	RA
Will you feel uneasy if you were to operate this robot?	-	RA
Do you find the robot to be useful?	-	PU
Does using a robot make it easier to do the task?	↑	PU
Do you feel safe while using the robot?	↑	PS
Do you find using the robot to be enjoyable/pleasant?	↑	PE
Did you understand what the robot said to you?	-	UN
Would you like if the robot brings water on its own?	↑	AU

TABLE II

SECOND INTERACTION RESULTS, SP: SOCIAL PERCEPTION, RA: ROBOT ANXIETY, PU: PERCEIVED USEFULNESS, PS: PERCEIVED SAFETY, PE: PERCEIVED ENJOYMENT, UN: UNDERSTANDING, AU: AUTONOMY. CHANGE IN OPINION IS INDICATED AS Δ AND SYMBOLS REFERS TO THE AVERAGE OF CHANGE OF OPINION, "↓" NEGATIVE CHANGE, "↑" POSITIVE CHANGE AND "-" MEANS NO CHANGE.

In terms of social perception, the participant seemed to feel less interested to talk with the robot, perhaps realising from their first interaction that the robot cannot hear them or lacks conversational abilities. However, they liked the help offered by the robot even more after second interaction. They also felt a bit less anxious (RA) and safer (PS) about the robot after their second interaction, this is a common effect found in HRI with repeated interactions [5], [23]. They found the robot to be more enjoyable/pleasant (PE) than before perhaps knowing exactly what the robot can do and how easier it is making it for them to carry water using the robot (PU).

In addition to the above questions (Table II) we asked the participants, *"Would you like to use the robot in the future for water carrying?"*. All 3 participants answered positively with a "Yes". Which suggests that the 3 participants would like to have such a robot to help them with water carrying activity. Also when asked *"Would you miss having the robot around?"*, all 3 participants answered with an emphatic "Yes", One participant stating *"Definitely, we will worry. It will be like one person is missing in family. This robot is like a human only. It is doing a work that one person should be doing. So when it is not there, it feels as if one person is missing."* It seems they had started to develop a bond with the robot [24]. However, having repeated interactions with more number of participants in a long-term study can help to confirm these findings.

V. Discussion

Most of subjects were females in our study, this was largely due to the fact that in Indian villages women are entrusted the job of fetching water while men go out for farming activities and do other jobs. In the pre-questionnaire, 8/11 participants perceived the robot like a small vehicle or car when asked *"What do you think this is?"*, perhaps because they could associate their experience of the Husky UGV with a car which has 4 wheels. Interestingly 2 participants who had high school education called it as a 'robot' they had seen one in a School exhibition. One called it as *"Vehicle that speaks"*.

When asked about their familiarity with technology like Radio, TV, phones, smart phones, computers, only 2 subjects (who had high school education) had been exposed to a computer while others were familiar with the radio, TV and phones. The level of education and technology awareness of the rural subjects might have affected how they perceived the robot. Previous HCI studies in rural India have indicated that non-literate and low-literate populations relate to technology in different ways [25], [26].

Even though the participants realised that the robot is being tele-operated we noticed elderly women thanking and even blessing the robot (not the tele-operator) for bringing the water to their house. We anticipate that this perception may have been influenced by the fact that they did not have to carry the water themselves for the day thereby making the robot appear more useful. We do not suggest that our findings can be generalised across rural India. Also robots are a distinct novelty in rural India, and we cannot take participants' reactions when first exposed to the robot to be truly representative of how they would interact with it once the novelty effect wears off [22].

A. Lessons and Limitations

Conducting HRI studies "in the wild" is always a challenging prospect. Especially when it comes to subjects in rural populations. Most of the subjects in this study lived on a daily wage basis and had their own daily routines to carry out their household chores like cattle feeding, cooking, washing etc. They were not keen to commit a fixed time for the study. It was difficult to predict when they would need to fetch water. They had different water requirements and time schedule for fetching water. Some would do it early in the morning, others later during the day. It was challenging for researchers to be present with the robot when they required water. On some days there would be no water in the tank because the water pump motor broke down, so nobody could fetch water. Due to these factors we could only recruit 11 participants during the 10 days on the field, 2 hours each day before sunset. Perhaps training a few local people on how to use the robot might help in terms of practical use of such a system in rural settings.

The queue at the water tank was another issue. The robot had to wait for its turn along with the participant in the queue for it to be used. It is important to understand the task routine details for robots to be deployed in such a context where resources are shared between subjects. Another observation is that for the subjects their time in queue was an opportunity in their busy day to socialise with others in their community. The introduction of a robot to fetch water could fragment the social fabric of their community, and it is critical to examine such considerations when introducing technology in rural villages.

We could not use statistical tests while reporting results in this paper. Use of likert scales for questionnaires was not feasible for rural subjects as they had a very poor understanding of such scales [27]. Hence use of alternative scales or a different mode of collecting data needs to considered with rural subjects. Questions also needed to be over simplified for the subjects since they exhibited poor understanding of quantitative measures such as the number of hours it took them to fetch water each day, where on enquiry the participants would state it took them a few hours, finding it difficult to specify the duration. Certain qualitative measures needed to be explained better, like for instance, some subjects found it difficult to discriminate between usefulness versus their likeability of the robot.

During the study the robot was not autonomous, although this was a desired feature from the participants. Achieving true autonomy with navigation in highly uncertain outdoor terrain can be very challenging [28]. In fully autonomous situations, safety around dynamic obstacles in a village setting such as children and even animals needs to be taken in to consideration. Some houses had a very narrow fence entrance thereby making it more challenging.

It was difficult to control people outside the study, for example a lot of children constantly surrounded the robot and walked along when it was following the participant to deliver water to their house. Due to these confounds it was not possible to carry out video analysis (frequency of gazing towards the robot, reaction time to robot's speech etc) from the videos recorded during interaction.

Approaching people to volunteer for the study was particularly challenging due to cultural constraints. The women in the village were hesitant to communicate initially with male researchers in our team. We had to recruit a female researcher to ease the flow of communication. Researchers should consider cultural implications with subjects while conducting such studies in rural contexts.

It is also very important while running studies with rural subjects to set the right expectations regarding the study. For this reason right at the start of study we told the participants that the robot will be taken back after the study, so that they don't have any unrealistic expectations of this robot being provided to them as a ready solution to carry water.

VI. Conclusion

Most HRI research is carried out in urban environments with people from developed countries. To the best of our knowledge this is the first HRI study carried out in rural environment "in the real wild" with naive subjects. The robot's technological acceptance and social perception was generally positive and we found a gender bias in terms perception of the robot. Also repeated interaction with three participants showed reduced anxiety and increased acceptability of the robot.

HRI in rural settings is a hugely unexplored research area where social robots could potentially be used to create a positive impact for the wider community. The HCI community has engaged increasingly with development through an interdisciplinary field known as "information and communication technologies for development", or ICT4D [29]. We hope from our novel work the HRI research community can also explore interesting research opportunities and work with the underprivileged populations where the people are hopeful of change and stand to gain a great deal from technological solutions to alleviate the drudgery from their daily lives.

Although the practical and economic implications of using such a technology for people from impoverished backgrounds can be challenging, our aim in this research was only to study the feasibility and perception of technology in rural context. One side-effect of "robots in the wild" could be theft, vandalism, or "robot bullying", could someone's possession of a robotic technology lead to social friction or the robot can be adopted by the community as a shared commodity? these are open research questions which require further investigation. The lessons and insights gained from this initial study will help shape our future research. In the future we would like to carry out long-term studies going beyond the novelty effect involving more number of participants with repeated interactions and study their perception.

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