A Social Robot for Explaining Medical Tests and Procedures: An Exploratory Study in the Wild

Roel Boumans
Behavioural Science Institute
Radboud University
Nijmegen, Netherlands
roel.boumans@ru.nl

René Melis
Geriatrics Department
Radboud University Medical Center
Nijmegen, Netherlands
rene.melis@radboudumc.nl

Tibor Bosse
Behavioural Science Institute
Radboud University
Nijmegen, Netherlands
tibor.bosse@ru.nl

Serge Thill
Donders Institute for Brain, Cognition, and Behaviour
Radboud University
Nijmegen, Netherlands
serge.thill@donders.ru.nl

ABSTRACT

Healthcare professionals often have little time to explain medical tests and procedures. Social robots capable of verbal dialogues may contribute to informing patients and the public in general about such tests and procedures, for example in general practitioner or hospital waiting rooms, nursery homes, as well as in public spaces. As an example of latter, an exploratory study was conducted at the Lowlands music festival in August 2022. A social robot explained a blood pressure measurement and a grip strength measurement to participants. Participants were asked to value the expected clarity of the explanation before the explanation, the experienced clarity after the robot explanation but before the actual physical measurements, and after the physical measurements. 172 participants completed the interaction (99 female, 57 male, 8 non-binary, 8 undisclosed). The mean interaction duration was 2.02 minutes (SD=0.40 minutes).
Participants found the explanation after the interaction with Pepper clearer than they expected beforehand. Participants found the clarity of the explanation, after they had actually undergone the physical examination, even higher than before the physical examination. This study indicates that social robots are potentially useful to explain medical tests and procedures.

CCS CONCEPTS

• Human-centered computing • Human computer interaction • Empirical studies in HCI

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KEYWORDS

Social robot, Health care, Explanation medical procedure, Field study in the wild.

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1 INTRODUCTION

Healthcare professionals often have little time to inform patients about upcoming medical tests and procedures related to diagnosis and treatment, since a typical consultation takes about 10 minutes [1]. Such medical tests and procedures include measurements such as blood pressure measurements and grip strength measurements, diagnostic imaging, and physical examinations [2]. If healthcare professionals need to explain a test or procedure, they cannot spend that time on having a dialogue with the patient on what matters most to them. This time spent by the healthcare professional is also directly related to healthcare costs for society. Moreover, healthcare costs for society are also increasing due to the aging of the population, the fact that people are reaching an increasingly higher age, and the shortage of available healthcare personnel [3], [4]. More communication options for explanations through various channels and on various times and locations that do not require healthcare personnel may contribute to decreasing costs.
Although healthcare institutions often provide paper leaflets and information on their websites for patients to study at home, patients often do not read information leaflets provided beforehand [5]. Many people use the internet to search for medical information on their situation, but for a large group of digitally

illiterate people searching for information on the internet is too complex [6]. Furthermore, healthcare intervention explanations are not always understood the first time they are given. Upon arrival in the hospital, patients on their patient journey through a hospital spend a lot of time waiting in a waiting rooms. The hospital waiting room could be a good environment to provide additional explanatory information about medical tests and procedures, since patients are there anyway and are also more focused on the upcoming patient journey. Patients scheduled for diagnostic and therapeutic procedures may experience anxiety for the procedure itself or the outcome [7]. Additional ways of providing sufficient, personalized information on the test and procedure without time pressure may reduce anxiety. Social robots may be able to explain medical tests and procedure using their verbal and multimodal dialogue functions.

We propose a social robot that can provide verbal and multimodal explanations about an upcoming physical test and procedure. We also propose the social robot that can measure anxiety on part of the patient and is able to react to measured anxiety levels. Such empathic reactions have already been demonstrated in the context of healthcare status interviews by social robots [8].

A social robot can be placed in many locations where there is a need for information on medical tests and procedures, such as drugstores [9], general practitioner or hospital waiting rooms, nursery homes, but also other public spaces such as shopping malls, large event venues and festivals. It provides an additional possibility to provide information on potential medical procedures and interventions, that people might be concerned about. The ability of a social robot to have a verbal dialogue on these tests and procedures, supported by photos or videos, is an easily accessible way of providing information.

Much research has been done into social robots for healthcare, as becomes clear from recent systematic reviews on that topic [10]–[17]. However, almost all studies referenced in these reviews concern a form of treatment by a social robot, and not the use of a social robot for explaining an upcoming medical test or procedure. This study intends to provide a contribution to research into this specific use case, and its purpose is to evaluate a social robot in providing information about a medical test and procedure in a public space. Therefore our research question is "do people find explanations of medical tests and procedures given by a social robot clear?".

2 BACKGROUND

The explanation of medical tests and procedures has been investigated in relatively few studies. Neerincx et al. studied a social robot that support children in diabetes management, and explanation of the purpose of self-management was part of the procedure [18]. In a related area, supporting people with taking their medicines is well-researched. Ferrante et al. evaluated a social robot supporting asthma patients in adherence to their intervention program [19]. Ishiguro (2019) proposed a robot intervention program for instructing patients to take their medicine in a pharmacy [20]. Robinson studied the areas of need that older people may have at home, and for which robotic solutions exist, and taking medicine has been one of them [17]. In fact, robots supporting medicine reminders is also a typical use case. For example, Pillo is a (now discontinued) robot that acts as an automatic medicine dispenser [21]. For this study, we therefore formulated our first hypothesis as "Participants will find the medical test procedure as explained by the social robot clearer after explanation", and the second hypothesis as "Participants will find the explanation received from social robot clearer, when they have undergone the physical examination".

In this study, a social robot is defined as a robot having all social attributes by which an observer judges the robot as a social interaction partner [22]. A physical test and procedure is defined as a means to obtain health information and diagnose pathological and nonpathological conditions of the human body [2].

3 METHOD

Participants were recruited at the Lowlands music festival in August 2022 [23]. This festival is one of the largest music festivals in the Netherlands and welcomed about 65,000 visitors during the three day program. As part of this program, a specific area of the terrain was dedicated to research institutions conducting research under the label of Lowland Science. Each institution had a booth on that terrain, including Radboud University Medical Center (RadboudUMC). There, RadboudUMC conducted an experiment on measuring the resilience indicator parameters 'blood pressure' and 'grip strength' among festival visitors. This experiment will be reported elsewhere. The study reported on here took place within the context of that experiment. The festival was a great opportunity to test the social robot explanation procedure in the wild.

Figure 1 - Pepper at the booth entrance, hidden behind the queue

Pepper version 2.9 was used [24]. Pepper was located at the entrance of the booth (figure 1). Participants started the interaction with pressing start on Pepper's tablet (figure 2).Pepper started with saying (statements translated from Dutch into English herein): "Hello, nice to see you. I will explain the

experiment to you. Can you indicate how clear or unclear you think my explanation will be?" Participants could select one of seven buttons with the utmost left button marked "very unclear" (clarity value = 1) and the rightmost button "very clear" (clarity value = 7), comparable to a 7-point Likert scale. Then the robot stated "I will explain to you using a short video how we are going to measure your blood pressure." The robot started the first video on blood pressure measurement. While the video played, the robot would explain the examination as shown in the video to the interlocutor. Next, the robot stated "After that, we will measure your grip strength. We will play the video." and played the second video on grip strength measurement, while also explaining this examination. Both videos combined lasted about 1 minute. Then the robot asked: "How clear or unclear did you find my explanation?" and participants could select again one of seven buttons as before. Then the robot asked participants to enter age and gender, and said thank you. The overall interaction with Pepper would take about 1.8 minutes.

Figure 2: Participant at Lowlands interacting with social robot

After having completed the actual blood pressure and grip strength measurements (duration about 10 minutes), participants were asked to indicate again their opinion on the explanation clarity, this time on a paper form with the same scale. Participants were able to execute the complete interaction independently, i.e. without researcher support. A video of the interaction has been provided as supplementary material and can also be found on YouTube at https://youtu.be/XEsmHKP-nyA.

The expectation ratings principle by Tedesco and Tullis, as referenced by Sauro and Lewis, was used as primary outcome measurement [25], [26]. Expectation ratings address the relationship between the experienced clarity of the explanation after performing it, compared to how it was expected before the explanation. The clarity value corresponding to the selected button at start and end of the Pepper interaction was digitally stored. This allowed for a paired samples t-test. For practical reasons, the measurement at the end of the physical examination was done on paper. Thus, the clarity was measured at three moments in time: before the robot explanation, after the robot explanation, and after the participant underwent the blood pressure and grip strength measurements and could review the explanation against their own experience. Comparison of the three means was done with a one-way ANOVA. Statistical analysis was done using SPSS 28 (IBM, NY, USA). The research has been approved by the ethical commission of the Radboud University under reference number ECSW-LT-2022-8-15-2428. All participants provided informed consent.

4 RESULTS

213 participants started an interaction with Pepper. After data screening, 172 participants completed the interaction. 50 participants completed the paper form after the actual physical examination. The mean age of the participants was 33.3 years old (SD=11.6). From the participants, 57% indicated their gender as female, 33% as male, 5% as non-binary, and 5% did not want to disclose their gender. The mean interaction duration was 2.02 minutes (SD=0.40 minutes). The scores of the participants on the expected clarity of the explanation before the interaction, the experienced clarity of the explanation after the interaction, and the clarity of the explanation after having experienced the actual physical examination are depicted from left to right in figures 3, 4 and 5.

Participants found the explanation after the interaction with Pepper (M=6.13, SD=1.35, figure 3) clearer than they expected beforehand (M=5.38, SD=1.37, figure 4), t=-5.72, df=173, p<.001. The clarity after physical examination, thus at the end of the procedure, (M=6.56, SD=0.61, n=50, figure 5) was higher that the experienced clarity after Pepper explanation but before physical examination (M=6.13, SD=1.35, n=172), t=-2.19, df=220, p=.015. Levene's test showed non-equal variances between the three groups. Applying Welch's ANOVA gave F(2, 208.84) = 37.45, p<.001, thus a significant difference between the three groups exists. A post hoc Games-Howell test confirmed this (Table 1).

Table 1 - Games-Howell post hoc test results (group 1 = before Pepper explanation, group 2 = after Pepper explanation, but before physical examination, group 3 = after physical examination)

					95%CI	
I	J	Mean Diff. (I-J)	SE	p	LB	UB
1	2	-0.74	0.15	<.001	-1.09	-0.40
	3	-1.18	0.14	<.001	-1.50	-0.86
2	1	0.74	0.15	<.001	0.40	1.09
	3	-0.43	0.13	.004	-0.75	-0.11
3	1	1.17	0.14	<.001	0.85	1.50
	2	0.43	0.13	.004	0.11	0.75

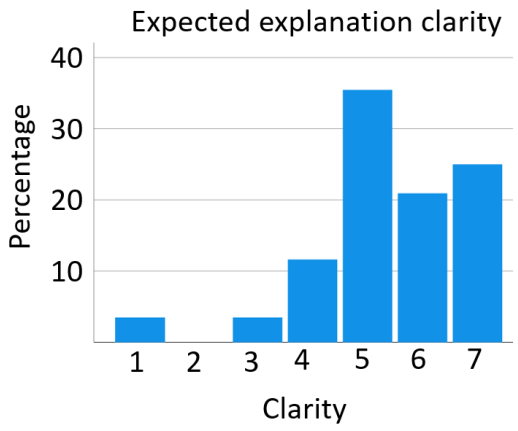

Figure 3: Expected clarity of the explanation by the robot (note: no participants gave a score of 2).

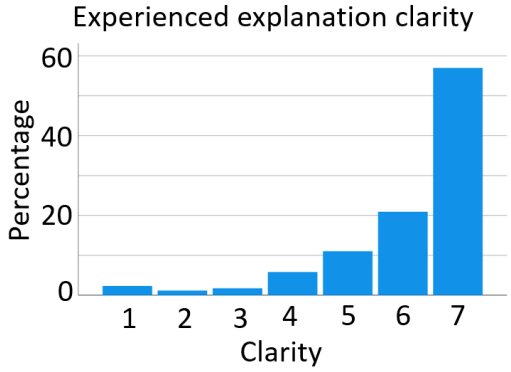

Figure 4: Experienced clarity of the explanation by the robot

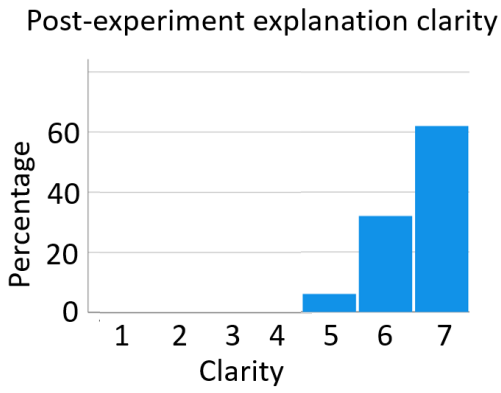

Figure 5: Explanation clarity after the participant has undergone the blood pressure and grip strength tests

5 DISCUSSION

The first hypothesis "Participants will find the medical test procedure as explained by the social robot clearer after explanation" is confirmed by this experiment. This means that a social robot may be a supportive and acceptable means to explain upcoming medical tests and procedures to patients.

The second hypothesis "Participants will find the explanation received from social robot clearer, when they have undergone the physical examination" was also confirmed by this experiment. The participants, when they looked back at the experiment, felt that their experience matched the explanation they had received beforehand from the robot.

The Pepper robot provides the explanations as well as asks the questions verbally. In addition the robot uses its tablet to show the questions, the answer buttons and the videos. This raises the question whether a tablet alone shouldn't suffice. However, Mann et al. conducted a study comparing the interaction between humans and robots or tablet delivering healthcare instructions [27]. They showed that participants had a more positive interaction with the robot they used for their study than participants had with a tablet. The use of the robot resulted in a higher trust, enjoyment and desire for future interactions.

Patients that will undergo a physical test and procedure may experience anxiety for the test and procedure or the intervention results [28]. Additional ways of providing information on the test and procedure, such as with a social robot, may reduce this anxiety. Social robots that, next to explaining, are also able to reliably measure anxiety on part of the patient, and are able to react to measured anxiety levels, might even improve the user experience. This could be a topic for future research.

Some remarks should be made regarding the preliminary conclusion of the robot's acceptance as an explaining device. First the novelty effect may have influenced the results, many participants said they had not interacted with a robot like Pepper before. Secondly, not all participants who started the interaction with Pepper (n=214) also finished it (n=172). There is no record of why participants did not complete the interaction. Given the dynamic situation of the festival, there can be many reasons not necessarily related to their opinion on the robot interaction.

In conclusion, this study gives an indication that social robots may be useful to explain medical tests and procedures. Further research is required to demonstrate that explanation by social robots leads to a lower anxiety towards these tests and procedures among patients.

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