Wedding Robotics: A case study

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***Abstract*—In this work, we propose to study a social robot in a wedding context, where it plays the role of a wedding ring bearer. We focus on the interaction with the audience, their expectations, and reactions, rather than in technical details. We collect data from 121 individuals belonging to two different groups, those who have seen the robot behaviour (live or recorded versions) and those who did not see the robot performance. We divide the study into three parts: i) the reactions of the guests at the wedding, ii) a comparison between subjects which were exposed or not to the robot behaviour, and iii) a within-subjects experiment where after filling a survey, they are asked to see the recorded robot behaviour. The guests reacted positively to the experiment. The robot was considered likeable, lively and safe by the majority of the participants in the study. The group that observed the robot's behaviour had a better opinion on the use of robots in wedding ceremonies than the group that did not observe the experience. This may suggest that a higher presence of robots in social activities will increase the acceptance of robots in society.**

***Index Terms*—humanoid robot, social robotics, human-robot interaction, social experiment, case study.**

I. Introduction

Human-robot interaction (HRI) is a challenging problem and an emerging research area (see [1] for a survey up to 2007). Robots can be a good solution in the future to fight against the loneliness of the elderly or to be companions in the daily life. Many works have exploited HRI in the area of assistive robotics. There are several ongoing research works where robots are used to help the elderly [2], [3] or interact with children in a paediatric hospital [4], or in a kindergarten scenario [5]. Moreover, entertainment robots are also proposed in the literature [6], [7], [8], [9] for gameplay and dance. Many of the works in HRI are focused on the technical problems of perception, decision-making, navigation and less on the interaction itself and on the human expectations. However, the interaction is made by two agents: the robot and the human being, so the human factor must be taken into account. To address this point, several human studies were developed for benchmarking the interaction in a human perspective (see [10] for a review up to 2010).

Social robotics is the field of study where robots behave as social agents. This field is gaining importance since robots are increasing their presence in daily environments and humans are sociable creatures who seek interaction. Human interactions are sometimes taken as a model to follow in this area. However, humans can expect different outcomes of the interaction with a robot, thus, it is important to improve HRI based on human expectations. Humans can see a robot within four interaction paradigms [11]: as a tool, as a cyborg extension, as an avatar or as a social partner. In this work, we proposed a humanoid robot as a wedding ring bearer. We focus on the interaction itself and less in the technical details and robustness of the robotic platform. We are interested in how the robot is accepted in this wedding scenario and how the demographic data influences the human expectation of the robots' behaviour and the interaction paradigms.

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Fig. 1: The NAO robot prepared for the wedding

II. Related Work

Robots for entertainment have been proposed and demonstrated in real scenarios for several decades now [12]. In the entertainment context, robots are machines that are designed to give an enjoyable experience for the human. A successful example is soccer robotics. There are various types of leagues from small to large size robots and also humanoids. However, to the best of our knowledge, there are no studies on the social aspects of soccer robotics and how humans get engaged and enjoy the experience. In Ming et al [9], it is proposed a robot able to play the rock-paper-scissors game with a human, exploiting a 3D depth camera and a microphone to acquire the human decisions. Again, the focus is on the technical aspects and not on the evaluation of the five human participants during the experiments, where the delay between each action was pointed out has the main issue of the interaction. Robots in theatres are also proposed in [6], [7]. In this HRI scenario, the robot plays the role of an actor interpreting a real play.

(a) (b) (c) (d) (e)

Fig. 2: NAO robot delivering the wedding rings. The whole video can be found at https://www.youtube.com/watch?v=KcMV-_VxztQ

In [6], it was proposed a play only composed of robots, however, an analysis of the success of the experiment, in the human perspective, was not present. In [7], the robot is on stage with other human actors and the goal was to play an actor role in a traditional manner. Once more, this work is focused on the design and software implementation and the HRI evaluation method is missing. In wedding robotics, there are some examples of robots as wedding ring bearers, from aerial to mobile robots. An industrial robot, ABB IRB 120, is used to deliver the rings to the bride in [13]. Drones are used in [14], [15] to give the rings to the grooms. Mobile robots are also present in [16], [17], [18]. In [16] a bomb disposal robot served as the ring bearer and in [17]. Along with a review of robotic ring bearers, the most impressive fact was the robot was used to lead the wedding. However, in none of the described situations, a humanoid robot was used as a wedding ring bearer.

A. Our contribution

In this work, we propose a humanoid robot as a wedding bearer. To the best of our knowledge, this is the first research work that exploits a humanoid robot in a real wedding situation and studies the reaction of the audience to the experience. Moreover, we compare the audience's opinion with subjects who did not see the robot delivering the wedding rings, in order to assess the impact of the actual physical realisation of the experience.

III. Experimental Design

A. Social Context

The experiment was performed at a religious Portuguese wedding with almost 200 guests (including children). The NAO Robot (see Fig. 1) was used as a wedding ring bearer and around 25% of the guests have agreed in filling a questionnaire about the robot performance. A similar online survey was made to individuals which were not present in the wedding and did not see the robot performing this particular task.

B. Design protocol

The research protocol and the evaluation method was designed based on recommendations found in [10]. For instance, the chosen design for the study and the *a priori* target number of participants to find statistically significant results. Moreover, we follow all the steps recommended by Bethel et al., from developing the study concept (a robot wedding ring bearer), choosing the suitable environment (a real wedding environment), the type and number of robots used (one humanoid robot - NAO robot) and conducting the study following the devised protocol. A humanoid robot (see Fig. 1) was used to perform the delivery of the wedding rings in a real wedding scenario. The goal of this work is to focus on the human-robot interaction and not in the implementation robustness or technological innovation. The robot asks for the wedding rings to an assistant person, grasps them and walks towards the groom to deliver the rings. The movements were pre-programmed and the only feedback read from the environment was the tactile sensors on the head, either to start the behaviour (receiving the instruction from the assistant person) or to open the hand to release the rings (received by the groom). In Fig. 2, one can see the whole movement of the robot. The study is divided into three parts: (i) an evaluation of the reactions of the guests at the wedding using the GodSpeed questionnaire series [19], (ii) a between-subjects experiment where we compare the opinions of two types of subjects – those who saw the robot and those who did not – regarding the use of robots in a wedding context, and (iii) a within-subjects experiment where we compare the subject's answers before and after seeing a movie of the robot delivering the wedding rings. The assessment of the subjects' reactions was done through an online survey written in Portuguese and disseminated over the Internet.

IV. Implementation

A. The robotic platform

The humanoid robot NAO (see Fig. 1) is used in this research work. NAO is a 58 cm high humanoid robot equipped with RGB and IR cameras (vision sensing) and an IMU on its chest (a vestibular system). It has 25 degrees-of-freedom (DoF) including moving arms, legs, head, and feet, and it can interact with humans through touch sensing (in the head, hand and feet) and acoustic signals (it has microphones and speakers onboard). NAO can be programmed in C++ or Python language as well as with a proprietary block diagram language, the Choregraphe software, distributed by Soft Bank Robotics (see Fig 3).

B. Programming

In this experiment, it was used the proprietary block diagram language since it is a simpler method to deploy a working routine. The block diagram of the designed program can be

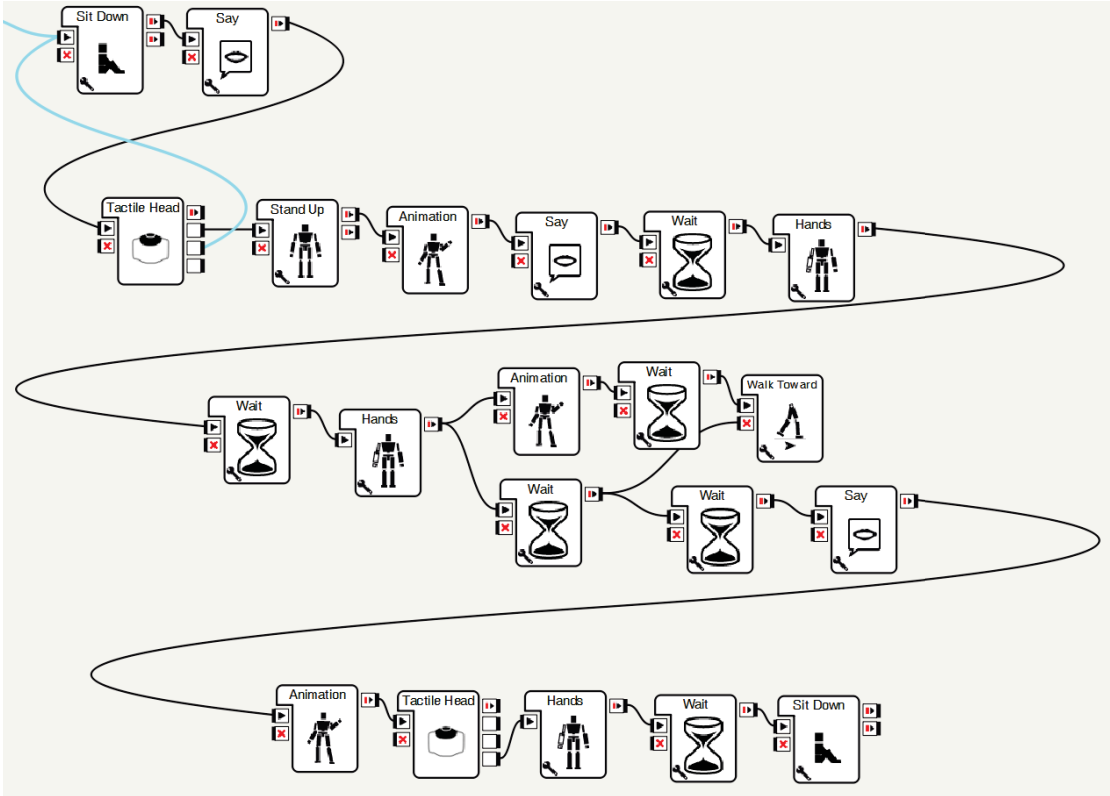


Fig. 3: The instructions given to the humanoid robot NAO using Choregraphe software.

seen in Fig. 3. The robot will start in a sit down idle position and wait for a command given through the touch sensor on the head (*Tactile Head* block, in the second row). The command is given by the assistant person at the precise time when the rings should be delivered to the groom. The *Animation* Block encodes the movement of the hand; Raising it, when asking the assistant for the rings or delivering them to the groom. The *Hands* block controls the open and closing of the fingers and is used to grasp or to release the rings. The other blocks in the diagram are off-the-shelf routines distributed with the Choregraphe software, whose documentation can be found in http://doc.aldebaran.com/.

The experiment was developed with Choregraphe 1.12 compatible with NAOqi 1.12. The generated file (nao-wedding.crg) for the behaviour described above is available online for download in a repository on GitHub (https://github.com/vicentepedro/nao-wedding).

V. Results

A. Reactions at the wedding

The overall reaction of the audience, in a qualitative evaluation, was positive. They were surprised to see a robot as a wedding ring bearer when, usually, it is a child to play this role. From the informal conversations with wedding guests, many referred that robots will likely be used in the future in wedding scenarios.

It was not possible to formally inquiry all the 200 guest, so the authors have collected a sub-set of fifty-four (54) subjects to perform the study.

The Godspeed[1] questionnaire series [19] was devised to measure users perception of robots in terms of Anthropomorphism, Animacy, Likeability, Perceived Intelligence, and Perceived Safety. It was used in this work to evaluate the perception of the human subjects to the role of the NAO robot in the wedding context. It is composed of 24 Likert-scale questions, from 1 (negative opinion) to 5 (positive opinion), regarding the topics shown in TABLE. I.

The overall result of the questionnaire (median value and the Inter-Quartile Range (IQR) of each question) can be seen in TABLE. I. Statistically speaking, 13 questions were answered by the subjects with a median value of 4 (good), and 11 questions were answered with a median of 3 (average). The most frequent IQR (18 questions) was 1. The answers with a media of 3 reflect and indecisive opinion of the subjects since 3 is central value of the Likert-scale questions. These "uncertain" opinions were more frequent in the areas of Anthropomorphism and Perceived Intelligence. The more positive answers (median 4) were observed in the areas of Likeability, Perceived Safety, and Animacy, respectively. Therefore, the robot was perceived as a safe and enjoyable agent during the

[1]The authors of the original work [19] named the series "Godspeed" since it is intended to help creators on the development of their robots

Anthropomorphism		
Question	*Median*	*IQR*
Fake-Natural	3	1
Machinelike-HumanLike	3	1
Unconscious-Conscious	3	2
Artificial-Lifelike	3	2
Moving rigidly-Moving elegantly	3	1
Animacy		
Question	*Median*	*IQR*
Dead-Alive	4	1
Stagnant-Lively	4	1
Mechanical-Organic	3	1
Artificial-Lifelike	3	0.75
Inert-Interactive	4	1
Apathetic-Responsive	4	1
Likeability		
Question	*Median*	*IQR*
Dislike-Like	4	1.75
Unfriendly-Friendly	4	1
Unkind-Kind	4	2
Unpleasant-Pleasant	4	1
Awful-Nice	4	1
Perceived Intelligence		
Question	*Median*	*IQR*
Incompetent-Competent	4	0
Ignorant-Knowledgeable	3	1
Irresponsible-Responsible	3	1
Unintelligent-Intelligent	4	1
Foolish-Sensible	3	1
Perceived Safety		
Question	*Median*	*IQR*
Anxious-Relaxed	4	1
Agitated-Calm	4	1
Quiescent-Surprised	3	1

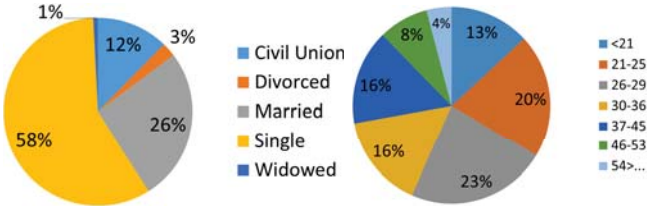
TABLE I: Results of the wedding guests on the Godspeed questionnaire series. It is composed of 24 Likert-scale questions, from 1 (negative opinion) to 5 (positive opinions) divided into five (5) areas. The central tendency (median) and the variability (IQR) for each question can be seen. The Likeability was the section with higher median (*median*=4).

experiment.

In a close look upon some of the questions, one can see some higher values of variability. In the Anthropomorphism section, the question about consciousness and artificialness have divided the opinions of the subjects with a median value of 3 and a high variability of IQR = 2. Moreover, the questions Dislike-Like and Unkind-Kind, belonging to the Likeability section, have a median value of 4 and an IQR of 1.75 and 2, respectively, which can mean that the subjects either like a lot the robot or are somehow indifferent (the third quartile was 5 in both questions and the first quartile was 3.25 and 3, respectively). Regarding the section Perceived Intelligence, the Incompetent-Competent question has a median value of 4 and a small IQR (zero) which can be correlated with the general opinion of the robot being competent in the task of delivering the wedding rings.

B. Between subjects design experiment

The data for this experiment was collected through an online survey filled by 121 individuals. The survey was composed of some questions regarding demographic information and Likert-scale questions from 1 to 6 in order to assess the



(a) Civil Status (b) Age interval

Fig. 4: Civil Status and age interval. Best seen in colour.

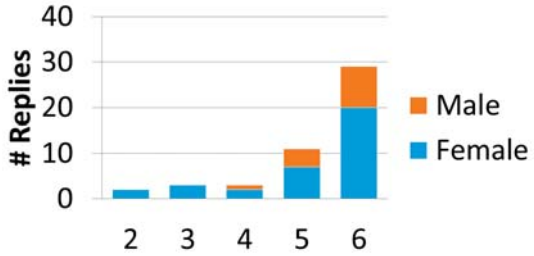
perception of the subjects for a robot wedding ring bearer. We asked the subject three particular questions on the online survey: i) "Did you or would you like to see a robot as a wedding ring bearer?", ii) "Would you use a robot as a wedding ring bearer?" and iii) "Do you prefer a robot or a child as a wedding ring bearer?". The participants were divided into two groups. The first group (Group 1) was composed of 54 subjects who either were at the wedding or saw the recorded movie of the robot afterwards. The second group (Group 2) had a size of 67 persons who neither attended the wedding ceremony nor saw the live recorded movie of the robot wedding ring bearer. The participants' average age was 31.71 years, with a median value of 28 years and a mode of 25 years old. Moreover, the majority of the inquiries had Portuguese nationality and around 50% of the participants were female with contact with technology.

The civil status and the age interval of the participants can be seen in Fig. 4. The majority of the subjects were single and under 36 years old.

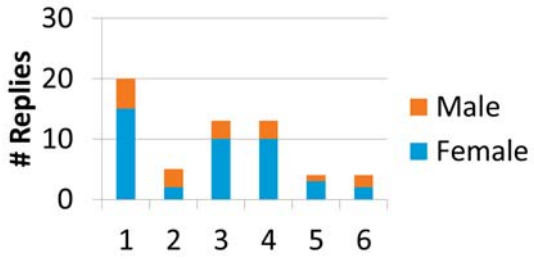
The experiment showed some statistically significant differences between the two groups.

The graphical representation of the answers to the first question (like *vs* not-like) can be found in Fig. 5. The differences between the two groups are clear: the first group have liked to see the robot delivering the wedding rings and the second group would not like to see it. We also see a tendency in the female gender to respond with lower values when compared to the male subjects. The statistical analysis of the results can be found in TABLE II. We used the non-parametric Mann-Whitney U test to show the statistic relevance of the studied independent variable: be exposed to a robot delivering the rings. The Mann-Whitney U test is a non-parametric test which does not assume a particular distribution (e.g normal distribution) for the data which, in the presence of ordinal data (e.g a Likert-scale question), is fundamental for a correct statistical evaluation. Moreover, the null-hypothesis (H_0) assumes there is no different between the median values of the two sets/groups. In TABLE II, H_0 was rejected with a p-value smaller than 0.001 and the effect of being exposed to the robot wedding bearer cannot be discarded.

In the second question (use *vs* not-use) the tendency to a positive opinion of the Group 1 subjects, i.e. towards the use of a robot in a wedding context, is maintained. In Fig. 6 the answers of both groups can be seen. Subjects belonging to the

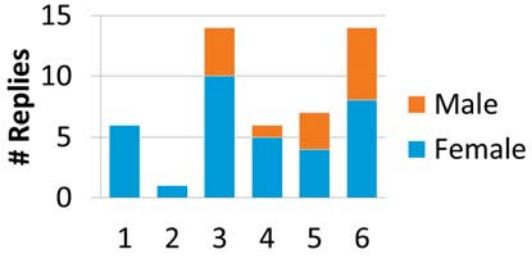


(a) Group 1: Attended the wedding or saw the movie

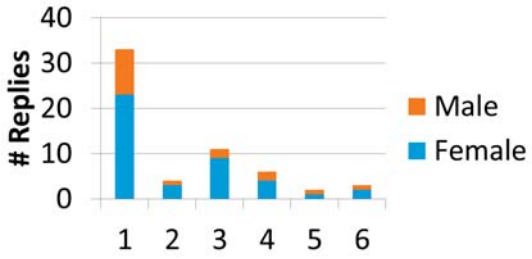


(b) Group 2:Neither attended or saw the movie

Fig. 5: Answers to the question: "Did you or would you like to see a robot as a wedding ring bearer?", where, 1 corresponds to "No, I did not" and 6 to "Yes, I did".



(a)



(b)

Fig. 6: Answers to the question: "Would you use a robot as a wedding ring bearer?", where 1 corresponds to "very unlikely", 6 to "very likely"

	Median	Mode	IQR	Mann-Whitney U test
Group 1	6	6	1	$p < 0.001$
Group 2	3	1	3	

TABLE II: Statistical analysis of the question: "Did you or would you like to see a robot as a wedding ring bearer?", where, 1 corresponds to "No, I did not" and 6 to "Yes, I did".

second group keep a quite different sight about a robotic ring bearer compared with Group 1. A statistical analysis is shown in TABLE III. As in the first analysed question, we applied a Mann-Whitney U test comparing the two Groups median and we reject the null-hypothesis with a p-value lower than 0.001.

In the third question (robot *vs* child), the results show also a statistically significant difference between the two groups, although not as strong as in the previous two questions ($p\text{-}value = 0.0117$). The group 1 chooses (mode) the option "I prefer a child rather than a robot" and the second group chooses (mode) the option "I only prefer a child".

C. Within-subjects design experiment

The subjects from the previous experiment who did not see the robot performance were asked to respond again to the questionnaire after seeing the recorded movie. Unfortunately, it was not possible to convince all the participants of the previous study to fill the online form again. Therefore, we collected 31 answers of the initial 67 subjects.

	Median	Mode	IQR	Mann-Whitney U test
Group 1	4	3	3	$p < 0.001$
Group 2	1	1	2	

TABLE III: Statistical analysis of the question: "Would you use a robot as a wedding ring bearer?", where 1 corresponds to "very unlikely", 6 to "very likely"

Although the median values after watching the video were higher (compared to the first assessment), it was not possible to reject the null-hypothesis in the questions evaluated in Section V-B due to the small number of subjects in this part of the study. Anyway, it was possible to detect a high correlation between the paradigm associated by the participants to this HRI (Avatar, Tool, Sociable Partner or Cyborg extension [11]) with the willing of using a robot as a wedding ring bearer. In Fig. 7, one can see that those who see the robot as a sociable partner have a higher probability of using it as a wedding ring bearer. Moreover, the perception of the robot's size could be one of the reasons for the mismatch between the results in this section and Section V-B. The relationship between the answer to the question "Did you liked to see the robot as a wedding ring bearer?" and the perception of the robot size can be seen in Fig. 8. The ANOVA analysis revealed a statistical difference in the evaluation of the robot, with an F-statistics=6.88 and p-value=0.0036, depending on the robot's size perception. Furthermore, in Fig. 8 can be seen the three used answers ("Ideal", "Should be larger" and "Too small") and the classification of the subjects who liked the least, which classified the robot's size as "Too small".

VI. Conclusions and Future Work

In this work, we have presented a study of a social robot in a wedding context, where it plays the role of a wedding ring bearer. The qualitative reaction of the audience at the wedding

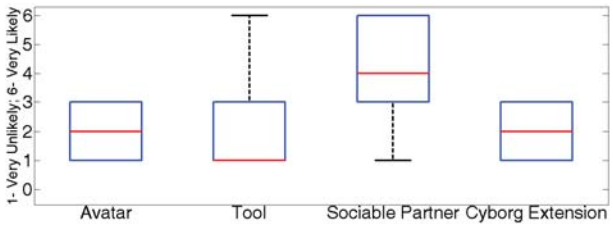


Fig. 7: The relationship between the chosen paradigm and willing to use the robot as wedding bearer.

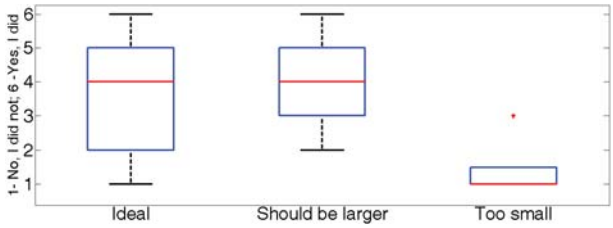


Fig. 8: The relationship between the evaluation of the robot wedding ring bearer and the perception about the robot's size.

was quite positive with a reasonable result in the GodSpeed questionnaire series. The comparison between subjects which attended the wedding or saw the recorded videos afterwards, with those who were not exposed to the robot, has shown a statistically relevant difference. According to this difference, we can conclude that seeing a robot delivering the wedding rings produces a reasonable effect in the subjects' reactions towards robotic wedding bearers. Moreover, the chosen paradigm by the subjects for this HRI experience (Avatar, Tool, Sociable Partner or Cyborg extension) and the perception of the robot's size will influence the probability of using a robot as a wedding ring bearer, suggesting that taller robots can be more suited to this application. The wedding is a religious event where people tend to be conservative about the historical traditions. The fact that the audience had a good reaction to the experience is a relevant indicator that robots can be part of our daily society in a near future. As future work, we plan to increase the sample size of the within-subjects experiment, which was not enough to reject the null-hypothesis. Furthermore, we would like to implement some of the ideas given by the subjects in the survey, e.g, "using a robot as a DJ at the wedding", "show where is the guest's table" or "be an assistant for the guests in answering frequently asked questions (FAQ)". Other social contexts can be also exploited to assess the general opinion of robotics in the society and to understand if the observation of the robots in actual social contexts can improve the opinion of persons towards the use of robots, as happened in the current study. We conjecture that with an increased presence of robots in our daily life, they will be more accepted and more trustworthy by humans.

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