Getting to know Kaspar
Effects of people's awareness of a robot's capabilities on their trust in the robot

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Abstract— **In this work we investigate how humans' awareness of a social robot's capabilities affect their trust in the robot. We present a user study that relates knowledge on different quality levels to participants' ratings of trust. Primary school pupils were asked to rate their trust in the robot after three types of interactions: a video demonstration, a live interaction, and a programming task. The study revealed that the pupils' trust is not significantly affected across different domains after each session. It did not appear to be significant differences in trust tendencies for the different experiences either; however, our results suggest that human users trust a robot more the more awareness about the robot they have.**

I. INTRODUCTION

This work uses the concepts of trust and awareness, which are somewhat interlinked. Trust has been researched in the robotics field from many different angles. In general, the goal for Human-Robot Interaction (HRI) trust studies is to see if the human is able to trust in the robot in different scenarios, and what characteristics will affect the trust in one direction or another. In social robots, specifically, the trust in a robot companion is of critical importance to model a smooth and safe interaction. Regarding awareness, many different definitions exists in literature, but we chose one of the most widely used definitions, whereby awareness will be defined as how a subject understands the actions of another subject or subjects, in this case a robot. This understanding allows the subject to make a mental model of the abilities and capabilities of others, thus creating certain expectations of how the others would react in different situations. As we can see, this mental model will impact as well on the trust that the subject will have in the robot. In this study, we present and discuss the effects of different levels of awareness of a robot in primary school children related, and how it affects their trust in the robot. This study was carried on in the context of the UK Robotics Week 2018 [1]; this event allows students in the United Kingdom to be involved in modern technologies via different activities related with robotics, such as workshops, lectures, lab visits, etc. We conducted this research in two local schools, a primary and a secondary school. We analysed the secondary school pupils perceptions of trust towards a different robot, Pepper, in previous work [1]. In this study we report on results involving the child-size humanoid robot Kaspar. Note, a comparison between the results of both studies goes beyond the scope of this paper. Our hypothesis for the current study is that modifying the level of children's awareness of the robot by increasing the children's understanding the robot's different capabilities, will affect their trust in the robot. We can predict two different possible outcomes. Being more aware of what the robot actually can and cannot do, trust may decrease. Alternatively, if the rising level of awareness also corresponds with an increase of the likeability of the robot, it is possible that the children tend to trust in it more. The remainder of this article is structured as follows. We will cover the background for the work in Section II. The approach taken in our experiment is presented in Section III, whereas in Section IV we will discuss our findings. Finally, Section V will highlight our main contributions.

II. BACKGROUND

As trust is a widely researched phenomenon in Human-Human, Human-Computer and Human-Robot Interactions, there are different definitions of trust. In this study we adopted one of the most prevalent definitions [2]: "Trust can be defined as the attitude that an agent will help achieve an individual's goals in a situation characterised by uncertainty and vulnerability" [3].

Trust is constructed from a perception of ability, benevolence and integrity [4]. Higher trust is associated with the perception of higher reliability [5]. Rossi et al. [6] showed that the perceived trust of the human in a robot drops drastically when a robot presents behaviours that can lead to severe consequences. Moreover, other aspects can affect the peoples' perceptions of robots, such as the embodiment of a robot [7], [8], [9], system transparency and adaptability [10], and a deeper awareness of a robot's functionalities and operation.

In Human-Robot Interaction, Atkinson et al. [11] suggested that humans' trust in robots, and consequently a successful interaction, increases proportionally with a greater shared awareness of the agents involved, activities, and situations between human users and robots. Tseng et al. [12] developed a human awareness Decision Network model where the robot adapts its behaviours in response to the different feedback of the user for meeting her expectation.

Moreover, a lack of human awareness in robots might lead the person to overtrust the robot and its functionalities. Abney et al. [13] define overtrust as the willingness of a person to accept the risk of delegating a task to a robot if 1) she believes that the robot is able to complete it or 2)

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her expectation is that the robot is able to mitigate the risk. Borenstein et al. [14] found that 62% of paediatric patients, their parents, and other caregivers would trust a robotic exoskeletons to be able to handle dangerous situations even if the robot did not have that capability. Booth et al. [15] investigated participants' responses to a robot's request to enter a secure-access student dormitory. In their study, the robot was acting either as an anonymous robot, or as a food delivery robot. They observed that participants were more likely to let the food delivery robot enter the building or in situations when they were in a group.

In Human-Robot Interaction several definitions of "robot awareness" exist [16], [17], [18], [19]. In this work, inspired by Drury et al.'s work [18], we define HRI awareness simply as "the human understanding of the capabilities and functionality of a robot: to be aware of environment and people presence around itself; to interact with one or more humans according social conventions; to perform a specific activity; and to have artificial intelligence."

In [1], we observed that children' awareness of being able to program different robots' behaviours led them to believe that the robot Pepper is able to handle critical situations and cognitive tasks, such as helping them with their homework. Moreover, the live interaction with the robot increased the participants' willingness of having Pepper in their homes.

Finally, we should note the role emotions play in humans' trust and acceptance of a robot in a Human-Robot Interaction. Indeed, exhibition of socially interactive behaviours is a key factor in human acceptance of an autonomous robot [20], [21]. A robot that is able to show emotions helps to facilitate the interactions with a human [22].

Ficocelli et al. [23] defined a model to determine the appropriate emotions that a robot needs to show to elicit the well-being of a patient in an assistive interaction. Rincon et al. [24] presents a robot that was able to have non-verbal communications, like perceiving and displaying human emotions, to elicit empathy in a daycare centre.

Syrdal et al. [25] showed that a Pioneer robot with dog-inspired affective cues communicates a sense of affinity and relationship with humans. Song et al. [26] used a robot that was able to express emotions through colours, sounds and vibration to solicit a more natural interaction between people and robots.

III. APPROACH

The focus of the event was both on the programming of a humanoid robot called Kaspar via the Scratch programming language using body movements, gesture and other non-verbal cues, and on collecting pupils' perceptions of the robot during three different levels of interactions by means of questionnaires. While the programming through Scratch has been described by Moros et al. [27], in this paper we focus on how the pupils' trust in the robot changed, depending on the level of interaction with, and thus awareness of the robot.

The pupils were exposed to three different types of HRI: a video HRI presentation, a real live HRI interaction and a HRI session programming the robot. As a concrete goal, during the programming sessions, pupils were asked to focus on the implementation of emotions in HRI. We collected pupils' perceptions of the robot through questionnaires.

A. Method

We observed and analysed participants' behaviours during three different levels of interactions with the robot Kaspar.

Kaspar is a fully programmable humanoid robot designed and built by the Adaptive Systems Group at the University of Hertfordshire[2]. This robot has the size of a small child, 22 DOF, and it is specifically designed to help children with autism to help them to interact and communicate with other people. The first version of Kaspar was built in 2005, but since then many improvements have been made and features have been refined. The robot has been part of several international projects, and also has been used in schools as well as in private houses and other research facilities ([28], [29], [30]).

Fig. 1. A child interacting with the humanoid robot Kaspar.

Participants were asked to watch a video of the Kaspar robot, where they saw the robot interacting with a member of the research team. The video presented Kaspar and the children could see some of the capabilities. Then, they were presented with a real Kaspar robot, in demo mode, which was interacting with them. They were allowed to watch it, but the robot was controlled by a research team member. During these first two interactions, the robot was teleoperated, but from the view of the children it seemed autonomous. Finally, they had a face-to-face experience with Kaspar, which they programmed and then tested different behaviours on it. Participants were tested together during the first two interactions, while they were tested divided by their class groups for the programming section. The interactions were not randomised to measure the pupils perceptions of trust on increasing levels of awareness of the robot's capabilities. In order to analyse the interactions between the human participants and the robot, we asked the participants to answer a questionnaire at the end of each activity. All participants received a certificate of participation at the event.

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[2] `http://adapsys.cs.herts.ac.uk/`

B. Procedure

The event is organised in three different stages: 1) meeting the humanoid robot Kaspar, 2) interacting with Kaspar, and 3) programming Kaspar. In the first part of the event, pupils watched a brief introductory video in which an actor interacted with the robot. Then they were given 10 minutes to familiarise themselves with the system. Finally, we asked the pupils to programme 5 emotions. We used the theme of emotions to provide a pleasant and interesting experience in a robot storyteller scenario. Moreover, emotions are natural human behaviours and "they are parts of the very process of interacting with the environment."[31, page 51]. Frijda et al. also propose that emotions have direct or indirect social consequences on the individuals involved in the HRI.

Humans can feel several emotions however, Ekman [32] described in his work six universally recognised basic emotions: anger, disgust, fear, happiness, sadness and surprise. We chose the emotions (happy, sad, surprised, angry and silly), we believed the pupils might relate better to, inspired by Ekman's [32] findings. While "silly" might not be considered an emotion as such, we found it suitable to include since the event was meant to be a fun experience for the primary school children.

The children were also asked to prepare a small story using the emotions created to encourage them to explore the possibilities of linking emotions in a real-life scenario. Pupils told the story to the rest of the class.

C. Participants

We conducted the event in a local primary school in Hatfield (Hertfordshire, United Kingdom). The event was conducted over a week in the school and participants were tested in their age year and class groups. We recruited 172 children, aged 7 to 10 [mean 8.87, std. dev. 0.85], 53% boys and 47% girls, and all had previous experience using the Scratch programming language.

IV. RESULTS

As part of the questionnaire, we asked about participants' previous experiences, their perceptions and expectations towards the Kaspar robot. All participants, but one, declared to not have any previous experience with this robot. The only participant with previous experiences with Kaspar took part in a previous study of our research group.

A. Questions Q3: Companionship

Participants expressed their willingness of having Kaspar in their home through a Yes/No/Maybe measure. The results of our study show that participants' likeability of Kaspar decreased after each interaction. After the video presentation, the majority of participants (60.67%) would like to have Kaspar in their home, 27.18% was uncertain if they would have liked to have Kaspar in their home and only 12.15% would have not preferred to have the robot. After the live HRI, the majority of participants (45.1%) expressed the preference of having Kaspar in their home, a preference that decreased (41.62%) after the programming HRI. After the live and programming HRIs, 31.2% and 34.7% pupils respectively did not want Kaspar in their home. While 23.12% participants were uncertain in their willingness of having Kaspar in their home after live interaction and programming session.

TABLE I

PAIRED SAMPLES T-TEST ANALYSIS COMPARING THE MEANS OF PARTICIPANTS' RESPONSES TO QUESTION Q3 ACCORDING TO THE THREE DIFFERENT HRI EXPERIENCES. FOR EACH PAIR OF INTERACTIONS IT SHOWS THE T VALUES, P-VALUE CORRESPONDING TO THE GIVEN TEST STATISTIC T, THE UPPER AND LOWER BOUNDS OF THE CONFIDENCE INTERVAL.

Q3 (kaspar in home)	**t**	**p**	**95% CID**
video - programming	$t\_171 = -6.471$	$p < 0.001$	$-0.539 - -0.287$
live - programming	$t\_171 = -5.225$	$p < 0.001$	$-0.473 - -0.213$

We also found a statistically significant correlation between the willingness of having the Kaspar robot in their home and the effects of the interaction ($p(2, 342) < 0.001, F = 27.298$). We performed a t-test analysis on the interactions' paired samples and we found that there are significant average differences between the participants' perceptions of the robot and the type of interaction. On average, the ratings were lower after the programming HRI than both video and live HRIs (see Table I). We did not find any significant differences while comparing the video and live interactions' results ($p = 0.152$).

B. Questions Q4-Q7: Trust in the robot

Participants answered questions Q4-Q7 using a 5-point Semantic Differential Scales where 1 corresponds to "definitely no" and 5 corresponds to "definitely yes". All the ratings with values less then 3 were categorised as a negative response, with values equal to 3 were considered as uncertainty and values more than 3 were categorised as positive responses.

Question Q4 (helping with homework): We observed an increase of participants' trust in the robot after the live interaction and a decrease of their trust after the programming interaction. After the video HRI, the majority of participants (53.8%) would trust Kaspar to be able to help with their homework, and 23.12% were uncertain in the robot's ability of perform such task. After the live and programming HRI, the majority of participants that trusted Kaspar did not change (53.8%) while the percentage of uncertain participants increased respectively at 26% and 25.4%. The remaining participants were not completely confident in the robot (respectively at 19.7% and 20.2%).

We did not observe a statistically significant correlation between participants' trust in the robot to be able to help with participants' homework and the different types of interaction ($p > 0.5$).

Question Q5 (alarm clock): We asked participants if they trusted robot to be able to wake them up for going to school. We observed that participants were divided between trusting the robot (39.9%) and not confident in their trust in the robot (33.53%) after the video interaction. The live interaction with a real robot increased their trust in the robot (43.9%) and 27.18% were unsure if the robot was able to complete the task. The pupils' perceptions of the robot's capabilities changed slightly again after the programming session, 42.8% of participants declared to trust the robot with the task, while 31.21% remained uncertain.

We did not find a statistically significant correlation between participants' trust in the robot to be able to wake them up for going to school and the different HRIs they were tested with ($p > 0.5$).

Question Q6 (danger warning): We observed that participants were skeptical about the robot's ability of warning them of a danger after the different HRI interactions. Indeed, the majority of participants (50.9%, 54.4% and 47.4% respectively after the video HRI, live HRI and programming HRI trusted the robot. Their uncertainty of trusting the robot (21.4%) decreased slightly after the live interaction (20.23%) and increased again after the programming interaction (25.43%). Instead the participants who did not trust the robot remained stable (26.6%).

Participants' trust in the robot to be able to warn them of a danger was not found positively correlated with the three different HRIs ($p > 0.5$).

Question Q7 (danger help): Similarly to question Q6, participants were not completely confident in the robot's capability of helping them in case of danger after the different HRI interactions. We noticed that participants trusted more the robot after the programming HRI (47.4%) compared to both the video (40.5%) and live HRIs (43%). Interestingly, while the participants who did not trust the robot varied slightly after each interaction (33%, 29.5% and 31.2% respectively), we observed a bigger variations in those who were uncertain about the robot's ability of completing the task (26%, 27.2% and 20.8% respectively).

We did not observe any statistically significant correlation between the pupils' trust in the robot's capability of helping them in case of danger and the HRIs they were exposed to ($p > 0.5$).

Discussion

We did not find any statistically significant differences in the results of this study concerning the pupils' perception of trust in the robot's capabilities. We observed that pupils tendentially believed to be able to program the robot to handle the dangerous situations themselves, or have someone else available to program it for them. However, they trusted the robot to be able to do their homework, to wake them up to go to school, and to handle dangerous situations regardless their awareness of the real potential and limitations of the robot. Indeed, when we asked the participants to rate their trust in the robot in waking them to go to school, the live and programming interactions had a greater effect on their perception of trust than the video interaction. According to Deutsch [33], risk-taking and trusting behaviour are different sides of the same coin, and a person is willing to take a risk only if the odds of a possible positive outcome are greater than those for a potential loss. However, the perception of the risk might have been mitigated by motivations such as curiosity and fun [34]. Indeed, several pupils expressed their curiosity about Kaspar's characteristics and potentialities writing queries for the experimenter in the open comment sections. For example, participants asked about the material used for the robot's skin, the age of the robot and the possibility of having different hairstyles. Two pupils also asked if there was a female version of Kaspar. Pupils also enjoyed the interactions with Kaspar (see also Section IV-C.

C. Questions Q8-Q10: Programming Kaspar

At the end of the programming interaction, we asked participants to rate their experience of programming the Kaspar robot.

Participants answered questions Q8-Q10 using a 5-point Semantic Differential Scales where 1 corresponds respectively to ”very boring”, ”very hard” or ”definitely no” and 5 corresponds to respectively ”very fun”, ”very easy” or ”definitely yes”. All the ratings with values less then 3 were categorised as negative response, with values equal to 3 were considered moderate and with values more than 3 were categorised as positive responses.

Question Q8 (fun): The majority of the participants (95%) enjoyed programming Kaspar. Less than 2% thought it was Boring or Very Boring, found in two boys from the older grade and one girl from the younger grade, while 3.41% gave a moderate feedback.

Question Q9 (simplicity): At the question how easy it was for them to program the robot, 75% expressed a quite positive response, two children left the question blank, and 6% thought it was hard. The remaining participants gave a moderate response.

Question Q10 (recurrence): The majority of children gave a positive feedback (87%). Only two percent prefer to not repeat the experience, however they enjoyed programming the robot. The remaining participants (12%) expressed a more moderate response.

V. CONCLUSIONS

During the event, children successfully familiarised themselves with the scientific field of social robotics. The majority of participants stated they were happy about their interactions with the robots and the programming activities.

Our study shows that participants' awareness of the robots' real potential and limitations affected their perceptions of the robot, but not their trust in it. In particular, participants' awareness of being able to program different robots' emotions and behaviours decreased their likeability of the robot.

We believe that their perception of the robot might have been affected also by the embodiment of the robot. While, as discussed in Section II, trust is strongly associated with the perception of reliability and willing to take a risk [5],

[33], other aspects such as the appearance, type, size and proximity of a robot might also affect the user's perceptions of the robot [35], [36]. Indeed, Kaspar looks like a child, it has minimal facial features and he is not able to walk.

Contrary to our expectations, we did not find any significant differences in trust tendencies for the different HRI conditions. However we observed that the awareness of real capabilities of the robot, acquired during the programming phase, mitigated the negative participants' perceptions of the video interaction with the real robot. Our results suggest that the higher familiarity in programming the robot might lead them to believe that the robot is able to warn and help them in case of a danger, or wake them up for going to school.

Future work will compare the results of this study and those obtained by the study in the secondary school. Moreover, we aim to integrate these findings to investigate how an interactive, trustworthy relationship can be established and preserved between human users and their robotic companions in short-term and long-term interactions.

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