The Effect of Affective Robot Behaviour on the Level of Attachment After One Interaction

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Abstract— **Becoming emotionally attached to an assistive robot may have an impact on one's behaviour towards that robot. Therefore, it is important to investigate when attachment occurs and what strengthens it. This study investigated whether people can become attached to a robot after a single interaction, and whether the level of attachment differs according to the affective behaviour of the robot. No significant differences were found for the affective behaviour of the robot. This indicates that people do not become attached after a single interaction with a robot, and that affective behaviour does not influence attachment. However, non-significant differences and a low number of participants are reason for future research.**

I. INTRODUCTION

The number of older adults and their demand for care is growing, but the capacity to supply this demand is not [1]. Therefore, robots are being considered as a possible solution to meet the growing demand of care for older adults that cannot be met by the small number of caregivers. Before social robots can become useful additions to caregivers, the effects on older adults interacting with such a robot should be known. Becoming attached to a robot can provide benefits (e.g. alleviate loneliness and improve well being), but also disadvantages (e.g. increased dependence of the robot). The robot's affective behaviour may have an influence on this level of attachment, since affective behaviour results in a more natural interaction with the robot. However, the user may be deceived by this affective behaviour of the robot and raise false expectations of its abilities. Therefore, it is important to establish whether people become more closely attached to an affective robot with respect to a non-affective robot. This study aims to provide an impression to help planning a study regarding level of attachment of older adults to a social robot. It investigates whether there is a difference in level of attachment to a robot depending on the robot's affective behaviour after a single interaction.

II. BACKGROUND

The fact that people react to computers as social actors [2] is an indicator that they can become emotionally attached to machines and robots [3], [4]. If emotional attachment to a robot is high, the usability of this robot is perceived more positively and the intention to use it in the future is higher [5], [6], [7], resulting in a higher level of acceptance of this robot. Concerns of becoming emotionally attached to a machine or artificial agent (e.g. a too high level of dependency), have been raised at a theoretical level [4]. Therefore, the idea of becoming attached to a robot is not always welcomed. An example of this was found in a survey, where less than half of the participants thought it was acceptable for a child with Autism Spectrum Disorder to become attached to a robot [8]. Therefore, when and how attachment to robots occurs, and the consequences of this attachment, should be thoroughly investigated.

People have researched the level of attachment towards an assistive robot in the past, for example Weiss et al. [9] investigated whether adults and children could become emotionally attached to the robotic dog AIBO. They found that children became emotionally attached to the robot rapidly, where adults seemed to need a longer lasting interaction to form their first impression. However, as stated in the paper most adults observed the children that were interacting with the robot and did not interact with the robot themselves. This may have had an influence on the different outcomes for children and adults. Also, the number of adults participating in this experiment was far less than the number of children (18 versus 129) which may have had an influence as well. A different study that investigated attachment, which was performed by Sung et al. [5], found that people gave their Roomba vacuum cleaner a nickname and thought of it in terms of 'he' and 'she' instead of 'it'.

However, the studies mentioned above used non-anthropomorphic robots for their research. According to Weijers [10], it depends on the function and design of the robot whether it is perceived more like a machine or like a living thing. Also, people interact with social interfaces in the same way as they would with other humans [2]. This makes it likely that people become attached at a different level to a humanoid robot than the robots used in the studies mentioned before. Therefore, the study that will be discussed in this paper investigated the level of emotional attachment towards a humanoid robot. More specifically, it was investigated whether affective robot behaviour had an influence on the level of emotional attachment. It is expected, since affective robot behaviour results in a more natural interaction between a robot and its user, that affective behaviour results in people becoming more attached to the robot showing affective behaviour.

III. METHOD

In total 9 people (including 4 females) participated and completed the experiment (*min age* = 53, *max age* = 71, *M* = 61, *SD* = 4.8). Five participants interacted with a non-affective robot (2 female, 3 male), and four participants

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interacted with the affective robot (2 female, 2 male). Participants were recruited through distribution of an email to university staff. Only people of age 50 and over were asked to participate, since a follow-up research to this study will involve older adults, and in a previous study age showed to have an influence on how people perceived the robot [11]. Fig. 1 shows the experimental setup. The experiment was run using Wizard-of-Oz, where behaviours are pre-programmed but can be run according to the responses of the participants. The wizard/experimenter was located behind the blue screen shown behind Pepper in Fig. 1, so they can hear the participants' responses but the participants could not see them operating the robot. As can be seen in Fig. 1, the robot used in this experiment is Pepper from Soft Bank Robotics [1].

The interaction involved a discussion regarding the seven wonders of the ancient [2] and modern [3] world. The robot would ask whether the participant could name some and would provide information on these wonders. If the participant could not name any more wonders, a list was shown on Pepper's tablet and it would ask what wonder the participant would like to discuss next. This would continue until all wonders were discussed. In the non-affective condition, the robot would not show affective behaviours during the interaction. In the affective condition, it would do so by for example saying a monument got destroyed in a fire showing sad behaviour or a monument still being mostly intact showing happy behaviour. The behaviours for showing these sad, happy and non-affective behaviours have been established in previous research [11]. Characteristics that were used to show the different emotions are head position and pitch of voice, among others. The interaction would last for approximately 20 minutes.

Before the start of the interaction, people were asked to fill in demographics and the Adult Attachment Scale [12] to determine their attachment style. After the interaction they had to fill in questionnaires regarding human and object attachment (adapted from [13] and [14]), together with the questions whether they thought the robot experienced emotions during the interaction and how often they would use the robot in the future if they had one for themselves. Questionnaires from both human and object attachment were used, as it depends on the robot's appearance and function whether it is perceived as an object or a living thing [10]. The human attachment questionnaire is divided in two categories: care and over-protection.

IV. RESULTS

All participants interacting with the non-affective robot reported they did not believe the robot experienced emotions during the interactions. All participants interacting with the affective robot reported that they did believe that the robot experienced emotions during the interaction. This indicates the implemented behaviours were perceived as intended.

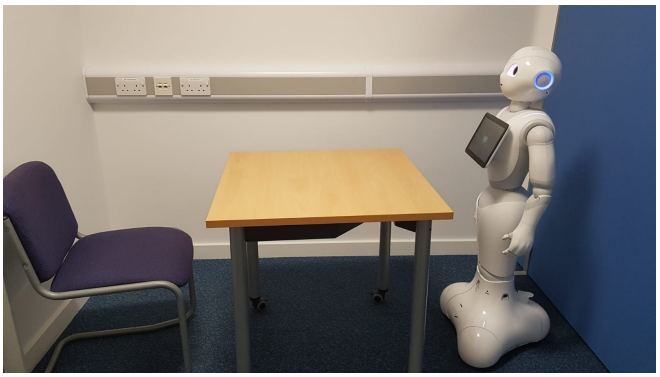

Fig. 1. Experimental set-up

The affective state of the robot did not have a significant influence on object attachment ($F(1,9) = 1.94$, $p = 0.21$). There was no significant effect of the robot's behaviour on person attachment found, neither for care ($F(1,9) = 0.027$, $p = 0.87$) nor for over-protection ($F(1,9) = 2.30$, $p = 0.17$). No correlations were found between participants' attachment style and object or person attachment. This would suggest that the robot's affective behaviour does not have an influence on people's attachment towards the robot after a single interaction.

None of the participants felt the robot cared much for them, since the care score of the human-attachment questionnaire was low for all participants. Some participants did feel the robot was over-protective. Although, as mentioned before, these results were not significant. This perceived over-protection occurred more for participants who interacted with the affective robot (3 out of 4) than the non-affective robot (1 out of 5). Participants interacting with the affective robot scored on average lower on the care-statements for the robot ($M = 15.0$, $SD = 4.2$ for the non-affective robot, $M = 10.8$, $SD = 5.0$ for the affective robot). These participants scored on average higher on the over-protection statements for the robot ($M = 7.8$, $SD = 2.5$ for the non-affective robot, $M = 10.0$, $SD = 1.6$ for the affective robot). Even though not significant, on average participants interacting with the affective robot scored a bit higher on object attachment ($M = 1.80$, $SD = 0.59$) than participants interacting with the non-affective robot ($M = 1.72$, $SD = 0.81$), which may suggest that people can become more attached to a robot showing affective behaviour. This result holds for the intention to use as well, where participants interacting with the affective robot scored a lower average ($M = 3.75$, $SD = 2.2$) than participants interacting with the non-affective robot ($M = 3.80$, $SD = 2.3$). A low average indicates higher intention to use. Even though not significant, the trend was found that people interacting with the affective robot would be more willing to use it in the future than participants interacting with the non-affective robot, as 1 out of 4 indicated they would not use the robot at all for the affective condition, where 3 out of 5 participants indicated this for the non-

[1] https://www.softbankrobotics.com/emea/en/robots/pepper

[2] https://www.wonders-of-the-world.net/Seven/List-of-the-seven-wonders-of-the-ancient-world.php

[3] https://www.wonders-of-the-world.net/Seven/List-of-the-seven-wonders-of-the-modern-world.php

affective robot.

V. DISCUSSION

The robot's affective behaviour did not have a significant influence on people's attachment. A potential cause can be the low number of participants. Another possible explanation for the absence of significant results is the nature of the interaction; that it was too informative and not personal enough for people to form an attachment. However, the interactive nature of the interaction was chosen so the interaction would remain the same for all participants, which would be harder to control when it would have been more personal.

Even though results were not significant, differences were found between conditions for human attachment, object attachment and intention to use in the future. The low scores for the care statements of the human-attachment questionnaire may be caused, as mentioned before, by the informative nature of the interaction, with too few personal additions. This may also have resulted in higher scores for over-protection, since participants might have felt they were not given enough freedom for a natural interaction with the robot.

Overall, attachment scores were low (average of 1.72 and 1.80 out of 5). This is similar to the result found by [9], which indicated that adults need more time than a single interaction to become attached to a robot.

Lastly, differences between the two conditions were found for willingness to use the robot in the future. However, since the number of participants was low this can also be caused by interpersonal differences. This will be investigated in future research.

VI. CONCLUSIONS

This study aimed to establish whether affective robot behaviour has an influence on a person's attachment towards that robot after a single session. Results show that behaviour does not have an influence. However, the small number of participants may have influenced these results, since non-significant differences between the two conditions were found. Therefore, this topic will be investigated in more depth in the future. Future work will investigate the effect of affective robot behaviour on older adults and their attachment towards the robot after several interactions spread over a long-term period, also taking into account habituation. It is expected that older adults will become more easily attached to the robot, since they may have fewer interactions on a daily basis compared to the participants in this study (university staff), which may influence their expectations of interacting with a robot.

ACKNOWLEDGMENT

This work has received funding from the European Unions Horizon 2020 research and innovation programme under the Marie Skodowska-Curie grant agreement No 721619 for the SOCRATES project

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