Children Perceived Perception of a Mini-Humanoid Social Robot based on a Psychometric Scale: a Pilot Study in Greece - PP

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Abstract. There is a growing interest in the integration of social robots in different applications in our daily lives. However, it can be challenging to design a social robot that is perceived positively among the target end-users. Psychometric scales can be used to give insights and assist in the designing of an acceptable social robot. In this study, the Greek adaptation of the Human-Robot Interaction Evaluation Scale (HRIES) has been considered to evaluate the attitude of children toward a developed social robot. Questionnaires were used to collect data from 40 neurotypical children before and after interacting with the social robot. The results showed no statistical differences due to gender. The analysis of the questionnaire scores revealed changes in the children's perceptions after the session with the robot. This implies that direct interactions with a social robot helped in altering existing perceived attitudes toward social robots. Assessment tools, such as psychometric scales, are necessary to evaluate the acceptability of social robots.

Keywords: Social robots acceptability · Psychometric scales · Robot design for children.

1 Introduction

The advances in technology are allowing the rapid integration of new methods, sensors, and techniques in healthcare, such as using wearable devices to monitor health (e.g., blood sugar), advanced sensory in prosthesis, and robots to provide assistance in surgery and therapy [1][2][3][4][5][6][7][8][9][10][11]. These advances have allowed the rapid integration of robots in many aspects of human lives, such as elderly care and autism therapy [12][13]. Additionally, the advancements in hardware and sensor fusion technologies are enabling the execution of various tasks which can be performed by social robots during interactions [14][15][16].

Social robots are developed to aid users through social interaction, creating strong communication bonds, and perceive and display emotions [17].

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In recent years, there has been a great interest in the design and deployment of social robots that meet the requirements of autism therapy and interventions [18][19][20][21][22][23][24]. Robots' morphological characteristics such as shape, size, and form factor were reported to affect intervention efficiency [25]. Hence, more research is needed to investigate critical areas in social robots for autism therapy, such as safety aspects, design, and user perceptions [26][27][28][29][30][31][32][33][34][35].

Fig. 1. The developed mini-humanoid robot that was considered in this study.

Due to the presence of a social robot in personal environments and their direct interaction with people, the impressions, attitudes of users, and their perceptions toward social robots require assessment [36][29][37]. User acceptance is affected by robots' design and thus different psychometric scales were developed based on various behavioral and psychological attributes [31]. The idea of how individuals perceive robots is crucial not only to better understand the interactions with robots, but also to design and develop robots that are considered to be acceptable among the target end-users.

A previous study with children with autism showed that a relatively smaller social robot compared to the children could play a role in its acceptance and was hypothesized that it gives the children more sense of control over it [38].

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Hence, in this study, children's perceived perception toward a developed mini-Humanoid social robot (i.e., in Fig. 1) are evaluated using the HRIES scale. The study acquired the responses from neurotypical children before and after presenting the social robot.

The rest of the paper is structured as follows. Section 2 describes related work and theoretical background while Section 3 presents the adopted methods. Section 4 provides the results and Section 5 discusses the findings.

2 Background

There are many methods that were considered to measure the effects of a robot's design and its acceptability among the target end-users. The Godspeed questionnaire is one example of an assessment tool that used Likert scale to measure the perceptions of users toward robots in terms of perceived safety, animacy, likability, intelligence, and anthropomorphism [39]. A recent study proposed a new scale that accurately measures the perceptions of robots and the willingness of humans to interact with them [40]. Another work focused on investigating the negative attitudes toward robots (i.e., NARS) based on 5-Point Likert scale questions that explored users' negative attitudes and the factors influencing their interactions with robots [41]. The assessment of ethical issues pertaining to the use of robots in therapy sessions for children with autism was the main focus of another scale [42].

Several studies investigated the perceptions and attitudes toward robots [36][43][44]. For example, a study investigated the effects of robots types and cultural backgrounds on the attitudes toward robots [45]. Results revealed that robots with high mental abilities elicited more hesitant attitudes. The social impact of comfort and negative attitudes toward robots between young, middle-aged, and older adults were explored in another study [46]. The findings showed that there were no significant differences between young and middle-aged adults responses. Another study investigated 49 participants' first impressions during an interaction scenario with a robot [47]. The study measured their perception changes over three sessions. The results showed that different perceptual dimensions stabilized and that perceptual differences persisted for robots with varying levels of humanlikeness across the sessions.

3 Methods

3.1 Participants

The data were collected from 40 typically developed children (45% females and 55% males) aged between $4-6$ years old attending a kindergarten in Athens, Greece. A written consent was obtained from the parent of each child prior to conducting the study. The procedures of this work did not include invasive or potential hazardous methods and were in accordance with the Code of Ethics of the Declaration of Helsinki.

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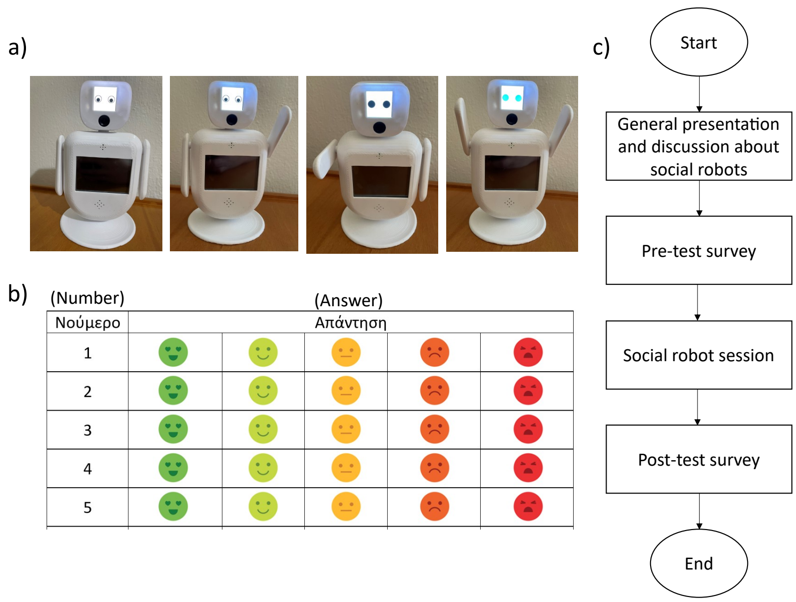

Fig. 2. The adopted methods in this study. a) The developed mini-humanoid robot performing different behaviors. b) The 5-Point Likert scale answer sheet. c) The flowchart of the procedures.

3.2 The Social Robot

The evaluation in this study considered a newly developed mini-humanoid social robot [14]. The robot is equipped with different sensors and actuators that allows the execution of various tasks such as speech recognition, motion classification, face detection, and the display of different gestures and moves (Fig. 2a). Furthermore, the robot is optimized to have low power consumption and it is 3D-printed with removable parts that enable customization and personalization.

3.3 Questionnaire Items

The questionnaire of the study included the 16 items listed in the Human Robot Interaction Evaluation Scale (HRIES) to study the perceived perception of the children toward the developed robot. The items in HRIES were presented in the form of questions and were translated to Greek. Uncanny, warm, and intentional items were translated to the closest meanings in Greek. To make it more convenient for the children, the answer sheet contained five emojis representing the 5-Point Likert scale (Fig. 2b). Pre-test questionnaire was considered to measure children's bias and perception toward social robots while post-test questionnaires were used to identify and measure possible changes to their perception after the interaction session with the mini-humanoid social robot. The 16 items of the questionnaire are presented in Table 1. The four subscales are based on the sum

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of their respective items. For example, the score for Sociability is the sum of the individual scores for items N. 2, 5, 7, and 12.

Table 1. The 16 questionnaire items and their corresponding Greek translation. Sociability subscale comprises items N. 2, 5, 7, and 12. Animacy subscale comprises items N. 3, 9, 13, and 16. Agency subscale comprises items N. 4, 6, 11, and 14. Disturbance subscale comprises items N. 1, 8, 10, and 15.

N.	HRIES Question	Greek Translation
1	Is the robot weird?	Μοιάζουν τα ρομπότ περίεργα·
2	Is the robot likeable?	Συμπαθείτε τα ρομπότ·
3	Is the robot alive?	Είναι ένα ρομπότ ζωντανό·
4	Is the robot intelligent?	Είναι ένα ρομπότ έξυπνο·
5	Is the robot warm?	Είναι ένα ρομπότ ευγενικό·
6	Is the robot self-reliant?	Μπορεί ένα ρομπότ να κάνει πράγματα μόνο του·
7	Is the robot trustworthy?	Μπορείς να εμπιστευτείς ένα ρομπότ·
8	Is the robot creepy?	Σας προκαλεί φόβο το ρομπότ·
9	Is the robot human-like?	Μοιάζει σαν ένας άνθρωπος το ρομπότ·
10	Is the robot uncanny?	Προκαλλεί απέχθεια το ρομπότ·
11	Is the robot rational?	Μπορεί να σκεφτεί ένα ρομπότ·
12	Is the robot friendly?	Είναι ένα ρομπότ φιλικό·
13	Is the robot real?	Είναι ένα ρομπότ πραγματικό·
14	Is the robot intentional?	Κάνει κάτι το ρομπότ σκόπιμα·
15	Is the robot scary?	Είναι ένα ρομπότ πραγματικό·
16	Is the robot natural?	Είναι ένα ρομπότ φυσικό αντικείμενο

3.4 Procedures

Participants were divided into 3 groups based on their classes at the school and each group took part in a two-fold survey: pre-test and post-test. In the pre-test survey, children prior to interacting with the social robot discussed with the teachers about robots in general and then they were shown a presentation about social robots as the conversation continued (Fig. 2c). This step was necessary as part of the introduction to the study and then to initiate the survey. Next, the children filled in the pre-test questionnaire sheets. In the post-test survey, the social robot was first presented to the children for around three min to explore and examine it. Next, the robot performed a short demo showing different set of behaviors. The demo of the robot was simple and limited to the requirements of the study and according to the guidelines of the teachers. Finally, the children filled in the post-test questionnaire.

3.5 Analysis

Cronbach's alpha test was used to measure the internal consistency of the questionnaire items. Mann-Whitney U tests were conducted to study the effect of

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gender and to evaluate the developed social robot on the perceived perception of the children before (i.e., Pre-test) and after (i.e., Post-test) the interactions in terms of the four subscales of HRIES, namely, Sociability, Animacy, Agency, and Disturbance. The statistical significance was set at $p<.05$.

4 Results

4.1 Internal Consistency

A reliability test using Cronbach's alpha test was conducted on all the questionnaire items and achieved an acceptable score of 0.72 [39].

4.2 Gender's Effect

To identify the differences, if any, of children's perceptions toward the robot due to gender, a Mann-Whitney U test was used on all the responses of males and females. The median response score for females (4.0) was not statistically significantly different compared to males (4.0), $p = 0.825$.

4.3 Questionnaire Items

The outcomes of the questionnaire items in pre-test and post-test were plotted in terms of the 5-Point Likert scale (Fig. 3). The pre-test plot shows that the agreement (i.e., Agree and Strongly Agree) responses scored the highest for the questions about natural, intentional, real, friendly, trustworthy, self-reliant, warm, intelligent, and likeable of social robots. As for the disagreement, the highest scores were for the questions about scary, uncanny, creepy, and weird of social robots. The post-test plot shows that most agreement responses were similar to that of pre-test, but with addition of rational feature of the presented social robot. As for the disagreement, the questions about scary, uncanny, creepy, and weird features of the social robot scored the highest. Direct comparison between the two plots reveals noticeable changes in the scores, such as in the questions about the natural, intentional, rational, and likeable features of the social robot.

4.4 Pre-test vs Post-test

To determine the effect of interacting with the social robot on the children's perception, Mann-Whitney U tests were conducted on the four subscales of HRIES before and after the interactions at $p<.05$. For sociability, the results showed no statistical significant difference between pre-test median (16) before the interaction and post-test median (17) after the interaction, $p = 0.064$. As for Animacy, there was no statistical significant difference between pre-test (14.5) and post-test (15), $p = 0.504$. The results for Agency showed no statistical significant difference between before (15) and after (15) interaction, $p = 0.823$. Similarly for Disturbance, there was no significant difference between pre-test scores (8) and post-test scores (8), $p = 0.984$.

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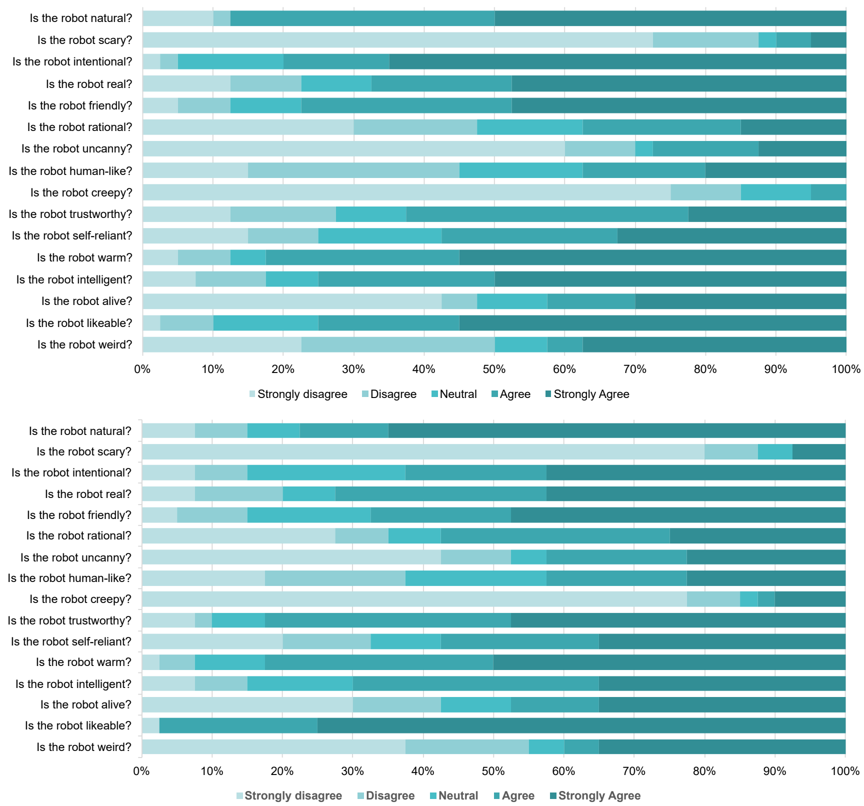

Fig. 3. The plots for the 5-Point Likert scale responses of the participants for the 16 questions. a) Pre-test survey. b) Post-test survey.

5 Discussion

Investigating the design features of a social robot and how are they perceived by the target end-users is an essential part to ensure its acceptability. Psychometric scales can be used to give insights about how different design choices are being perceived. In this study, the HRIES scale was considered to investigate children's perceived perception of a developed social robot. Two sets of the same questionnaire were considered before and after interacting with the social robot to identify any significant differences. Gender has been reported to affect the preferences toward humanoid robots [48]. However, in our study the statistical tests revealed no significant difference between the responses of males and females in their perception of the presented robot, which is aligned with a previous study [36].

The inspection of the questionnaire questions score in both tests revealed some changes in the children's perceptions of social robots (Fig. 3). The natural

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feature of the social robot achieved the highest agreement score in the pre-test while the likeability of the robot achieved the highest agreement in the post-test after presenting the social robot. This could be attributed to the direct interaction with a social robot that altered the children's perceived perception.

During the experiments, the children displayed different engagement levels and showed different interests in the social robot. The children were excited and curious about the robot. During the interaction session, the children demonstrated physical interactions and imitations, such as waving, movements, and speech, and also asked a few questions about the robot pertaining its functionalities and behaviors. The children also showed curiosity about how the robot being operated and enjoyed playing with the embedded touch screen.

The design of a social robot that is well-perceived among children requires repeated investigations and iterative improvements. The current study investigated children's perception of a social robot based on the HRIES scale, but it contained some limitations. There are many developed psychometric scales, but the study evaluated the robot based on one scale. The considered and developed social robot represents the first working prototype, and thus, it is limited in terms of functionalities, design, and appearance. Additionally, no comparison against other commercially-available social robots was conducted. The study did not investigate the perceived perception of children with special needs and was limited to 40 neurotypical children.

6 Conclusion

Investigating the acceptability of a social robot among the target end-users can be challenging. In this study, we investigated the perceived perception of a developed social robot among 40 children. Questionnaires based on the HRIES scale were used twice to collect data before and after the session with the social robot. The children's interactions with the robot provided important insights about the robot. The analysis of the questionnaire items showed changes in the children's perceived perception of social robots. The statistical analysis of the two tests (i.e., pre-test vs post-test) showed no statistical significant difference for the subscales of HRIES. Additionally, no statistical differences were found due to gender.

Future work should consider the integration of children with special needs and compare their perceived perception of the social robot to that of neurotypical children. Additionally, other psychometrics scales and social robots should be considered in the evaluation of the developed social robot. Finally, a follow-up work should use an improved design of the social robot with more functionalities and a refined appearance.

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