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Acceptance of a Social Robot for Improving Health Behaviors in Children

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Abstract. Social robots enable engaging natural interactions with humans, and therefore they can promote interactive guidance, motivation and education. However, little is known about the acceptability of social robots encouraging changes on health behaviours in children. We present a study to examine the acceptance of social robots towards improving the health behaviors of children. 99 children 9-12 years old participated in the study. A social robot was programmed to show an interactive quiz for health education and assessment of behaviors in mental health and physical activity. The robot was able to provide motivational feedback to the children and recommend individualized goals. Children highly liked the robot overall on a 5-point scale (4.8±0.6). The movement and talking capabilities of the robot were liked the most. Interestingly, older children (11-12 years old) were significantly more interested in the playing capabilities of the robot than their younger counterparts (9-10 years old) (p=0.001). The results of this study show the high acceptability of social robots for health promotion by children, and the need for the conduction of further studies in this area.

INTRODUCTION

Social robots promote natural interactions with humans, and as a result they can be valuable assistants for various education, guidance, and training purposes [1, 2]. It is also well known that children enjoy interacting with robots [3]. In particular, the engaging characteristics of social robots, e.g., ability to talk, understand their environment, and react, can be drivers for the engagement, motivation, and learning of children, which are important for the effective management or prevention of diseases [4]. In this light, the potential of social-robot interventions for child healthcare has been demonstrated in the literature [5, 6].

A significant public health challenge is the provision of preventive healthcare interventions, which should start from childhood, towards preventing the onset of life-threatening diseases such as mental disorders, diabetes and cardiovascular disease [7, 8]. To this end, the adoption of healthy behaviors (or healthy habits) by children at young age, such as self-management of stress and regular physical activity, is important [9], [10]. Innovative tools and approaches are required which can engage children and promote health behavior changes in their daily life. In this context, social robots with their interactive, education and entertaining capabilities, can facilitate health promotion for children.

Although the usefulness of social robots in healthcare has been demonstrated in several works [4], more studies are required to examine their acceptance by children. Such studies are necessary to improve our knowledge on which features of social robots are considered to be most acceptable, and therefore provide the ground for the development of social-robot interventions which could be widely adopted by children. Germane to this objective, we

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have conducted a study to explore the acceptance of a social robot-based platform aiming to improve the health behaviors of children. The developed social robot-based platform is enabled to provide health assessments of children based on questions asked by the robot, motivate the children to adopt healthy habits, and recommend individualized goals. The methodology and results of our study are presented in detail in the following sections.

METHODOLOGY

The Social Robot-based Platform

Our goal was to create an entertaining and motivational system which could engage children in the process of making positive changes on their health behaviors with focus on improving mental health and physical activity. In this respect, a social robot-based platform was developed with the aim to evaluate childrens' behaviours through a series of questions, encourage, and guide them towards health behavior changes. In particular, the social robot Cozmo was programmed to deliver the envisaged functionality [11]. Cozmo was chosen because it is programmable with an open Standard Development Kit (SDK) in Python, and provides interesting characteristics such as small size, ability to talk through text-to-speech instructions, movement on wheels, and capability to show emotions through animated eyes displayed on a small screen. Additionally, Cozmo is equipped with 3 cubes (empowered with accelerometers), which were used in the developed system as tangible objects that a child can touch and provide answers to the questions asked by the robot for assessment of health behaviors, towards providing an enjoyable gamified experience. Furthermore, a web application was developed in order to enable children view the questions asked by the robot in a written form along with instructions on how to provide their answers.

In Fig. 1, the overall conceptual framework of the system is depicted. The robot asks questions to children in the form of an interactive quiz in order to acquire personal behavioral data, e.g. "Do you feel calm?". Then, the child can answer either "Very often", or "Sometimes", or "Hardly ever" through touching one of the cubes. If the answer to the question is optimal, the child receives motivation from the robot through speech (e.g., "Great! This is so good for your health."), displays a happy face through its animated eyes, or requests from the child to have a fist bump (Fig. 1). If the answer to a question is not the optimal one, then the robot delivers an educational hint to the child, e.g. "It is better to be calm as much as possible. Maybe watching your thoughts and not having many worries could help you!", and also announces a personal behavioral goal to improve the behavior, e.g., "Try to do the following exercise 3 times/week to help you feel calm. Exercise: Feel the abdomen moving while breathing". Towards delivering an evidence-based healthcare prevention system, the questions for mental health assessment and physical activity assessment were derived from the State - Trait Anxiety Inventory for Children (STAI-C)

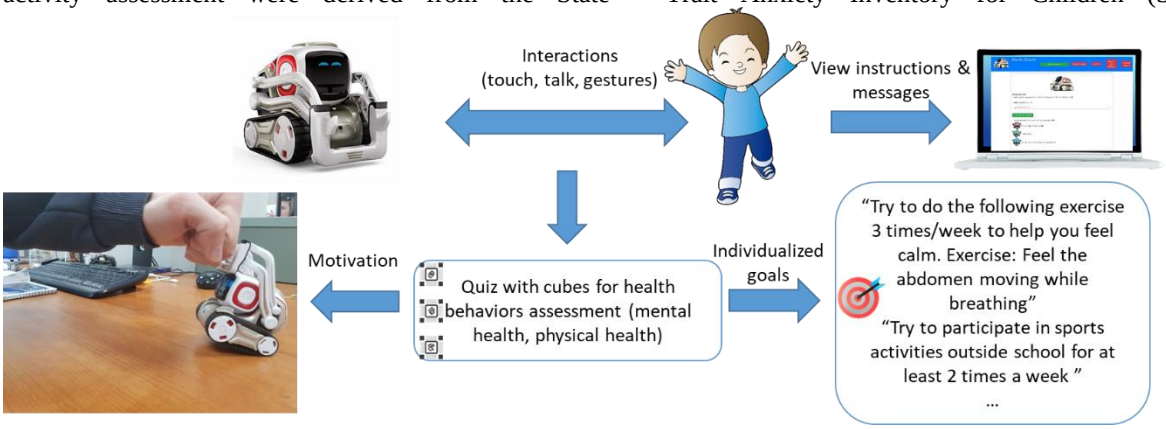

FIGURE 1. Conceptual framework of the social robot-based platform

instrument [12], and the Physical Activity Questionnaire for Children (PAQ-C) instrument [13], which are both widely accepted. Goals for health behavior change were adopted from a mindfulness-oriented meditation program for children to promote psychological well-being [14] and CDC recommendations to improve physical activity.

Acceptance Study with Children

In this section, we present the methodology for the conduction of an experimental evaluation study with children to assess whether the developed social robot-based platform is acceptable by the children. The study was conducted in a public school in Thessaloniki, Greece, with the supervision of teachers and researchers (Fig. 2). Consent forms were signed by parents prior to children's participation, providing detailed information about the aims and procedures of the study. Children at the age of 9-12 years with no mental health disease, were randomly selected by teachers for their participation. We selected children at this age group, because mental health issues and sedentary behavior often rises at this age, and children can also be able to complete questionnaires.

Children were expected to have a 20-minute interaction with the social robot platform, answer the questions asked by the robot, and receive feedback (motivation and goals). After the end of the child-robot interactions, children completed in hard copy a brief questionnaire with open-ended questions, as well as a question in a faces scale (1-5 scale) to assess the acceptability of the platform. A faces scale was used because children prefer it and it is considered appropriate [15].

We wanted first to assess the functions that children would like a robot to have (Q1: What functions would you like a robot to have?). Secondly, in accordance with acceptance models for social robots [16], we assessed the degree (1-5 scale) that the robot was likable by the children (Q2: How much did you like the robot Cozmo?). Then we asked one open-ended question on the robot features which children enjoyed the most (Q3: What did you like most in the robot?), and another on the robot features which children did not like (Q4: What did you dislike in the robot?).

The children's answers to the open-ended questions were categorized, and descriptive statistics were used for their analysis. The proportion z-test was utilized to identify possible gender differences or difference in answers between younger (9-10 years old) compared to older children (11-12 years old). Statistical significance was set to $p<0.05$.

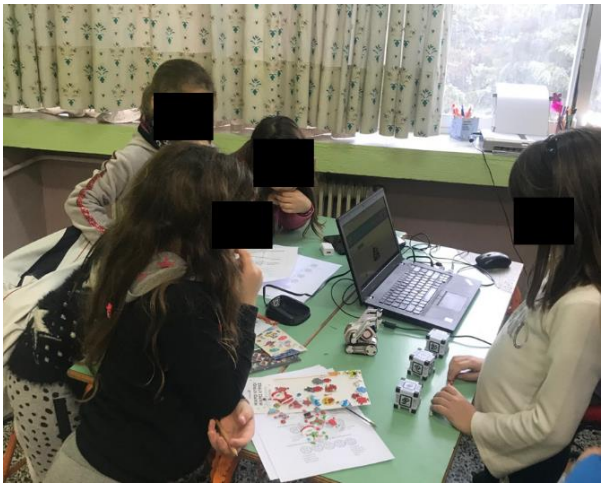

FIGURE 2. Children participating in the study

RESULTS

In total, 99 children (57 boys and 42 girls) participated in the study. Their mean age was 10.2±1.0 years. Table 1 shows in more detail the participation in the study according to gender and age group.

TABLE 1. Participant characteristics (age group and gender) in the study

Age	Participants	Boys	Girls
9-10 years old	63	36	27
11-12 years old	36	21	15
Total	99	57	42

Like-to-have Robot Features

In the open-ended question Q1 about what children would like from a social robot, the majority of the children (30%) gave the answer "To play with me". Interestingly, 18 children in the age group of 11-12 years provided this answer compared to 12 children in the age group of 9-10 years, denoting a statistically significant difference ($p=0.001$). 14 children (14%) answered that they would like the robot to help them with their coursework, and 11 children (11%) to speak with them in the native language (Greek). 11 children (11%) would also like the robot to communicate and understand. No gender differences were found in children's answers.

Acceptance of the Social-robot Platform in Terms of Enjoyment

The mean score for the question on whether children liked the robot (Q2) was 4.7 ± 0.6 (with max score 5), denoting those children liked the social robot platform highly. 93 out of the 99 children (93%), scored this item with ratings of 4 and 5. An interesting finding is that all 6 children which scored 3 or less were in the group of 9-10 years of age, which however did not reach statistical significance ($p>0.05$).

Most Likable Robot Features

The most likable robot feature (Q3) was the movement of the robot and its raising of arms, an answer which was given by 19 children (19%). 16 children (16%) liked the talking capabilities of the robot and 12 children (12%) enjoyed the playing capabilities of the robot. 11 children (11%) liked the appearance of the robot, which was denoted as "cuteness" in most cases (Fig. 3).

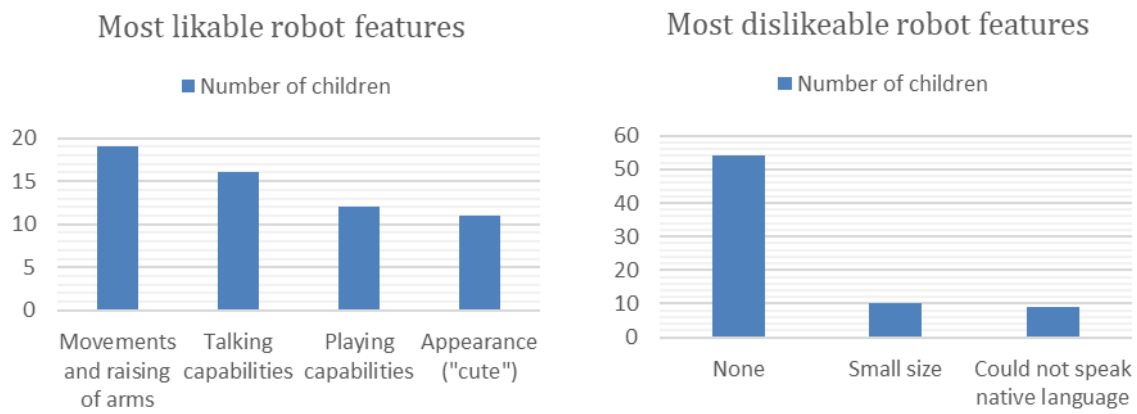

FIGURE 3. Most likable and dislikeable robot features

Most Dislikeable Robot Features

54 children (54%) responded that there was nothing to dislike in the social robot. 10 children (10%) found that the robot was small, and 9 children (9%) disliked the fact that the robot could not speak in their native language (Greek). No differences in responses were found in respect with the gender and the age group of the children.

DISCUSSIONS

We presented a study that explores the acceptance of a social robot-based platform promoting health behavior changes for children, with focus on improving their mental and physical health. The major finding of our study is that children highly liked the developed social robot. This shows the potential of social robot-based platforms to be widely adopted by children for health education, health assessment, and health behavior change purposes, which are necessary from early age in the scope of preventing life-threatening chronic diseases in adult life [17]. Further

research and longer-term studies are needed to examine whether social robots can actually facilitate the improvement of children's health behaviors in real-life.

Most children liked the movement and talking capabilities of the social robot. This reveals the importance of the interactive capabilities of robots towards creating engaging and enjoyable experiences, which are non-existent in other technological tools such as mobile or web-based apps.

The majority of the children found nothing to say about features of the robot that they disliked. However, few children expressed their concern with the small size of the robot and the fact that it could not speak Greek. Therefore, a bigger size in the design of social robots for children, and their ability to speak the local language, should be considered.

CONCLUSION

An interesting finding of our study was that children of older age (11-12 years old) were more interested in the playing capabilities of robots, compared to their younger counterparts (9-10 years old). In addition, some children expressed their interest in a social robot which could help them with their coursework. Future research is needed to verify those findings. In conclusion, our study showed the high acceptance of a social robot-based platform for health behavior changes, by children. This study adds to existing knowledge, factors which should be considered in the design of future social robots to promote better health, towards creating engaging and acceptable preventive healthcare interventions. Our study can inform the basis of further research in this area.

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REFERENCES

1. O. Mubin, C. J. Stevens, S. Shahid, A. Al Mahmud, and J.-J. Dong, "A REVIEW OF THE APPLICABILITY OF ROBOTS IN EDUCATION," *Technol. Educ. Learn.*, vol. 1, no. 1, pp. 1–7, 2013.
2. K. Winkle, S. Lemaignan, P. Caleb-Solly, U. Leonards, A. Turton, and P. Bremner, "Effective Persuasion Strategies for Socially Assistive Robots," in *ACM/IEEE International Conference on Human-Robot Interaction*, 2019, vol. 2019-March, pp. 277–285.
3. T. Belpaeme, J. Kennedy, A. Ramachandran, B. Scassellati, and F. Tanaka, "Social robots for education: A review," *Sci. Robot.*, vol. 3, no. 21, p. eaat5954, Aug. 2018.
4. J. Dawe, C. Sutherland, A. Barco, and E. Broadbent, "Can social robots help children in healthcare contexts? A scoping review," *BMJ Paediatr. Open*, vol. 3, no. 1, 2019.
5. L. Idzhar Ismail, T. Verhoeven, J. Dambre, and F. Wyffels, "Leveraging Robotics Research for Children with Autism: A Review," *Int. J. Soc. Robot.*, vol. 11, pp. 389–410, 2019.
6. Y. Lau, D. G. H. Chee, X. P. Chow, S. H. Wong, L. J. Cheng, and S. T. Lau, "Humanoid robot-assisted interventions among children with diabetes: A systematic scoping review," *International Journal of Nursing Studies*, vol. 111. Elsevier Ltd, p. 103749, 01-Nov-2020.
7. C. Waddell, J. M. Hua, O. M. Garland, R. D. V. Peters, and K. McEwan, "Preventing mental disorders in children: A systematic review to inform policy-making," *Canadian Journal of Public Health*, vol. 98, no. 3. Canadian Public Health Association, pp. 166–173, 01-May-2007.
8. L. M. Sanders, J. S. Shaw, G. Guez, C. Baur, and R. Rudd, "Health literacy and child health promotion: Implications for research, clinical care, and public policy," *Pediatrics*, vol. 124, no. SUPPL. 3, pp. S306–S314, Nov. 2009.
9. A. Triantafyllidis *et al.*, "Computerized decision support and machine learning applications for the prevention and treatment of childhood obesity: A systematic review of the literature," *Artif. Intell. Med.*, vol. 104, p. 101844, Apr. 2020.
10. M. K. Crossman, A. E. Kazdin, and E. R. Kitt, "The influence of a socially assistive robot on mood, anxiety, and arousal in children," *Prof. Psychol. Res. Pract.*, vol. 49, no. 1, pp. 48–56, 2018.

11. A. Triantafyllidis, A. Alexiadis, D. Elmas, K. Votis, and D. Tzovaras, “A social robot-based platform for prevention of childhood obesity,” in *Proceedings - 2019 IEEE 19th International Conference on Bioinformatics and Bioengineering, BIBE 2019*, 2019.
12. L. D. Seligman, T. H. Ollendick, A. K. Langley, and H. B. Baldacci, “The utility of measures of child and adolescent anxiety: A meta-analytic review of the Revised Children’s Manifest Anxiety Scale, the State-Trait Anxiety Inventory for Children, and the Child Behavior Checklist,” *J. Clin. Child Adolesc. Psychol.*, vol. 33, no. 3, pp. 557–565, 2004.
13. K. F. Janz, E. M. Lutuchy, P. Wenthe, and S. M. Levy, “Measuring activity in children and adolescents using self-report: PAQ-C and PAQ-A.,” *Med. Sci. Sports Exerc.*, vol. 40, no. 4, pp. 767–72, Apr. 2008.
14. C. Crescentini, V. Capurso, S. Furlan, and F. Fabbro, “Mindfulness-Oriented Meditation for Primary School Children: Effects on Attention and Psychological Well-Being,” *Front. Psychol.*, vol. 7, no. JUN, p. 805, Jun. 2016.
15. D. L. Wong and C. M. Baker, “Pain in children: comparison of assessment scales.,” *Okla. Nurse*, vol. 33, no. 1, p. 8, Mar. 1988.
16. M. Heerink, B. Kröse, V. Evers, and B. Wielinga, “Measuring acceptance of an assistive social robot: A suggested toolkit,” in *Proceedings - IEEE International Workshop on Robot and Human Interactive Communication*, 2009, pp. 528–533.
17. G. Cruden, K. Kelleher, S. Kellam, and C. H. Brown, “Increasing the Delivery of Preventive Health Services in Public Education,” *American Journal of Preventive Medicine*, vol. 51, no. 4. Elsevier Inc., pp. S158–S167, 01-Oct-2016.