Social Robot for Health Check and Entertainment in Waiting Room: Child's Engagement and Parent's Involvement

Anouk Neerincx
Utrecht University
Utrecht, The Netherlands
a.neerincx@uu.nl

Thirza Hiwat
Utrecht University
Utrecht, The Netherlands
t.f.hiwat@students.uu.nl

Maartje de Graaf
Utrecht University
Utrecht, The Netherlands
m.m.a.degraaf@uu.nl

ABSTRACT

To provide effective support in child health care, social robots' behaviors should be well-tailored to the care context and situated user needs. This research focuses on a social robot (iPal) in the waiting room for a vaccination. In an experiment, children performed the health check and hereafter, to kill the time, a game, either with the robot or a tablet. Child's behaviors and self-reports were recorded. The children seemed to be more positively engaged when interacting with the robot (higher motivation to play a game, higher interaction volume, more smiling during the health check, more gesture and/or verbal expressive behaviors, less mobile phone distraction). Further, their individual characteristics (like age and personality) and the social context (e.g., parent's presence) affected children's engagement (e.g., higher for young children) and parent's involvement (e.g., higher with the tablet group, resulting in a higher percentage of answered questions during the health check). Here, we identified an interesting trade-off: the current robot supports child engagement (distracting from the stressful vaccination), but hinders the collaboration between parent and child. In future research, we aim to improve the collaboration support of the robot.

CCS CONCEPTS

• **Computer systems organization → Robotics**; • **Human-centered computing → Field studies**.

KEYWORDS

child-robot interaction, human-robot interaction, social robots, pediatrics, child health care, vaccinations

ACM Reference Format:
Anouk Neerincx, Thirza Hiwat, and Maartje de Graaf. 2021. Social Robot for Health Check and Entertainment in Waiting Room: Child's Engagement and Parent's Involvement. In *Adjunct Proceedings of the 29th ACM Conference on User Modeling, Adaptation and Personalization (UMAP '21 Adjunct), June 21–25, 2021, Utrecht, Netherlands.* ACM, New York, NY, USA, 6 pages. https://doi.org/10.1145/3450614.3463413

UMAP '21 Adjunct, June 21–25, 2021, Utrecht, Netherlands

ACM ISBN 978-1-4503-8367-7/21/06…$15.00
https://doi.org/10.1145/3450614.3463413

1 INTRODUCTION

Children are starting to encounter robots in school, therapy and entertainment settings. Many scholars agree that social robots may get a prominent role in children's daily life and have beneficial effects on children's learning, social behavior and emotional well-being (e.g., [3], [8]). Within health care, social robots can help during hospitalization by distracting the children during medical procedures, providing emotional support for dealing with diseases, or support their well-being during the hospital stay [7]. Examples of positive effects on children range from experiencing distraction to less stress of pain, to more relaxation and smiling [13]. Although research on child-robot interaction in the medical and educational domain show promising results, little research has been done in the real world and there is a lack of long-term studies. Therefore, the ecological validity is generally low [3, 7, 16].

To study real-world child-robot interactions in the health care domain, our university started a collaboration with the Dutch child and family center (CJG Capelle). This center provides basic health care for children age 0-18, focusing on physical and mental health as well as family care. Examples of their work are monitoring growth, coaching at schools, and giving various types of training to children as well as their parents. Focus groups with parents and employees of the CJG highlighted the need to first investigate social robots in low-risk settings, such as vaccination days [14]. In 2019, CJG acquired humanoid robots (iPal Robots) to study their support potential in their practices, as one of the first child health care providers in the Benelux [1]. In the first study, the robots were used as a distraction for the children waiting in line or for children getting vaccinated (during a mass vaccination day).

Getting a vaccination can be very stressful and painful for children [6]; a social robot can relieve the stress during vaccination [4]. However, the time spent in the waiting room can be stressful for children as well, providing an additional support opportunity [22]. Particularly, the robot could provide support by performing the required health check with the child and hereafter, to kill the time, to play a (distracting) game with the child. This paper presents an experiment in which this robot support was provided and tested during the vaccination consultation hours at CJG. To test of the robot brings about a higher engagement, and to identify potential benefits and drawbacks of the robot, children performed the check and game with either the robot or a tablet. Further, the experiment will provide insight in the effects of child characteristics (e.g., age, personality) and social context (e.g., presence of parent) on this engagement (to be addressed in the interaction of the next version of the robot).

[1] https://cjgcapelleaandenijssel.nl/robots-bij-cjg-capelle/

2 BACKGROUND

Addressing the user needs and individual preferences in the design of the robot is key for a successful deployment [2]. By using appropriate socially expressive behaviors and interactions styles, interacting with the robot can be engaging and enjoyable for most children [24]. Furthermore, children differ in their, often context-sensitive, needs and preferences, requiring sound personalization [14].

Robots are used as entertainment and as toys, but also in healthcare and rehabilitation to motivate, stimulate and comfort children [19]. Most children experience health care in their lifetime (like hospitalization, vaccination and dental procedures), which can cause anxiety during childhood and can be stressful and painful for children [6]. Today, technology is increasingly being used in healthcare to improve the quality of life of patients and, at the same time, to shape the practices of healthcare professionals. Robots seem particularly suitable to assist in the care of vulnerable subjects, such as children and elderly. In pediatric healthcare, applications running on cellphone and tablets have already been used to interact with the children. However, social robots have shown to increase the likability and naturalness of the interaction and have shown to provide some help in accepting advises. Particularly, the physical presence and rich ("natural") interaction may advance the health-technology support [17]. Moerman et al. [13] highlighted three areas in which a social robot might enhance a child's well-being: Offering distraction during a medical procedure, offering emotional support for dealing with a serious disease and enhancing well-being during hospital stay. Multiple studies have been published exploring the effect of the social NAO robot during a medical procedure with children. In two studies by Beran et al. ([4], [5]), a NAO robot was used to distract children during flu vaccination as many children experience an anticipatory fear of needles. Before, iPads were used as a distraction during vaccination with parents reporting that their children experienced less pain during the vaccination compared to children who did not play with the tablet ([12], [9]). The robot gave blowing commands during the vaccination which is a method used by nurses to distract the children. The children in the robot group experienced less stress and pain, and less avoidance behavior [4]. The children also smiled for a relatively longer period of time, as well as their parents [5]. However, the amount of crying time was not significantly different. The robot does not seem to extinguish the perceived pain, but it can help children and parents to cope with the experience by making the environment more friendly.

Another research, that also used robots during vaccination, concluded that the robot seemed to supply actual relief to the children in a situation of discomfort or even fear and/or pain. Temporal effects of the interaction with the robot were an increase in happiness, while decreasing the anxiety and fear value during the interaction [17]. These results were in line with Farrier et al. [9] who reported that children interacting with a humanoid robot during the procedure demonstrated less pre-procedural and procedural fear and less procedural pain than children in a standard care group. Unfortunately, a precise reason for the low fear and pain could not be determined as the actions performed by the robot were executed differently between interactions with children. A possibility is that the movements may have been mesmerizing for children to watch, or its voice may have been soothing, or its physical representation of human characteristics may have engaged them. The researchers concluded that children's painful and fearful experiences during various medical procedures could be reduced with the introduction of a humanoid robot.

The previous studies used a robot as a distraction while Murphy the Miserable Robot by Ullrich et al. [22] used a NAO robot as a companion to support children's well-being in emotionally difficult situations, such as waiting for a medical procedure. Murphy is positioned in the waiting room and acts like another patient. Children waiting in the room can interact with Murphy. Interacting with a robot is still uncommon and novel thus stimulating; exploring the functions and capabilities of Murphy may already be a captivating experience making the child forget the actual reason for being at the waiting room. The reactions to Murphy were positive, children saw him as a friend and enjoyed his companionship. In this way, the robot was able to improve the waiting time for the children [22]. This study highlights the opportunity to use a social robot in the waiting room before vaccinations as well.

Even though social robots seem very promising in healthcare practices such as vaccinating children, the effect of a social robot in the waiting room has barely been studied. The physical nature of social robots makes the machines more useful and capable of a better performance compared to other technologies. The interaction is richer and more effective. However, other cheaper technological interventions that can provide a distraction for the children seem effective as well. In the educational domain, robots and tablets have been compared; Jost et al. [10] analyzed user behaviors on a memory game using a tablet and a robot. In the experiment, three conditions were tested: (1) playing a game with a robot and a tablet, (2) playing a game only with the robot, (3) playing the game only with a tablet. Here, the participants seemed to prefer the robot compared to the tablet. However, robots and tablets have not been compared in the child health care domain. Therefore, this study explores the additional value of deploying a social robot compared to a tablet, at the CJG during vaccination consultation hours, on child's experience in the waiting room (self-report questionnaires, and behavior observations).

3 RESEARCH METHOD

During the consultation hours, children and the parents had to wait in the waiting room until they were called to receive the vaccination. When entering the waiting room, the children and parents were welcomed by a host who asked a couple of health-related questions. In the experiment, this health check was performed by the robot by asking the questions and displaying them as a video at its tablet. After the health check, children could spend the remaining waiting time playing a game (tic-tac-toe) on the robot's tablet. The control group received the same health check and game, but on a tablet. The method was inspired by research by Ulrich et al. [22]. This experiment was done with a between-subjects design with a two-level independent variable (robot vs. tablet). Participants were assigned to each group randomly. Qualitative data was gathered using video-analysis and quantitative data was gathered using questionnaires and measuring interaction time.

3.1 Participants

All participants for this experiment had an appointment for the vaccination consultation hour at CJG Capelle aan den IJssel and were asked to participate on the spot, if they were accompanied by an adult and spoke Dutch. Participants were not asked to take part in the study if another participant was taking part in the study at the same time. 18 children participated in the experiment (mean age = 10,61, SD 3,21), with an age range from 4 to 15. 11 girls and 7 boys participated in the experiment. Since this experiment was partially held during COVID-19 lockdown, some participants had to wear masks. About 47,1% (8 participants) wore a mask during the experiment, 52,9% (9 participants) did not. The robot group consisted of 9 children, 6 girls and 3 boys, with a mean age of 9,89 and SD 3,4. The tablet group consisted of 9 children, 5 girls and 4 boys, with a mean age of 11,33 and SD of 2,91.

3.2 Data Collection

To observe behavior, a coding scheme was created after analyzing the video's shortly to determine which behaviors occurred in the different groups. The categories of Serholt & Barentdregt [18] were adopted and by adding a category of posture and a category for parents the final coding scheme was created. Besides the qualitative data, quantitative data was gathered using a questionnaire to gather the subjective opinions of the children. The questionnaire consisted of 15 questions, specific questions about the Fun (Engagement and Expectation) and acceptance of the robot were adopted from previous studies ([20], [21], [11]). Case-specific questions about the waiting room, the nervousness for the vaccination and the video were created for this study. All questions, except for age and gender, were asked using the smiley-o-meter [15], a 5-point Likert scale using smileys to represent the answers.

3.3 Materials

The robot used for this experiment is the humanoid iPal ® Robot developed by Nanjing AvatarMind Robot Technology. AvatarStudio was used to create a script for the robot to perform during the interaction. The iRemoterApp was used to control the robot via the tablet (Samsung Galaxy Tab A 8.4.). The same tablet was used for the tablet group. The health check video was made based on the mandatory questions the CJG vaccination consultation host has to ask. Both robot and tablet used the robot voice to ask the health check questions. In the usual waiting room, there is a table with a wooden tic-tac-toe board to play with for the waiting patients. Using the website https://playtictactoe.org/ in Google Chrome the participants could play the game digitally directly after the video on the robot had ended, or by clicking on the site's tab when watching the video on the Tablet. Last, a Nikon D3200 camera on a tripod was used to record the participants.

3.4 Procedure

When a child and a parent entered the waiting room, the researcher asked if they came for the vaccination consultation hour. If that was the case, the researcher explained the purpose of the research and that it would not take any extra time. Explaining that the child and parent only had to watch a video on the technology during the waiting time and had to answer a short questionnaire after the vaccination. If the child and parent agreed on participating, the guardian filled in a consent form (for participation and recording of the interaction). After the consent form was filled in, the participant sat either on a chair in front of the robot or the table. For the tablet group, the researcher brought the tablet to the participant and shortly explained that they must click on the tab to open the game. For the robot group, the researcher could control the robot using the iRemoterApp, clicking on the interaction of the health video on a tablet containing the app. After the video started the participant just needed to react and behave as they wish. When the video ended, the CJG host checked if all the questions were answered correctly because the questions determine if a child can be vaccinated or not. She also asked if the parents had the vaccination papers with them. Next, participants could play the game if they wanted to. They did not have to. The experiment ended when the participant was called to go to the vaccination room. After the participants returned to the waiting room, the researcher walked over to the participant asking if they could fill in the questionnaire. Photos of the experiment can be found in Figures 1 and 2.

Figure 1: An interaction in the robot group.

Figure 2: An interaction in the tablet group.

3.5 Measures and Variables

3.5.1 Quantitative Data. The questionnaire consisted of child characteristics (i.e. age/gender) and 15 questions about the waiting and vaccination experience. The full questionnaire is available upon request. The questionnaire measured the level of fun the participants had during the interaction, perceived waiting time, attention and acceptance of the technology (based on Tielman [21]). Also, the interaction percentage was measured by the total amount of interaction divided by the total amount of waiting time.

3.5.2 Qualitative Data. To study the children's behaviors towards the robot, video analysis was conducted. By shortly analyzing the video's and using the coding scheme of Serholt and Barendregt [18] and Tielman [21], a coding scheme was created based on the participants verbal and non-verbal responses to the robot and tablet within the categories eye gaze, facial expression, verbal response and gesture, which are explained below.

- Gaze: All types of gaze that included the robot's face or the tablet screen were considered a sign of social engagement. Looking at the parents is also considered a sign of social engagement. While all other types of gaze not including the robot's face or tablet screen were considered a sign of no engagement ([18], [1]). An example is staring towards the researchers or a smartphone.

- Facial expression: Smiles were considered to signify engagement with the robot. Smiles also indicated that the participant was enjoying the interaction between the robot and or tablet. Timid or flushed smiles as a reaction to the robot's positive feedback were also considered a sign of engagement. All other facial expressions, such as nervous or confused expressions were not considered a sign of social engagement or interaction [18].
- Verbal response: If children reacted verbally to the robot's greeting, praise or question this was generally considered a sign of social engagement. If children did not respond to the robot at all, it was not considered as social engagement and thus a negative indication. Also, winning and losing verbal responses during the game were considered as a form of engagement. Laughter was also considered as a verbal response.
- Gesture: Greeting gestures such as waving, answering gestures such as nods or headshakes, and victory but also loser gestures were considered signs of social engagement. Furthermore, mirroring behaviors during the implicit probes were also considered more subconscious signs of engagement ([18], [23]).
- Posture/position towards the technology was introduced to the coding scheme to discover how interested the participants were in the game. With positive indications when they moved closer to the tablet screen or moved their chair closer to the robot. Negative indication occurred when the participants move away from the technology or had a non-active posture.
- Lastly, the parents were introduced to the coding scheme to see how active they were during the experiment. Looking at if they would also play the game or help the participant while interacting with the technology.

4 RESULTS

4.1 Quantitative Data

4.1.1 Fun. The fun measurement explored the engagement and the ambiance of the waiting room. No significant differences on funlevel in general were found. However, a Mann-Whitney U test indicated that the robot group (Mdn = 5.00, Mean = 4.56) was more willing to play another game with the robot than the tablet group (Mdn = 4.00, Mean = 3.44) was willing to play another game on the tablet, U = 14.500, p = 0.014.

4.1.2 Tension/Fear. The questions about tension/fear were self-constructed to see if there were significant differences in the experience of fear of the two groups. Cronbach's alpha is 0.718 which makes the scale reliable. We found no significant difference on fear between the two groups.

4.1.3 Interaction Time. To test if the participants interaction with the robot was significantly more than the tablet group, the interaction percentages were put to the test using an independent t-test. There was no significant difference between the interaction percentages, t(14) = 0.437, p = 0.669, despite the robot group (M = 76.95%, SD = 25.560%) having a higher interaction percentages than the tablet group (M = 70.31%, SD = 34.49%).

4.2 Qualitative Data

4.2.1 Observations During Health Check. In the case of the gaze of the participants during the health check, the robot group, as well as the tablet group, were focused on the video. Compared to the tablet group (TG), more participants of the robot group (RG) smiled during the health check (TG=0.00%, RG=66.67%), usually in the first seconds of the video when the robot began moving and at the end when the robot proposed to play a game. While the video played, especially when the harder questions showed up, the participants of both groups showed more serious facial expressions (TG=75.00%, RG=66.67%). A few of the participants of the robot group greeted the robot verbally (RG=22%). Participants of the robot group were more likely to respond verbally to the questions compared to the tablet group (TG=12.50%, RG=66.67%). During the video most participants of both groups did not show any gestures (TG=62.50%, RG=55.56%). When there were gestures in the tablet group the participants usually nodded to answer a question (TG=37.50%). The robot group also showed nodding gestures (33.33%) and one participant even waved and mimicked the technology (both RG=11.11%). During the video the participants of the tablet group moved closer to the video, compared to a few participants of the robot group (TG=100%, RG=44.44%). None of the participants moved away while the video was playing. The postures were engaging (TG=50.00%,RG=55.56%), but also neutral, non-active (TG=50.00%, RG=44.44%). The role of the parents was to see during the video if they would help answering the questions with their children. All parents of the tablet group helped their child answering the questions (100%), and almost all did the same thing for the robot group (77.78%).

4.2.2 Observations During Game. During the game, different behaviors were observed withing the different analysis categories. Almost all participants started playing the game and thus looked at the technology (TG=87.50%, RG=100%). More participants of the tablet group exchanged looks between their parents and the technology than the robot group while playing the game (TG=75%, RG=44.44%). Furthermore, 50% of the participants of the tablet group looked at their phone during the game opposed to 22.2% of the robot group. This suggests higher levels of engagement in the robot group. On the other hand, more participants of the robot group looked at the researcher (44.44%) compared to the tablet group (25%). Also, 22.22% of the participants of the robot group looked around compared to 12.50% of the tablet group. Verbal responses during the game were more frequent in the tablet group (75%) than in the robot group (44.44%). The tablet group also talked more about strategy during the game (TG=50%, RG=22.22%) and laughter occurred with 25% of the participants of the tablet group against 11.11% of the robot group. This could be because the children played the game together with their parents more often in the tablet group (62.50%) compared to the robot group (33.33%). Looking at the gestures 50% of the tablet group and 44.44% of the robot group showed no gestures during the game. Winning and losing gestures were seen among 50% of the tablet participants and 44.44% of the robot participants. Furthermore, 22.22% of the robot group showed other gestures like waving, walking etc. Posture wise most participants of both groups tended to move closer towards the technology during the game (TG=87.50%, RG=88.89%). Half of the participants of the tablet group moved away from the technology which can be directly after the game had started or after playing for a while. This happened to only 33.33% of the Robot group participants.

4.2.3 Other Observations. Another observation was that the younger children (4 − 10) seemed to be more intrigued and excited to see the robot compared to the older children (11 − 15). The younger children also seemed to be more invested in the game, moving closer and interacting longer with the devices while the older children often stopped after a few minutes playing the game. Some of the older children used their phone as a way to distract themselves while waiting to get vaccinated.

The video seemed hard for the younger children to understand. They could not answer the questions by themselves and needed their parents. Older children did seem to understand the questions but still checked with their parents whether they answered it correctly.

One participant (9) of the robot group discovered how to reach other apps of the robot and started exploring the possibilities of the robot. Eventually, the participant could walk with the robot following her using the camera. She also discovered to use a decibel meter, but before she could test it by screaming the researcher turned a video on the robot to prevent her from disrupting the waiting room. She seemed to enjoy the freedom to explore all the different abilities of the social robot.

Another participant (4) of the robot group was too young and shy to interact with the robot. He did wave when the robot waved but did not seem to understand the questions nor understand that the game could be played by touching the touch screen. After the help of his mother the participant started to play carefully.

5 CONCLUSION

This study researched the behaviors and self-report measures of children around a tablet or a social robot in the waiting room before getting a vaccination. Quantitative as well as qualitative data was collected. Results suggest higher levels of engagement in the robot group. First of all, the robot group was more willing to play another game with the robot and was less likely to quit playing the game. The robot group also had higher interaction percentages compared to the tablet group. Compared to the tablet group, more participants of the robot group smiled during the health check. A few of the robot group expressed special gestures like waving and mimicking the technology, which did not occur in the tablet group. Additionally, participants of the robot group were more likely to respond verbally to the questions compared to the tablet group. Furthermore, tablet group participants would look at their phones more often during the interaction. Behavior observations suggests that child characteristics, such as age and personality, are relevant for the success of the robot interaction. For example, younger children seemed more intrigued and exited to interact with the robot. Also, the presence and characteristics of a parent seemed relevant for technology preference. For example, in the tablet group, the parents were more involved. This was indicated by higher percentages of answered questions during the health check and higher participation of parents during the game. This suggests that the tablet might be a better medium for collaboration between parent and child, compared to a social robot. In short, we identified an interesting trade-off: the current robot supports child engagement (distracting from the stressful vaccination), but seems to hinder the collaboration between parent and child. In future research, we aim to improve the collaboration support of the robot.

6 DISCUSSION

This field study showed positive indications for the use of a social robot in the waiting room at child vaccinations. It was observed that the robot group tended to smile more and have more verbal responses than the tablet group while the robot played the video. This is in line with research by Beran et al. ([4], [5]), where children smiled longer during the vaccination when a social robot was used. Another observation during the game was that in the tablet group the parents were more involved, causing the children to be more verbally expressive. This is in line with Shahid et al. [19] and Straten et al. [24], as they concluded that children playing with friends were more expressive than children playing with a social robot. However, one other reason could be that the robot did not have any special gestures or dialogue during the game. If the robot had been more interactive during the game as well, the participants might have been more verbally expressive.

Further, child characteristics such as age did seem to matter while interacting with the two different devices. Younger children were more intrigued and excited to see the robot compared to the older children and tended to play the game longer on both devices. This indicates the importance of the design of the robot interaction. The design must match or consider the users' needs and perspectives [2], which will differ between children. A certain amount of personalization is therefore necessary [14].

Since this research was a field study, executed during the COVID-19 pandemic with a special user group (namely children), it has some *limitations*. Our sample size was small, which might cause our lack of significant results. Especially after a lockdown was announced, the clients seemed more reluctant to participate in our experiment. Also, many clients did not show up at their vaccination appointment. Furthermore, our small sample size was in a relative big age range. We found some interesting, although not yet conclusive, results regarding age differences. Additionally, using self-report measures in CRI has its own limitations. For example, our participants tended to give high ratings for both technologies ("ceiling effect"). Furthermore, self-report measures may also suffer from social desirability biases [8]. The waiting room is an uncontrollable environment where some participants have to wait longer than other participants. The room was sometimes more crowded than other times. Environmental factors could not be controlled and thus it is hard to determine whether the differences between the groups were due to the different devices or the external factors. However, since this field study was executed in the real-world, ecological validity is guaranteed.

For *future research*, it would be interesting to carry out the same experiment at other vaccination consultation hours, to enlarge the group size. We will use our recordings of the interactions to adapt our interaction design to the situation and age groups. This will result in a first version of a user model for this situated robot support. Our results indicate the importance of personalization of the interaction. Since at such vaccination consultation hours children from many different ages are visiting, it would be interesting to test different interaction designs suited for the specific child characteristics and parent presence.

REFERENCES

[1] Michael Argyle and Janet Dean. 1965. Eye-contact, distance and affiliation. *Sociometry* (1965), 289–304.

[2] Jenay M Beer, Karina R Liles, Xian Wu, and Sujan Pakala. 2017. Affective human–robot interaction. In *Emotions and affect in human factors and human-computer interaction*. Elsevier, 359–381.

[3] Tony Belpaeme, James Kennedy, Aditi Ramachandran, Brian Scassellati, and Fumihide Tanaka. 2018. Social robots for education: A review. *Science robotics* 3, 21 (2018).

[4] Tanya N Beran, Alex Ramirez-Serrano, Otto G Vanderkooi, and Susan Kuhn. 2013. Reducing children's pain and distress towards flu vaccinations: A novel and effective application of humanoid robotics. *Vaccine* 31, 25 (2013), 2772–2777.

[5] Tanya N Beran, Alex Ramirez-Serrano, Otto G Vanderkooi, and Susan Kuhn. 2015. Humanoid robotics in health care: An exploration of children's and parents' emotional reactions. *Journal of health psychology* 20, 7 (2015), 984–989.

[6] Kathryn A Birnie, Melanie Noel, Christine T Chambers, Lindsay S Uman, and Jennifer A Parker. 2018. Psychological interventions for needle-related procedural pain and distress in children and adolescents. *Cochrane Database of Systematic Reviews* 10 (2018).

[7] Julia Dawe, Craig Sutherland, Alex Barco, and Elizabeth Broadbent. 2019. Can social robots help children in healthcare contexts? A scoping review. *BMJ paediatrics open* 3, 1 (2019).

[8] Chiara de Jong, Jochen Peter, Rinaldo Kühne, and Alex Barco. 2019. Children's acceptance of social robots: A narrative review of the research 2000–2017. *Interaction Studies* 20, 3 (2019), 393–425.

[9] Christian E Farrier, Jacqueline DR Pearson, and Tanya N Beran. 2019. Children's fear and pain during medical procedures: A quality improvement study with a humanoid robot. *Canadian Journal of Nursing Research* (2019), 0844562119862742.

[10] Céline Jost, Marine Grandgeorge, Brigitte Le Pévédic, and Dominique Duhaut. 2014. Robot or tablet: Users' behaviors on a memory game. In *The 23rd IEEE International Symposium on Robot and Human Interactive Communication*. IEEE, 1050–1055.

[11] Rosemarijn Looije, Mark A Neerincx, and Vincent de Lange. 2008. Children's responses and opinion on three bots that motivate, educate and play. (2008).

[12] Alisa McQueen, Chelsea Cress, and Alison Tothy. 2012. Using a tablet computer during pediatric procedures: a case series and review of the "apps". *Pediatric emergency care* 28, 7 (2012), 712–714.

[13] Clara J Moerman, Loek van der Heide, and Marcel Heerink. 2019. Social robots to support children's well-being under medical treatment: A systematic state-of-the-art review. *Journal of Child Health Care* 23, 4 (2019), 596–612.

[14] Anouk Neerincx, Denise L Rodenburg, Maartje MA de Graaf, and Judith FM Masthoff. 2021. Social Robots to Support Child and Family Care: A Dutch Use Case. In *Companion of the 2021 ACM/IEEE International Conference on Human-Robot Interaction*. 367–371.

[15] Janet C Read and Stuart MacFarlane. 2006. Using the fun toolkit and other survey methods to gather opinions in child computer interaction. In *Proceedings of the 2006 conference on Interaction design and children*. 81–88.

[16] Nicole Lee Robinson, Timothy Vaughan Cottier, and David John Kavanagh. 2019. Psychosocial health interventions by social robots: systematic review of randomized controlled trials. *Journal of Medical Internet Research* 21, 5 (2019), e13203.

[17] Silvia Rossi, Marwa Larafa, and Martina Ruocco. 2020. Emotional and behavioural distraction by a social robot for children anxiety reduction during vaccination. *International Journal of Social Robotics* 12, 3 (2020), 765–777.

[18] Sofia Serholt and Wolmet Barendregt. 2016. Robots tutoring children: Longitudinal evaluation of social engagement in child-robot interaction. In *Proceedings of the 9th nordic conference on human-computer interaction*. 1–10.

[19] Suleman Shahid, Emiel Krahmer, and Marc Swerts. 2014. Child–robot interaction across cultures: How does playing a game with a social robot compare to playing a game alone or with a friend? *Computers in Human Behavior* 40 (2014), 86–100.

[20] ML Tielman. 2013. *Expressive behaviour in robot-child interaction*. Master's thesis.

[21] Myrthe Tielman, Mark Neerincx, John-Jules Meyer, and Rosemarijn Looije. 2014. Adaptive emotional expression in robot-child interaction. In *2014 9th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*. IEEE, 407–414.

[22] Daniel Ullrich, Sarah Diefenbach, and Andreas Butz. 2016. Murphy Miserable Robot: A Companion to Support Children's Well-being in Emotionally Difficult Situations. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems*. 3234–3240.

[23] Tanya Vacharkulksemsuk and Barbara L Fredrickson. 2012. Strangers in sync: Achieving embodied rapport through shared movements. *Journal of experimental social psychology* 48, 1 (2012), 399–402.

[24] Caroline L van Straten, Jochen Peter, and Rinaldo Kühne. 2020. Child–robot relationship formation: A narrative review of empirical research. *International Journal of Social Robotics* 12, 2 (2020), 325–344.