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Children's perceptions of social robots: a study of the robots Pepper, AV1 and Tessa at Norwegian research fairs

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Abstract

This article studies perceptual differences of three social robots by elementary school children of ages 6–13 years ($n = 107$) at research fairs. The autonomous humanoid robot *Pepper*, an advanced social robot primarily designed as a personal assistant with movement and mobility, is compared to the teleoperated *AV1* robot—designed to help elementary school children who cannot attend school to have a telepresence through the robot—and the flowerpot robot *Tessa*, used in the eWare system as an avatar for a home sensor system and dedicated to people with dementia living alone. These three robots were shown at the Norwegian national research fair, held in every major Norwegian city annually, where children were able to interact with the robots. Our analysis is based on quantitative survey data of the school children concerning the robots and qualitative discussions with them. By comparing three different types of social robots, we found that presence can be differently understood and conceptualized with different robots, especially relating to their function and "aliveness." Additionally, we found a strong difference when relating robots to personal relations to one's own grandparents versus older adults in general. We found children's perceptions of robots to be relatively positive, curious and exploratory and that they were quite reflective on their own grandparent having a robot.

Keywords Social robots · Human–robot interaction · Pepper · AV1 · Tessa · Norway

1 Introduction

Social robots are increasingly becoming integral parts of our daily human lives and offer great possibilities for enhancing quality of life (Fong et al. 2003; Sparrow and Sparrow 2006; Brose et al. 2010; Riek 2017). At the same time, they pose novel problems and challenges (Pols and Moser 2009; Tøndel and Seibt 2019; Turkle 2012, Östlund and Frennert 2014). The aim for this paper is to explore children's perceptions of social robots, which we explore through three different robots. Through this comparison, our first research question is how presence can be understood and conceptualized differently with different robots, especially relating to their function and "aliveness." A second research question is how the personal relations to one's own grandparents coupled with social robots is understood versus relations with the elderly/older adults in general.

The design criteria chosen for the robots, reflecting their intended usage area, holds great importance in ensuring that social robots are successfully embedded in the daily life of human users. Health care and education represent two of the most promising fields for social robots (Bennett et al. 2017; Belpaeme et al. 2018). Within health care, gerontechnology—technology for elderly care—holds the promise of transforming how elderly care is organized, conducted and assessed. With the advancement of social robots, surveillance technology, smart journaling systems, Big Data and

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AI utilized for symptom analysis, the health-care sector is facing deep structural changes, and robots are often seen as the personification of technological embeddedness. Robots are also one example of a technology that is facing criticism from end users, especially from health-care workers and particularly concerning robots that have direct and deliberate contact with humans, e.g., lifting them (Wright 2018) or socializing with them (Fong et al. 2003).

At the other range of the age spectrum, children have also been identified as a user group who can greatly benefit from robots, especially those tied to education (Tanaka et al. 2015). One of the most studied groups of children are those with autism, for which robots have been used as a mitigation technology. They have been used especially for teaching socially acceptable behavior (Kim et al. 2013; Cabibihan et al. 2013) and have provided promising findings on helping children with social problems develop more empathic understanding. One study by Robins et al. (2006) shows that children with autism interacted more easily with a man dressed and behaving like a robot compared with when he was dressed and acting like a regular human.

In this article, we explore perceptual differences of three social robots with widely different designs in terms of functionality, size, and degree of automation. The setting for the study was a Norwegian yearly research fair. In two iterations of the event, we exposed young visitors to three different social robots: the humanoid autonomous robot Pepper—an advanced social robot primarily designed as a personal assistant with movement and mobility—with a simpler teleoperated robot "AV1" (pronounced /a-v'e-'ɛn/ [from Norwegian]) that is designed to help elementary school children who cannot attend school by providing a telepresence in the classroom through the robot; and thirdly, the flowerpot robot Tessa, used in the eWare system as an avatar for a home sensor system and dedicated to people with dementia living alone (Project eWare). These three robots differ widely in usage, functions, price, mobility and design.

We tested them at a research fair for elementary school children in Norway and collected data on the interaction between human and machine. Bartneck et al. (2009) emphasize the need for standardized measurement tools for human robot interaction, focusing in their literature review on five key concepts of social robots: anthropomorphism, animacy, likability, perceived intelligence and perceived safety. We build on these five categories in our discussion. In the following parts, we give an overview of the three robots used in this research, before describing our methodology. This is then followed by a discussion focusing on two key findings: the importance of design of robots and that of care envisioning for personal relations.

2 A fauna of social robots

Defining what a robot actually is a conflicted terminological question. The Oxford dictionary defines a "robot" as: "(especially in science fiction) a machine resembling a human being and able to replicate certain human movements and functions automatically."[1] In the article "A robot in every home," Bill Gates (2007, p. 65) wrote that:

> *It may be increasingly difficult to say exactly what a robot is. Because the new machines will be so specialized and ubiquitous—and look so little like the two-legged automatons of science fiction—we probably will not even call them robots.*

Within the category of robots, the subcategory "social robot" is defined by Breazeal (2003, p. 167) as "the class of robots that people anthropomorphize in order to interact with them" and further denotes that a "sociable robot is able to communicate and interact with us, understand and even relate to us, in a personal way… socially intelligent in a human like way" (Breazeal 2004, p. 1). Jones's (2019) study on how "robot-assisted childcare" is constructed in the public domain of the Internet shows that robots for children are often branded as "companion robots," whereas robots targeting the family as a user group are branded as "home robots."

Today, social robots' main functionality is to be social companions to humans—to talk to, entertain, educate and remind people, and they "are designed to imitate human sociality ideally allow for mutually adaptive interaction that involves the robot as a partner or friend as opposed to a tool" (Brinck and Balkenius 2018, p. 2). Even though definitions are blurred, KPMG estimated that sales of personal service robots would be "~35 million units between 2015 and 2018, with ~1.5 million of them having social robot characteristics" (KPMG 2016, p. 5). This means that social robots, the focus of this article, represent only about 5% of total robot production. In their study "What is a Robot Companion—Friend, Assistant or Butler?", Dautenhahn et al. (2005) found that people are predominantly favorable to robot companions. In this study, people frequently stated they would like a future robot to perform the role of a servant, which could be seen in accordance with the human "butler" role. Jones's (2019, p. 454) claim that "most people encounter socially interactive robots mainly through information about them, hence interact with objects constructed in narratives about these robots" is something we want to take into real life. However, there has also been a discussion about the technological determinism—that robots follow a predetermined trajectory of what we think they should do—versus a

[1] From: https://www.lexico.com/en/definition/robot.

social constructivist view on how functions are implemented also based on current sociotechnical needs, assumptions, and values.

Östlund and Frennert (2014, p. 299) provide a list of concerns relating to social robots, particularly in relation to older people: (1) [The] role of robots in older people's lives, (2) factors affecting older people's acceptance of robots, (3) lack of mutual inspiration in the development of robots for older people, (4) robot esthetics, (5) ethical implications of using robots in caring for older people, (6) robotic research methodology, and (7) technical determinism versus social construction of social robots.

In particular, they warn that older people are "assumed to have a general need for social robots due to societal changes such as ageing demographics and demands from the health-care industry" (Östlund and Frennert 2014, p. 308).

Agreeing with this, we want to provide a case study of three social robots: Pepper, AV1 and Tessa[2], (Fig. 1), especially relating to Östlund and Frennert's (2014) concerns: (4) robot aesthetics and (5) ethical implications of using robots. These robots were chosen as they are quite different in form, size and function and would therefore provide interesting comparative data. In addition, the robots have a wide target-user demographic, targeting older adults, but also children, primarily in the domestic sphere of the user.

	Pepper	AV1	Tessa
Main target group	Service, education and health-care sector	Children unable to attend school due to illness (thus having to stay at home/in the hospital)	Older adults with mild to middle stage dementia living alone and their (in)formal caregivers
Design	Anthropomorphized young human	Humanoid head with moving body	Flowerpot design with anthropomorphized eyes
Material	White plastic	White plastic	Natural wood body with props in colored felt material
Operation	Autonomous	Teleoperated	Semi-autonomous (sound only, no movement)
Communication	Generated voice and robotic vision	Bi-directional sound and video (video-conference functionality)	Text-to-speech
Movement	Head, body and arms; floor movement using wheels	Body rotation (360°); up and down head movement	No movement
Height	121 cm	26.8 cm	24.5 cm (without the flowers)
Weight	28 kg	1 kg	2.4 kg

[2] In this study Tessa is viewed from the perspective of its role in the eWare project, not as a single product from Tinybots.

2.1 The human-like robot Pepper

Pepper is a humanoid social robot originally created by Aldebaran Robotics in France, then acquired by SoftBank in Japan. According to SoftBank, Pepper is "the world's first social humanoid robot able to recognize faces and basic human emotions" (SoftBank Robotics). Pepper's construction ($42.5 \times 48 \times 121$ cm and weight of 28 kg) gives it the same height and weight appearance as a 7-year-old human child. It features two cameras in the mouth and head, a 3D camera in the eyes, four microphones in the head and a gyroscope torso with sensors for touch and bumping detection. These all contribute to the robot projecting quite lifelike features, i.e., less of a doll projection and more of a being projection (Aldebran Documentation 2020).

One previous study of Pepper explored how children and adults interact with Pepper at a shopping mall (Aaltonen et al. 2017), finding that children preferred to physically interact with it (e.g., by giving high-fives and tickling it), while adults were more interested in the voice recognition abilities. Most of the research on Pepper is technical, e.g., about the omnidirectional features of movement (Lafaye et al. 2014). Tanaka et al. (2015) studied Pepper as an educational agent fostering remote learning.

As of December 2015, the cost of Pepper in Japan was \$1931 in addition to a monthly fee of \$360 (paid over 3 years for support). In total, this is only half of its European purchase price, making it far more available for the Japanese market, as well as available for private customers. In Europe, it is primarily sold to companies and research institutions.

2.2 The school robot AV1

AV1 is a teleoperated robot designed with the primary purpose of letting children and young adults who suffer from longtime illness participate in school activities from the comfort of their own home. AV1 is implemented with simple features that allow the child to participate on their own

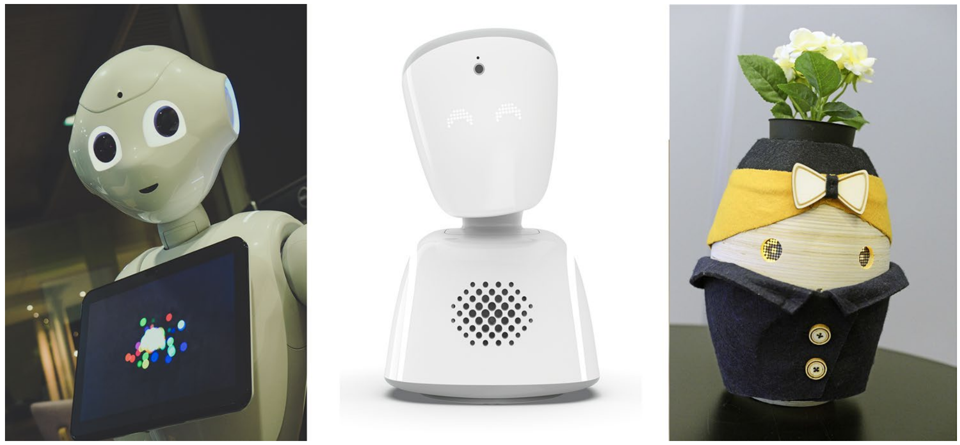

Fig. 1 From left to right: Pepper, AV1, Tessa Photo credits:"Pepper" by Owen Beard."AV1" by noIsolation. no"Tessa" by Kim Sørenssen/ NTNU

terms. By using an app to control the avatar, the child can look around the classroom (360°), in addition to tilting the head upward and downward to look at both the blackboard and books or articles on the desk. Using colored LED lights on the avatar's head, the child can signal raising their hand to answer or ask a question, and, if they are not feeling up to it, signal that today they want to simply listen to the lecture.

The dimensions of AV1 is 17.5 × 12.9 × 26.8 cm and weighs ≅ 1 kg. It has a four-cell Li-Ion, 14Ah, 3.6 V battery, and lights in its eyes (2 pcs white LED), top (16 pcs RGB LED) and bottom (2 pcs white LED). It also possesses a 13 MP camera, an 8-Ω loudspeaker, and an electret microphone. AV1 is made by the Norwegian company "No Isolation", which aims to "reduce loneliness and social isolation through warm technology" (No Isolation 2019). Their primary products are geared toward combating loneliness and social isolation, especially for children and older adults (No Isolation 2019). The classroom as an arena for robot–human interaction and co-production, is not new (Obaid et al. 2018), but it is important to keep in mind that the primary user of AV1 is only at the school through teleoperation while physically being in their own home or at the hospital.

2.3 Flowerpot robot Tessa

Tessa, created by the Dutch company Tinybots, is a nonmobile social robot designed to look like a flowerpot. Tinybots' vision is to empower people to be independent and more self-sufficient in their own lives: "in the moments when no one is around, Tessa supports independence" (Tinybots). The purpose of Tessa is to support daily routines of the users by giving voice messages and reminders. The robot is anthropomorphized with amber-colored LED eyes that blink in regular intervals, giving the illusion of some autonomy. Caregivers connect to Tessa through the help of a mobile application and schedule reminders and messages for their elderly family member. Tessa can connect to a Wi-Fi network using 2.4 GHz Wireless LAN (Tinybots 2018). Although avoiding water is recommended, Tessa is waterproof. This is a necessity considering the top of Tessa is decorated with a fake flower, and older adult users with dementia may forget that it does not need watering.

During the research fair, Tessa was presented as a part of the eWare system, where it works in symbiosis with the Sensara Senior Lifestyle System, a lifestyle-monitoring technology. The Sensara System consists of a limited number of small sensors installed at strategic places in the home and is wirelessly connected to a gateway. The gateway is plugged into an Internet router and couples the data from the sensors in the cloud and a Sensara mobile application. Through the mobile application, the caregivers can monitor the older adult user and receive alerts of deviations from their normal routines. Tessa and the Sensara System are connected through the eWare cloud that hosts core data and the eWare mobile application. The eWare project is funded by the Active Assisted Living Programme under the European Union's research and innovation framework programme Horizon 2020. The primary target groups for the eWare project are people in the mild to middle stage of dementia who live alone and their (in)formal caregivers.

3 Method: survey and observations

Survey data were collected in 2017 and 2019 during the annual research fair "Forskningstorget" (English: "The research fair") in Trondheim, Norway. The event is especially targeted to elementary and high school children, who are invited to look at and experience different scientific projects. The fair exhibited a range of different objects and activities, such as Segways, collections of sea animals and insects, urban landscaping and "medical operations" on stuffed animals. The event was held in a large tent placed in central areas of the city, with different projects exhibited in separate booths where visitors were invited to take a closer look or even try out emergent technologies.

In 2017, our booth was named “Welfare Technology—Social Robots”[3] and demonstrated both an AV1 and a Pepper robot. The audience was invited to interact with AV1 by some of their group looking at the phone connected with AV1, while others in their group carried AV1 outside of the tent, allowing the group remaining in the tent to see the outside view through AV1 and interact with the group carrying AV1 by rotating its head and turning on the lights on the robot’s head. The demonstration of Pepper started with the robot introducing itself and the team, the games “Guess my age” and “Guess my mood” and a movement sequence called “Move with Pepper.” Viewers were then invited to participate in a survey regarding their perception of the three robots. In addition, we collected demographic non-identifiable data on the participants, such as age and gender. The total number of survey participants was 115, with a gender representation of 61 male and 53 female participants, as well as one who did not wish to answer the question. The average age of participants, ranging from 6 to 79, was 17.56 years. As elementary school children were our primary point of investigation, our analysis considers respondents with an age range of 6–12 years (mean age 10.27, $N=77$; 38 girls, 38 boys, and one who did not wish to answer). At our booth in the science fair, Pepper had the following dialog, which was spoken in English:

> *Hi everybody, my name is Pepper, and I am a robot. I was born in France, and most of my family lives in Japan. Now I live here in Trondheim at NTNU. I just got to Norway, so I haven’t quite mastered the language yet, but I am currently taking Norwegian lessons in order to learn your beautiful language. Today we are going to play guessing games together, and I will show you how I handle an accident. But first we need to warm up a bit together. I will now demonstrate movements, and I would love it if you would move with me. Are you ready?*

In 2019, our booth was named “Can game technology and robots improve health?” and consisted of the eWare system with Tessa and the Sensara System as well as an exercise game with a stationary bike (Fig. 2). The audience was introduced to the eWare system and listened to a brief spoken message from Tessa. The message was written as a direct message through the eWare web application and

Fig. 2 Our booth in the 2019 Research Fair featuring Tessa as a part of the eWare project and an exercise game: Photo by Kim Sørenssen/NTNU

varied according to external factors, such as the weather. Most of the messages contained a self-introduction and a greeting. One example of this message is: “Hello, my name is Tessa, and I am a robot. I hope you have had a nice day, even though it is raining.” (The greeting was spoken in Norwegian, English translation provided by the authors.) The audience was also encouraged to write a customized message for Tessa to speak. After the introduction, the audience was invited to participate in a survey regarding their perception of Tessa There were 30 survey participants; this was lower than in 2017 because the survey was only given during 1 day of the 2-day fair. The participants of the survey ranged from 10 to 13 years in age, with an average age of 11.33 years. It consisted of 10 male and 18 female participants, as well as 2 who either did not wish to answer or answered “other.”

This study tested three widely different robots, which showed unique problems, rationales and benefits. AV1, a robot for elementary school children, was quite suitable for this test setting. It was easy to demonstrate by spitting two groups and thus teleoperating AV1. For Tessa, a robot designed for older adults with mild dementia, the elementary school children were in the opposite age spectrum of the primary user group; however, they could be potential secondary users, when visiting older family members that could have robots like Tessa. Therefore, their opinions are also valuable. The Pepper robot is branded as an “all-around” social robot with multiple functions. Because of its high level of anthropomorphization and functionality, we saw it as a stark contrast to the more simply designed robots AV1 and Tessa.

The data collection from both years included a qualitative component in addition to the survey. Some of the audience were asked questions such as “Do you think this robot could help the elderly” and “Do you think this robot could help your grandparents?” along with follow-up questions

[3] In Norway, and its Scandinavian neighbors, the term “welfare technology” (Norwegian: velferdsteknologi) has been adopted as the term used to describe how the well-being of the population can be enhanced and advanced by technological solutions, especially by giving user autonomy over their own life, increased safety, and social inclusion (NOU 2012).

to elaborate on why or why not. As Bartneck (2009, p. 71) writes, "The success of service robots and, in particular, of entertainment robots cannot be assessed only by performance criteria typically found for industrial robots." We have thus included questions fitted to the social aspect of these robots. As we were not aware of Bartneck's (2009) "Goodspeed questionnaire" at the time of the experiment, it was not included in our data collection. However, in retrospect, using a standardized questionnaire fitted to the sociocultural context could have strengthened the findings of this study. The survey was created using Wufoo (SurveyMonkey). Answers were anonymized, and all data were processed in Microsoft Excel, sorted and categorized based on commonalities between the data gathered. We then analyzed the data through thematic coding, finding themes and relations in the data, the findings of which are presented and discussed in the following section.

4 Findings and discussion

The first item in the questionnaire was if participants found the robots "cute." As the data show, there is an overwhelming perception that all three of the robots are cute, with 23–29% strongly agreeing to this statement, with an additional 35% (Pepper), 45% (AV1), and 57% (Tessa) agreeing. For the negative spectrum (disagree and strongly disagree), we find 22% (Pepper), 10% (AV1), and 0% (Tessa), and the neutral opinions (coupled with "I don't know") to be 17% (Pepper), 15% (AV1), and 20% (Tessa). This could partly be explained by the design of the robots. They are all small, but Pepper is of similar height to many of the children participants, but also taller than some (Fig. 3).

The next parameter we asked participants to assess was whether or not they perceived the robot as "cool." This question was added to cover the positive associations more thoroughly due to children of that age, especially boys, laying quite a different meaning into the words "cute" and "cool." For Pepper, 38% strongly agreed that it was cool, 48% agreed, 6% were neutral, 3% disagreed, and 4% strongly disagreed. For AV1, 43% strongly agreed that it was cool, 47% agreed, 7% were neutral, 1% disagreed, and 3% strongly disagreed. For Tessa, 70% strongly agreed that it was cool, 23% agreed, 3% were neutral, and 3% did not know. Nearly all participants either agreed or strongly agreed that the robots were cool. However, Pepper and AV1 had a larger share of respondents that agreed than strongly agreed, whereas, with Tessa, there was a clear majority for "strongly agree." This was quite surprising to us, but we think this could be related to the fact that the survey participations of year 2, where Tessa was introduced, had more time to interact with the robot. Again, as in the previous parameter, no one disagreed directly to the question regarding Tessa (Fig. 4).

The third parameter evaluated whether they perceived the robots as "scary." For Pepper, 3% strongly agreed that it was scary, 5% agreed, 7% were neutral, 32% disagreed, and 53% strongly disagreed. For AV1, 1% strongly agreed that it was scary, 3% agreed, 7% were neutral, 25% disagreed, and 64% strongly disagreed. For Tessa, 0% strongly agreed or agreed that it was scary, 3% were neutral, 20% disagreed, and 73% strongly disagreed and 3% did not know. Although the vast majority respondents did not find any of the robots to be scary, Pepper had the most ambiguous response. This was perhaps the parameter that holds the strongest cultural connection as Hollywood movies are littered with killer robots and strongly affect our perception of robots in the real world (Søraa 2019). At 121 cm tall, Pepper was taller than some of the respondents, and height is a trait traditionally associated with power. If a grown man of 170 cm would meet a robot of 2 m, there would probably be some insecurity present.

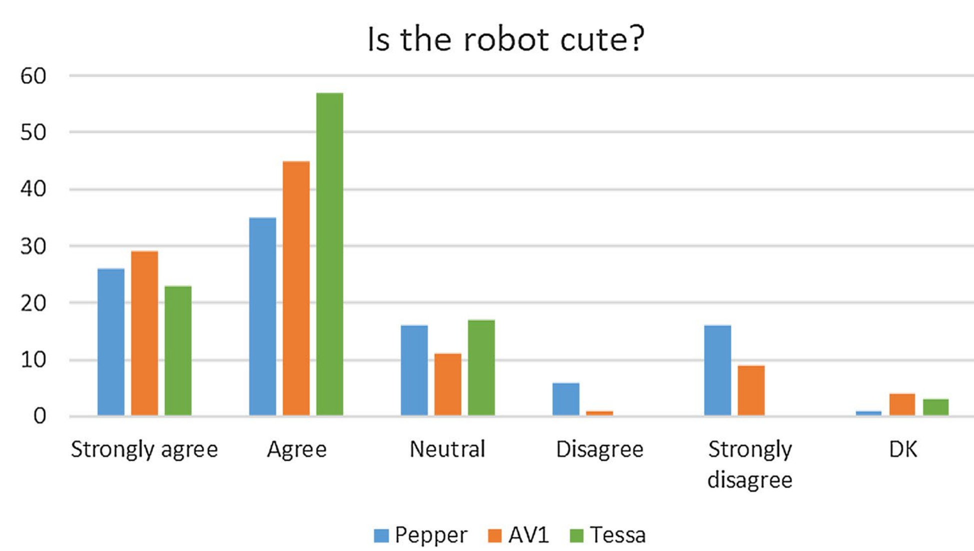

Fig. 3 Responses to the question "Is the robot cute?"

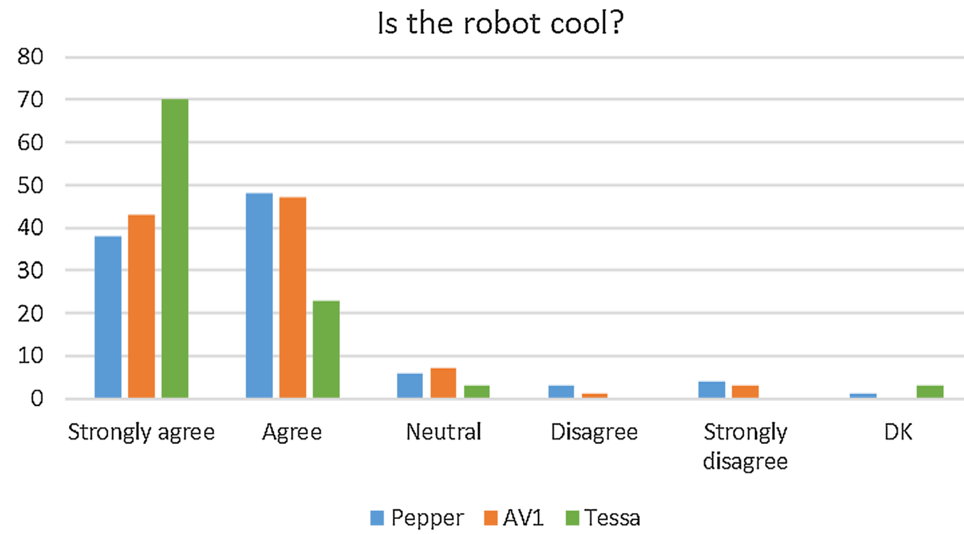

Fig. 4 Responses to the question "Is the robot cool?"

It seems viable to consider the correlation between how human the robot looks and the possibility of children finding it scary. In fact, Pepper is on top of the list, although with a small percentage, followed by AV1 where the human resemblance is less than Pepper, and lastly Tessa which no one considered scary. This may be explained by the uncanny valley effect (Mori 2012; originally 1970), reflecting a hypothesis "that a person's response to a humanlike robot would abruptly shift from empathy to revulsion as it approached, but failed to attain, a lifelike appearance." In the qualitative part of the second research year, some of the participants were asked what they thought robots in general look like. Several participants answered, "Not like that" or "Different than this one" while pointing at the robot Tessa. Being designed as a flowerpot seems to make it differ from their perceptions of robots. One person commented: "The voice is a little bit scary," indicating that elements of Tessa could be perceived as less likable (Fig. 5).

By analyzing the results relating to the question "Is the robot lifelike?", we can see that children's perceptions of robots vary greatly depending on robot designs. A Finnish study in a shopping mall found a similar willingness to interact. They conclude that "careful balancing between the robot being entertaining (esp. children) and purposeful (adults)... should not be mutually exclusive" (Aaltonen et al. 2017, p. 54). We found similar results for our experiments, with children emphasizing the entertainment value of the robots while holding a deep fascination with the creatures, whereas adults were more pragmatic in their interaction with the robots, asking questions about what functions it had and how they work. As recommended by Bartneck (2009, p. 78), results of surveys on social robots in this early stage of their implementation in society should not be interpreted as absolute values, but rather as a tool for comparison (Fig. 6).

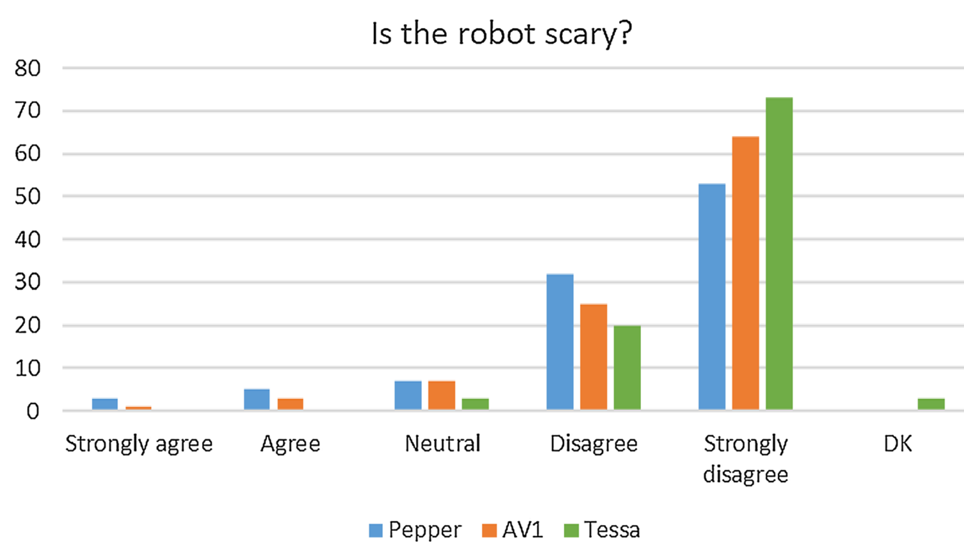

Fig. 5 Responses to the question "Is the robot scary?"

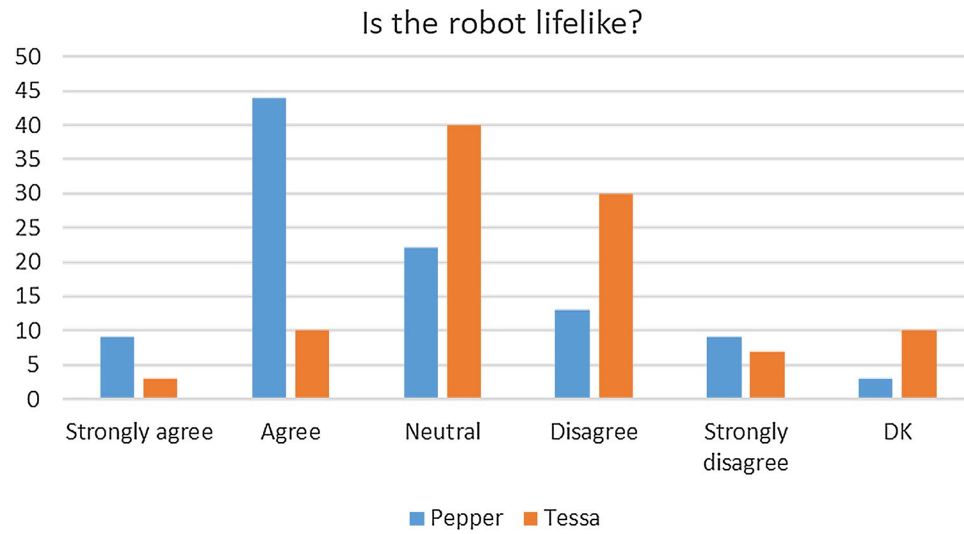

Fig. 6 Responses to the question "Is the robot lifelike?"

By adding "do not know" (DK) as an alternative answer some participants' actual opinions might have been lost. If one experiences contradictory thoughts and/or feelings toward the object of which one is asked to consider, or is concerned one will not be able to defend one's answer due to lack of knowledge, it is often easier to respond with DK compared to choosing a weighted response (Krosnick and Presser 2010).

4.1 Technical difficulties

Fairs, especially those happening inside tents placed outdoors, represent one of the most difficult environments for controlling sound and light quality. Some difficulties include strong sound reflections, a large amount of ambient noise and sudden variation of light intensity. Such harsh conditions had a strongly negative impact on the performance of the robots, especially for Pepper due to the more advanced functionality presented. The Pepper robot experienced technical difficulties regarding two pre-programmed algorithms: "Guess my mood" and "Guess my age." Pepper had trouble recognizing faces and could often not give a response to the question at hand. The researchers tried adjusting the lights, which seemed to be too weak, by placing floodlights at different angles. However, it was not possible to find the right lighting conditions in the fair tent, and therefore the functions were inconsistent. This concurs with the experiences of Kalaiselvi and Nithya (2013), who found that algorithms meant to recognize faces did not work properly when the lighting was too weak or too strong (e.g. a bright lamp).

Pepper's speech recognition was also challenged at the research fair, which was quite noisy with sound sources coming from different directions and even reflected back from the roof of the tent. This caused some misunderstandings between the robot and its interlocutor. When speaking with fairgoers, Pepper could, for example, freeze and stop the established dialog. When trying to guess the age of a person, it was sometimes wrong by several decades, which the interlocutor sometimes perceived as offensive. As with the lighting challenges, noise problems have also previously been experienced by Gardecki and Porpora (2017). The malfunction of the Pepper robot could have had an impact on the participants' perception of the robot in general, causing them to answer more negatively compared to what they would have, had they seen the robot fully functional in more controlled environmental conditions. However, one could argue that the more controlled the conditions, the less natural or realistic the setting would be. In reality there are few contexts where sound and lighting settings are ideal, making this scenario an ideal test site for a more realistic evaluation of Pepper's functionalities.

Tessa, on the other hand, had less issues with the setting. Its reduced set of functionalities makes it less sensitive to the environment, and, because Tessa is designed for users with potential hearing disabilities, the volume can be adjusted up to a relatively high level. Most of the time, there were no difficulties in hearing the robot, even with a lot of background noise. This is suitable for the older adult user group it is constructed for, who often have a TV on with high volume.

Another possible explanation of negative perceptions regarding Pepper is that a humanoid robot may elicit higher expectations on the interaction capabilities when compared to less sophisticated robots, as are Tessa and AV1. Therefore, the disappointment led by a lack of communication would be correspondingly larger with regard to Pepper then to its less-humanoid counterparts. Additionally, cultural factors, such as what different social groups expect a robot to be able to do, should also be taken into consideration (Nomura and Nakazawa 2017). Through conversation with some of the children who participated, the researchers learned that many had prior experience or were already familiar with AV1 and its purpose and function. Due to this robot being made solely

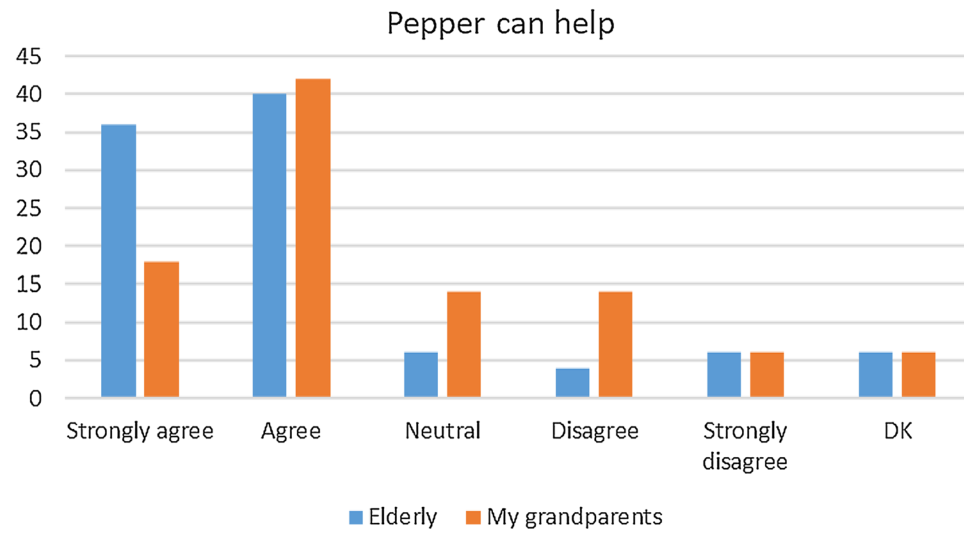

Fig. 7 Responses showing whether children believed Pepper could help their grandparents or the elderly in general

for helping school-aged children, this robot might be easier to relate to for our participants compared to the Pepper robot, which was presented as a potential helper for older adults. Tessa, on the other hand, was mostly unknown to the children, and although it had a familiar design (being a flowerpot), they were quite unsure and curious about what it could actually do when interacting with them.

4.2 "But not my grandparents"

As the current discourse on social robots relates strongly to elderly care (Wright 2018; Fong 2003; Van Wynsberghe 2016), it is interesting to learn how young people think about robots taking care of the elderly. Van Wynsberghe (2016, p. 1) states: "Make no mistake, the robots are coming! The question then is: what will this new technology do to the age-old practice of care-giving?" In that regard, a key finding in the research data is the juxtaposition between the two questions which we asked in relation to the social robots Pepper and Tessa: (1) "The robot can help the elderly in their daily lives" and (2) "The robot can take care of my grandparents." AV1 was not included in these questions since it is not targeting older adults as a user group. With these two questions we wanted to see if the participants showed any bias toward bringing robots into their own life, especially when tied to the elderly in their own family. Our hypothesis was that robots could potentially be more accepted when they took care of someone rather than a loved one, as interpersonal connections to one's own grandparents might affect the acceptance rate of robots.

The results support our hypothesis. 76% strongly agree or agree that Pepper can help the elderly), but only 60% would similarly allow it to help their own grandparents (see Fig. 7). Around 10% disagree or strongly disagree that Pepper can care for elderly, while double the amount—20%—disagree or strongly disagree that Pepper can take care of their own grandparents. The results thus show that a much larger percentage of children are positive toward allowing Pepper to take care of the "elderly" in general as compared to "my grandparents" in particular. The same trend can be observed in the negative side of the scale, a much larger percentage shows reluctance on allowing Pepper to take care of "my grandparents" than the generic "elderly." The Tessa robot, on the other hand, had a quite positive response, with over 97% strongly agreeing or agreeing that Tessa can help the elderly and with 86% allowing it to watch their own grandparents (see Fig. 8). 10% are neutral toward Tessa taking care of their grandparents, as exemplified by this quote from one of the respondents (11 years old):

> *I think it can help my grandmother because she's a bit forgetful. But not my other grandparent [X], because that one is unsure about technology.*

The discrepancy between whether the children thought the Pepper robot could watch over older adults or their own grandparents could potentially be explained by the age and the relatively good health of their grandparents. The children who answered our survey were aged 6–13 years, and their grandparents could be aged below 50 in some cases. Furthermore, at the age of 80, many older adults are still living an active lifestyle and managing quite well on their own, so there might not be a visible "need for a robot." Our participants might not perceive their own grandparents as "old and frail" compared to the elderly in general. This is exemplified by this quote from one respondent (11 years): "I think it can help my great-grandfather because he is quite forgetful, and he lives alone." This child thinks that their great-grandparent, but not their grandparent could benefit from the robot, indicating, presumably, that grandparents would be too young to be perceived as needing to live with a robot.

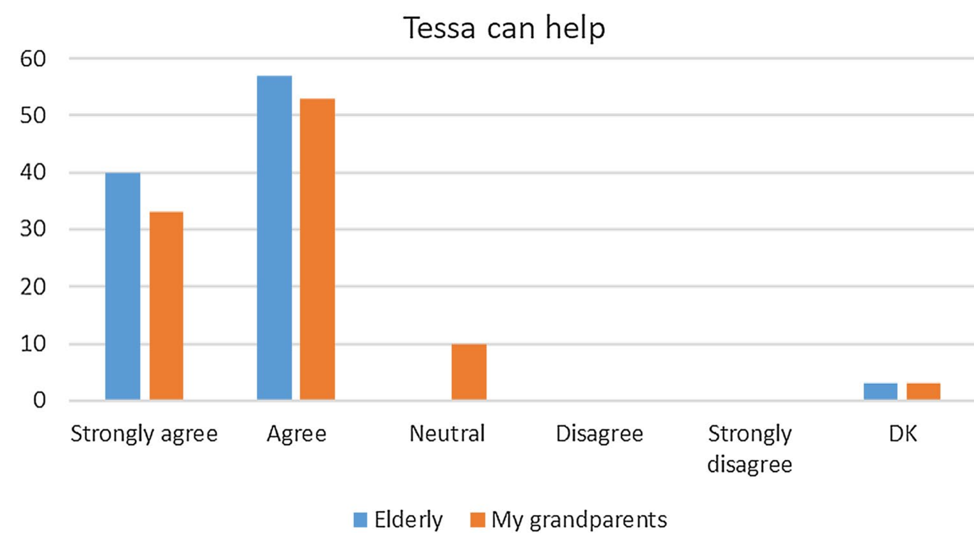

Fig. 8 Responses showing whether children believed Tessa could help their grandparents or the elderly in general

4.3 Measuring social robot and human interaction

Bartneck's (2009) suggestion for a standardized measurement tool for human robot interaction and his five key concepts of social robots—anthropomorphism, animacy, likability, perceived intelligence and perceived safety—can be seen in the following way in our study:

4.3.1 Anthropomorphism

All robots have some degrees of anthropomorphization, although it is clear to all that these are in fact technological entities and not humans except, perhaps, for Tessa, which could be mistaken for a normal flowerpot. This became apparent for an earlier prototype of the robot, as test users would water the plant on top. However, later designs of the robot, including the version we had on display, were made to be waterproof. Pepper, with its measurements approximating a 7-year-old child and larger degree of mobility, is the robot that is perceived as most humanoid. As Breazeal (2003 p. 167) discussed, social robots are robots that people anthropomorphize to interact with them. However, for Tessa, this is a mixed entanglement of anthropomorphization and "plantification,", i.e., people want to relate to it as a plant as well.

4.3.2 Animacy

As we could see in our question about the robots being "lifelike," we see a correlation to anthropomorphization as described above. Since Pepper moves about, gesticulates and is pre-programmed to be a bit "quirky" in its speech, people were charmed and found it more alive; Aaltonen et al. (2017) showed comparable findings. Our participants did not agree, for the most part, that Tessa was very lifelike, which we presume can relate to it being quite stationary and not moving save for the blinking. As we did not question the participants about the animacy of AV1, no data can be presented on this. Our reasoning for not the question of AV1 is that the teleoperation of AV1 by a child gives it a certain amount of human embodiment and animacy in its own right when used in a classroom setting. This is similar to findings by Choi et al. (2014, p. 1069), who found people to perceive "autonomous robots as more intelligent than tele-operated robots while they felt more social presence toward tele-operated robots than autonomous robots."

4.3.3 Likeability

For likeability, our study shows some different parameters concerning whether the participants found the robot to be "cool," "cute" or "scary." Whereas both AV1 and Tessa scored relatively high on it being cute, participants found Pepper to be less so. This could perhaps be the fact that Pepper is quite tall, at least seen from the perspective of a child of the same height. Tessa, with its flowery appearance, and AV1 with its round eyes and no mouth, are designed more to have some degree of cuteness. As for the cool parameter, here Pepper scored better, which can relate to it having more functions. Tessa was also perceived as very cool, which, because of Tessa's lack of movement, we found surprising. For scariness, we see that all robots were quite well liked, but that participants tended to be a bit warier of Pepper—placing it a bit lower in Mori's (2012) Uncanny Valley.

4.3.4 Perceived intelligence

Because AV1 is teleoperated, and therefore controlled directly by another user, only Tessa and Pepper could be evaluated as being perceived to be intelligent independently of its operator. Communication and recognition are two aspects that can be linked with perceived intelligence. Tessa is possibly too simple to be perceived as intelligent. This simplicity is reflected as predictability—something totally predictable cannot be intelligent. However, Pepper is expected to be highly intelligent due to its claimed ability to recognize people and its advanced voice communication features, which exhibit a conversational level. As mentioned, due mostly to contextual circumstances (poor light and environment noise), both skills failed to impress the children, who were finally rather disappointed.

4.3.5 Perceived safety

This aspect, in our study, relates to the perceived capability of the robots taking care of older adults. However, since the demonstrations of the robots were limited, this aspect was not further investigated in this study.

4.4 Limits of the study and its design

The validity of the data must be read in the localized context, and the randomization of the fair attendees. The data material was collected at the same type of research fair, but in two separate years, which might have led to dissimilarities in the data collection. Firstly, different researchers were involved in the two fairs, which could have led to different ways of presenting the robots and/or communicating with the children. All participants in the research team were instructed to keep the description and conversation of the robots neutral to limit the risk of influencing the children's first impressions. In the first year the research team introduced the visitors to two robots, and in the second year there was only one robot present. Additionally, during the second year, there were more personnel operating the robot stand compared to the first year, allowing the visitors to engage for an extended period of time with the flower-pot robot, and it offered no reference of comparison with other robots.

As our data collection was dependent on who came by, a controlled data trial would be more representative, but as visiting the research fair is mandatory at school, a wide sample of attendees came by. The assembly of activities and objects at the fair varied as well. In the first year, the two robots were the only items at the booth, and in the second year the booth was shared with four stationary bikes connected with an exercise game. The exercise game had a screen where the game virtually took place, and gamers "drove" in virtual tanks with the force of the pedalling and shot other gamers by using controllers on their handle. This caught a lot of attention due to its popularity and significantly larger installment, and could have affected the size and type of attendants in that year's sample. There is a possibility that people more interested in robots came by our stands, thus affecting the data.

5 Conclusion: just enough?

This article has explored perceptual differences of three different social robots by elementary school children at Norwegian research fairs. We compared three social robots—the humanoid and autonomous service robot *Pepper,* the teleoperated school-bench robot *AV1*, and the semi-autonomous dementia care robot Tessa used in the eWare project—through quantitative data surveys and qualitative interviews of fair going children aged 6–13 years ($n = 107$). In comparing these three social robots, we found that robot design choices, such as size, materials and degree of mobility, seem to have a strong influence in children's perceptions. Robots with simpler, more direct functions are easier to grasp, especially for children. Even without the advanced movement capabilities or anthropomorphism of robots like Pepper—the AV1 and Tessa robots' design suits them better for a very specific context of use. These robots seem to have a "just enough" functionality for their intended tasks. They have a "just enough" size, a "just enough" function, and a "just enough" design. All-around-robots of a seemingly highly advanced level might be a bit further into the future, if we follow that determinism that equates the future of technological design with increasing sophistication and complexity. Or, perhaps "just enough" robot functionality is what society currently needs. For Pepper, we saw that much is still needed for it to perform in a sufficient manner, as there are still major technical problems. Additionally, we found a strong difference when relating robots to personal relations to one's own grandparents, versus older adults in general. The article finds that children's perceptions of robots tend to be positive, curious and exploratory. These perceptions are possibly more guided by an emotional connection, rather than a rational interpretation based on culture and notions of usefulness when compared with those experienced by adults.

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