International Journal of Social Robotics (2022) 14:875–891
https://doi.org/10.1007/s12369-021-00835-0

Children's Intention to Adopt Social Robots: A Model of its Distal and Proximal Predictors

Chiara de Jong[1] · Jochen Peter[1] · Rinaldo Kühne[1] · Alex Barco[1]

Accepted: 29 September 2021 / Published online: 30 October 2021

Abstract
Social robots have increasingly been entering children's daily lives and their domestic environment. Whereas various studies have shown children's enthusiasm towards social robots in, for example, an educational context, little is known about children's acceptance—or rejection—of domestic social robots. This paper aimed at filling this research gap by developing a model of children's intention to adopt a social robot at home, based on the Theory of Planned Behavior. Relying on data from a survey among 570 children aged eight to nine, we found that, before having ever interacted with the robot in real life, 82% of the children were willing to adopt the robot at home. Children's adoption intention was mainly predicted by hedonic attitudes and social norms, as well as by their general attitude towards robots, which was linked to adoption both directly and indirectly through hedonic attitudes and social norms. Our findings suggest that entertainment-related and normative considerations drive children's intention to adopt a domestic social robot.

Keywords Child–robot interaction · Human–machine interaction · Social robotics · Technology acceptance · Human–robot interaction

1 Introduction

With the recent technological developments, social robots which can be defined as robots that are capable of approaching human–human interaction [1]—have been entering the consumer market and the domestic environment [2, 3]. In 2019, the total number of robots for domestic and household tasks has grown by 40%, and the number of robots that are solely used for entertainment has grown by 13% [4]. Research has directed its attention to social robots for educational purposes (for a review see [5]), such as language tutoring (e.g., [6]) or physical therapy (for a review see for example [7]). These studies show that children are enthusiastic about using social robots (e.g., [8]) and highly appreciate and like them (e.g., [9–11]).

However, with social robots increasingly being made for use in children's homes, it is essential to gain also more insights into children's intended adoption, or rejection, of a social robot in a domestic environment. Compared to an educational environment, a domestic environment gives children more freedom to decide whether they intend to adopt—or reject—a technology. As a result, the present study centers on whether children intend to adopt, or reject, a social robot at home. We thus focus on the pre-adoption phase, that is, the phase before a child actually interacts with a robot (e.g., [12, 13]).

To date, little is known about the factors that are associated with children's adoption of a social robot and if knowledge exists, it typically lacks an elaborate theoretical basis [14]. The present study tried to initially fill that gap. Based on psychological models, we first identified concepts that are related to robot adoption. Subsequently, we proposed and tested a model of children's intention to adopt a social robot at home. Given the novelty of research on child–robot interaction (CRI), and the pertinent limited theoretical knowledge, this study should be seen as a tentative first step toward a better understanding of children's adoption of social robots.

✉ Chiara de Jong
c.dejong@uva.nl

Jochen Peter
j.peter@uva.nl

Rinaldo Kühne
r.j.kuhne@uva.nl

Alex Barco
abarcomartelo@gmail.com

[1] Amsterdam School of Communication Research (ASCoR), University of Amsterdam, P.O. Box 15791, 1001 NG, Amsterdam, The Netherlands

We focus on the Cozmo robot (Anki), which was available on the consumer market at the time of planning the study and has an advanced artificial intelligence back-end [15]. We chose Cozmo because of its ecological validity: It does not need to be programmed by the researcher or user and is, compared to other social robots, relatively affordable, which is not the case with other social robots often used to study CRI, for example NAO (Softbank Robotics) [16]. In this study, we focused on children aged eight to nine, because children in that age group (i.e., middle childhood) are capable of participating in surveys [17, 18] and master various social and relation skills relevant for studying child–robot interaction (CRI), which is not the case with younger children (e.g., [19]). Adolescents, in contrast, are more similar to adults compared to children in our age group [17, 20] and research on adults' adoption of social robots is readily available (e.g., [13, 21]).

1.1 Children's Adoption of Social Robots in Their Homes

With the domestication of social robots, the concepts of *acceptance* and *adoption* of a technology have become important. Acceptance is often defined as a repeated and longitudinal use behavior [21, 22] and is considered a process with different phases, starting with the pre-adoption (i.e., expectations) phase and ending with individuals incorporating the technology in their daily lives (e.g., [12, 13, 23]). Acceptance is conceptually different from adoption of a technology, which "[…] is regarded as the initial decision to buy and start using the technology" [13, p.4]. Adoption (or rejection) is preceded by the pre-adoption phase. In this phase, individuals gain knowledge and awareness of the technology and develop expectations about it, which eventually leads to an intention to adopt or reject the technology [12, 13, 24].

During the pre-adoption phase, a decision about a potential future use of a robot is based upon expectations and indirect experiences (e.g., video's and images of others using the technology). In contrast, after a real-life interaction with a robot, the decision is (mainly) based upon experiences with the technology [12, 13, 24–26]. When expectations about using a technology generated in the pre-adoption phase do not match experiences when using a technology, the technology may be rejected or its use discontinued [3, 12, 13, 27–29]. The pre-adoption phase is thus a crucial phase. In order to understand children's acceptance of social robots, it is therefore first necessary to focus on the pre-adoption phase and specifically on children's intention to adopt the robot (e.g., [23, 24, 30, 31]).

A few studies have investigated concepts related to children's intention to use a social robot prior to real-life encounters, such as motivation to interact [32], willingness to meet a robot [33], and openness to interacting with a robot [34]. The results showed that children aged eight to eleven had a high willingness to interact with a social robot prior to real-life encounters [34]. In another study, all 20 children (aged six to eight years old) said they were 'very much' motivated to interact with the robot [32], whereas in yet another study four out of the five children (aged five years old) wanted to interact with the robot [33].

These studies are informative in studying children's intention to adopt a social robot during pre-adoption. The present study, however, deviates from them for two reasons. First, the previous studies typically envisioned a child–robot interaction in the (very) close future (except for [34]). This potentially led to a selection bias: Given the envisioned interaction with the robot, only those children who already liked social robots probably participated in the study. We thus do not know whether children might reject a robot when given a real choice. Second, in the context of domestic robots, adoption does not only include a willingness to interact with the robot, but also a willingness to invite the robot into one's home [12, 13]. Both the context of use and its implications are different when using a social robot at school or in a library rather than at home [35]. For example, an earlier exploratory study found that children also seem to consider the opinion of other family members, the presence of pets, and the costs that come with using a social robot in their home (i.e., control beliefs), especially when rejecting a social robot during pre-adoption [36]. In line with previous studies, we therefore expected—as a general descriptive basis of our study—an overall high intention to adopt a social robot prior to real-life encounters.

2 A TPB-Based Model of Children's Adoption of Social Robots

The field of human–robot interaction (HRI) has paid considerable attention to predicting (adults') adoption and acceptance of social robots in an in-home context (e.g., [12, 13, 21, 26]). To our knowledge, four models have been developed that predict adults' acceptance of social robots [21, 26, 31, 37]. Three of these models are built on technology acceptance models, such as the Technology Acceptance Model (TAM; [38]) or Unified Theory of Acceptance and Use of Technology (UTAUT; [39]). The fourth model, the domestic social robot acceptance model by De Graaf et al. [26], is a psychologically oriented model relying on the Theory of Planned Behavior (TPB; [40]) and was tested in a domestic context, which makes it suitable for the purposes of this study. To optimally address the goals of their study, De Graaf et al. [26] translated the key concepts of the TPB into more specific factors, such as privacy, animacy of the robot, and status.

Like De Graaf et al. et al. [26], we relied on the TPB in building our model. However, given the novelty of the field of CRI and, consequently, the lack of fundamental research, we did not translate the key concepts of the TPB into more specific factors [40]. It is argued that the concepts in psychological models such as the TPB [40] are, and should be [27], universal—and thus applicable to CRI—with "the relative importance of each of the variables in the model [being] expected to vary as a function of both the behaviour and the population under consideration" [41, p. 274].

We opted, in line with De Graaf et al. [26], for a psychological model because, compared to technology-oriented models like the TAM [38], the TPB has been more successful in predicting the intention to use a specific technology [42], (for a more elaborate discussion, see [43]). Moreover, compared to the TAM, which focuses mainly on utilitarian factors and was developed for utilitarian technologies [44], the TPB is more comprehensive and also includes hedonic and social factors [26]. This is particularly important when dealing with children as earlier research has indicated [36, 45]. Finally, for a better understanding of children's intention to adopt a social robot, it is essential to also study user characteristics (i.e., child characteristics), which are more frequent in psychological models of human behavior than in more traditional technology acceptance models, notably the TAM.

A general proposition in theories of human behavior, such as the TPB [40], the Theory of Reasoned Action (TRA; [27]), and the Integrative Model [41, 46], is that human behavior results from a strong intention to perform the behavior, which in turn derives from beliefs about, and perceptions of, performing that behavior. These perceptions—which we call proximal predictors in this paper—consist of three main factors: *attitudes*, *social norms*, and *self-efficacy* [27, 40, 41, 46]. The extent to which each of these proximal predictors explains the intention to perform the behavior depends on the behavior as well as the population that are studied [41]. For a better understanding of children's intention to adopt a social robot, we opted for also studying background factors—which we call distal predictors—which both indirectly and directly affect this intention. These factors can inform us, beyond the proximal predictors, on children's adoption intention of social robots. Given the limited research in CRI, we additionally rely on adult-based literature on robot adoption and more general research on children to substantiate our TPB-based model.

2.1 Proximal Predictors of Social Robot Adoption

In line with psychological models of behavior [27, 40, 41, 46], we expected the following proximal predictors to be positively associated with children's intention to adopt the robot: attitudes, social norms and self-efficacy (H1– H3, see Fig. 1).

Attitude can be defined as "a latent disposition or tendency to respond with some degree of favorableness or unavoidableness to a psychological object." [27, p. 76]. Attitude in our study comprises of a *hedonic* and a *utilitarian* component [47]. This is in line with earlier TPB research in which an experiential and an instrumental component of attitudes has been distinguished [48–50].

Children typically approach social robots with enjoyment- and entertainment-oriented goals [45], which may translate into stronger hedonic attitudes toward social robots. When it comes to the utilitarian component of attitudes, which has been influential in earlier TPB research with children [48, 49, 51], specifically the usefulness and ease of use of a robot have been shown to be important [26, 52]. Therefore, we expected both hedonic and utilitarian attitudes to be positively related to intention to adopt the robot (H1, see Fig. 1).

Social norms "refer to what is acceptable or permissible behavior in a group or society" [27, p. 129]. They are based on what one believes important others think of the behavior—that is *injunctive norms* [40]—and on whether or not important others actually perform the behavior—that is *descriptive norms* [27]. For children, compared to adults, the behavior of others is more strongly correlated with their intentions [53]. Moreover, an exploratory study on children's beliefs for adopting a social robot has shown that children rely on the opinion of others when deciding to adopt or reject a domestic social robot [36]. Thus, we expected social norms to be positively related to intention to adopt the robot (H2, see Fig. 1).

Finally, *self-efficacy* [54]—or perceived behavioral control [27, 40] (for a discussion on the terminology see [55])—stems from Bandura's [56] social cognitive theory and is a direct predictor of intention and behavior [41, 46]. It consists of two components—the extent to which people believe they are capable of (i.e., capacity), and have control over (i.e., autonomy) performing a behavior [27]. In line with other research [26] and an earlier exploratory study on children's beliefs for adopting a domestic social robot [36], we expected that self-efficacy would predict intention to adopt a robot positively: The more children believe that they are capable of and have control over using the robot, the stronger their intention to adopt that robot will be (H3, see Fig. 1).

2.2 Distal Predictors of Social Robot Adoption

Besides proximal predictors and intention to perform a behavior, there are various other factors that can play a role in predicting behavior, such as biological sex and exposure to media [27, 46]. In line with the TPB [40], these distal predictors are assumed to be indirectly associated with the intention to perform a behavior, through proximal predictors. Variations in the intention to perform a behavior thus stem from differences in distal predictors, as they are related to

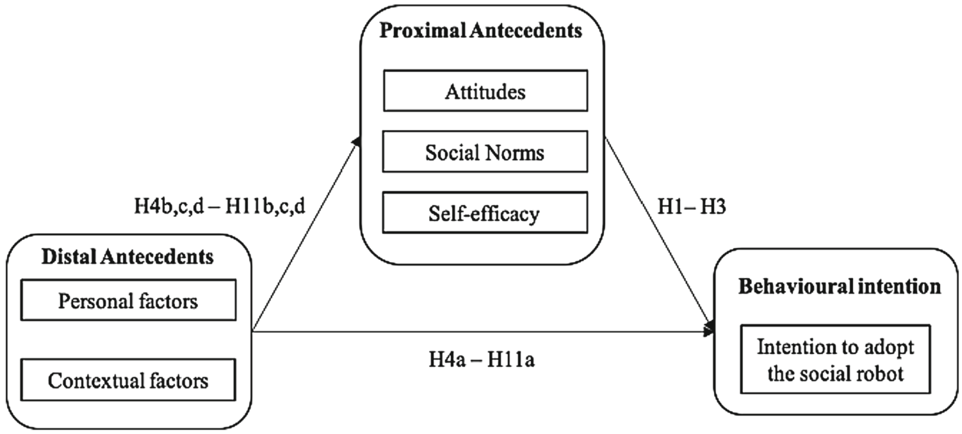

Fig. 1 TPB-based model of children's intention to adopt the robot

how people interact with, learn from, and form beliefs and perceptions about their environment [46].

As, in psychological models of behavior, there are no theoretical reasons to expect distal predictors to be related to all behavioral intentions and actual behavior similarly, distal predictors are considered population- and behavior-specific [27, 46]. Distal predictors should only be included if there is theoretical reason to believe that they are associated with a behavioral intention. If a distal predictor can be expected to be related to a behavioral intention, this relation is mediated by the proximal predictors [27, 43].

Based on research in HRI and CRI, we distinguish, in terms of distal predictors, between *personal* and *contextual factors*. We thus expected that personal and contextual factors would be related to intention to adopt a social robot indirectly through the proximal predictors attitudes (H4b–H11b), social norms (H4c–H11c), and self-efficacy (H4d–H11d, see Fig. 1). However, to establish such an indirect relation, we hypothesized in line with the TPB that, initially, personal and contextual factors would also be related directly to intention to adopt a social robot (H4a–H11a, see Fig. 1).

2.2.1 Personal Factors

Personal factors that have typically been identified to influence the evaluation of social robots as well as its acceptance in HRI include sex [57, 58], personality [58–60], attitudes towards robots [47], and anxiety [21, 47].

As for sex, previous research on acceptance suggests that girls show higher behavioral acceptance of social robots than boys (for an elaborate discussion, see [14]). We, therefore, expected that girls would show a higher intention to adopt the robot compared to boys (H4a). Similarly, as research on children's attitudes towards robots found girls compared to boys to have more positive attitudes towards robots [61], we expected girls to hold a more positive attitude towards adopting the robot at home than boys (H4b). In contrast, we expected boys, rather than girls, to hold more positive social norms (H4c) and show higher self-efficacy towards adopting the social robot (H4d). Girls are still consistently underrepresented in science, technology, engineering and mathematics (STEM) [62], an area strongly related to robotics, which may shape perceptions of social norms and self-efficacy [63]. Moreover, research has suggested that high-school girls approach technology with less self-confidence than boys [64], which is closely related to the concept of self-efficacy.

Personality traits, such as the openness to new experiences (i.e., a general willingness to try out new things; [65]) and agreeableness (i.e., being kind, considerate, and cooperative; [66]), have been found to positively influence children's acceptance of social robots [34, 67] (for an overview see [14]). We therefore expected that children who are more open and agreeable to also have a higher intention to adopt the social robot (H5a; H6a). In line with this, research on adult's acceptance of technology found positive associations between openness and agreeableness and several acceptance-related variables (i.e., use intention, usefulness, and subjective norms) [68]. Accordingly, children high on openness and agreeableness were also expected to hold more positive attitudes (H5b; H6b) and social norms (H5c; H6c) towards adopting the social robot. Finally, as openness and agreeableness tend to positively correlate with one's general self-esteem [69], which is related to self-efficacy [70], we expected these traits to have a positive association with children's self-efficacy (H5d; H6d).

Earlier research on children and technology also found that interest in technology in general [71] and robots in particular [34, 67] affected children's acceptance of technology or robots positively. Accordingly, we expected that children with a positive general attitude towards robots would show a higher intention to adopt the social robot (H7a). Moreover, we predicted that a positive general attitude toward robots would also translate into positive attitudes towards a specific robot (H7b), as beliefs about an object are generally formed by comparing it to something similar or related [40]. Finally, general attitudes towards a technology affect the evaluations and understanding of a specific aspect of, or behavior related to that technology [72]. This suggests that a positive general attitude towards robots is likely to positively predict social norms (H7c) and self-efficacy (H7d).

Research with adults on the acceptance of technology in general (e.g., [73]) and social robots in particular [13, 21, 47] has suggested that negative emotions and anxiety towards (using) a technology (i.e., concept-specific anxiety) negatively relates to its adoption and acceptance. Accordingly, we expected that anxiety towards using the robot at home would be negatively related to children's intention to adopt the social robot (H8a). Moreover, for adults, anxiety towards a technology has been found to negatively affect (utilitarian) attitudes towards that technology [21, 47] as well as people's self-confidence about their ability to use the technology [74]. Consequently, we expected also for children a negative association between anxiety towards using the robot and attitudes (H8b) and self-efficacy (H8d). Finally, based on perceptual tendencies, such as the false consensus effect [75], in which individuals generalize from their egocentric judgements and experiences to distributions in larger groups, it is plausible that children may project their own fears onto their perceived social norms, resulting in a negative association between anxiety and social norms (H8c).

2.2.2 Contextual Factors

HRI research has identified, among other things, technology density and exposure to social robots [12, 47, 59, 76, 77] as contextual factors that may be associated with user's adoption or acceptance of social robots.

An earlier study with children showed that density of technology in a household positively influenced children's adoption of a novel technology [78]. We thus expected children with a more technologically dense household to have a higher tendency to adopt the social robot at home (H9a). As a study with adults showed that experience with technology in the household was positively related to hedonic and utilitarian attitudes towards robots at home [76], we additionally expected the density of technology in a household to be positively related to children's utilitarian and hedonic attitudes (H9b). Moreover, against the background of broader theories of the family influence on children (e.g., ecological systems theory, [79]), which have also been applied to children's technology use [71], it is plausible that children who grow up in a technology-dense household will also hold more positive social norms (H9c) and consider themselves more efficacious with technologies (H9d), such as social robots.

As to exposure to social robots, several studies showed that real life encounters with robots lead to a more concrete conceptualization of robots and better ability to differentiate robots from other entities [80, 81]. Additionally, the amount of media exposure to robots, positively affected adoption intention, albeit indirectly [82]. As related research on adult's acceptance of robots suggested that familiarity can reduce uncertainty about what robots are (e.g., [83]), we expected children's real-life as well as their media exposure to robots to be positively linked to their intention to adopt the robot (H10a, H11a). Moreover, exposure to the technology in question (either in real-life or through media) is found to positively affect utilitarian and hedonic attitude of that technology for adults (for an overview see [47]). Consequently, we expected a positive link of real-life and media exposure to social robots with attitudes towards adopting the social robot (H10b, H11b). Given the positive impact of real-life and media exposure to robots documented in the literature [47, 83], as well as theoretical and empirical evidence of direct and mediated influences on social norms [84] and self-efficacy [54, 85], we predicted that children's real-life as well as their media exposure to robots would positively relate to their social norms (H10c, H11c) and self-efficacy (H10d, H11d).

2.2.3 Control Variables

Previous research (e.g., [61]) suggests that children with different ages, but in the same developmental stage, have comparable attitudes towards and acceptance of social robots, except for older children and pre-adolescents (for an overview see [14]). As we studied children aged 8–9, who are all in the same developmental stage, we added it as a control variable. Finally, given some exploratory evidence that children consider the size of the household as a reason for rejecting a robot [36], we added household size as a control factor in our model.

3 Method

As this study focused on the adoption intention, and thus on the pre-adoption stage, we only used data from the first wave of a larger, longitudinal panel survey about children's acceptance of social robots, which ran from July to December 2019. The Ethics Review Board of the Faculty of Social and Behavioral Science at the University of Amsterdam approved the study. The recruitment of participants and the data collection were done by Kantar Netherlands.

3.1 Sample

For the recruitment of participants, Kantar Netherlands used their existing sample of 124,827 participants (62,825 families), who were initially sampled largely randomly, precluding self-selection. This sample closely resembles the Dutch population in terms of sex, age groups, geographical distribution, and household size. After approaching the

1,574 families that were eligible for participation (i.e., having one [1] child aged eight or nine during data collection) and sending two reminders, 43.7% ($N = 688$) of the full sample consented to participate during the screening (i.e., the gross sample). All the children in this baseline sample had a typical development, which was defined, for the purposes of the study, as no cognitive, emotional, and/or physical impairments that would hinder filling in the questionnaire or interacting longitudinally with the social robot and the tablet. None of the families had a Cozmo robot at home.

The first data collection wave took place between August 21 and September 8, 2019. The response for this first questionnaire was 82.8% of the gross sample with a final net sample of 570 children (48.9% male, $n = 279$; 49.1%, $n = 280$, 8-year-olds) and an equal number of parents (39.1% male, $n = 223$; age: M = 40.97, SD = 5.55).

3.2 The Cozmo Robot

The Cozmo robot is a small caricatured robot that looks like a caterpillar and is inspired by Wall-E and Eve (Pixar) [86]. The robot is controlled by an app on a smartphone or tablet and it has face recognition and an emotion learning system (i.e., it develops and learns over time). The robot can freely explore its surrounding, play games, perform tricks and can be programmed. The robot does not speak, neither does it have speech recognition, but "interacts through beeps, movements and animated eyes" [86, p. 462].

As previous research has shown that children struggle with questions about a robot if only presented with a picture of the robot (e.g., [45]), we presented them with a 26-second video of Cozmo. In the video, Cozmo hovers around and picks up a block. Next, he puts it back down, expresses excitement over this action, and, finally, turns at the camera and 'looks' at it.

3.3 Procedure

During the selection procedure, children's parents were informed about the study, its data collection procedure as well as their and their children's rights as participants. Parents gave active consent for the full study for themselves and their child and were informed that, after participating, they could be randomly selected for the follow-up study, which included receiving a small social robot and a tablet at home for their child. We asked them to not tell their child that they could receive a robot for use at home before having completed the first questionnaire.

Parents first filled in an online questionnaire, which lasted 10 min on average. After that, children filled in an online questionnaire, which lasted around 30 min on average. We asked parents to stay with their child, especially during the beginning of the questionnaire, to answer any potential questions. However, we requested them to stay as neutral as possible to prevent them from influencing their child. Before the start of the questionnaire, children were informed, in child-appropriate language, about the procedure of the study and how data would be stored, and that they could withdraw from participation at any moment without giving a reason, which also included the possibility to request removal of data until seven days after participation. They were also told that they could take a break while filling in the questionnaire. To start the questionnaire, children had to explicitly confirm that they understood everything and that they wanted to start with the study.

The questionnaire started with an explanation of the five-point Likert scale, which was used for most questions, followed by two practice questions (see for a similar approach e.g., [87]). Children were asked to consult their parents and go through the practice items again in case they did not understand. The child-questionnaire consisted of two parts: one on Cozmo-unrelated variables (e.g., general attitude towards robots) and one on Cozmo-specific variables (e.g., intention to adopt Cozmo). After the Cozmo-unrelated part, children watched the video of the Cozmo robot.

At the end of the questionnaire, children and parents were informed about the goal of the study. The families that were not selected to participate in the follow-up in-home study, received an email with a debriefing for parents, as well as a child-appropriate debriefing for the children, which mainly focused on the workings of robots and the differences between humans and robots (see e.g., [45]). The parents and children of the families that did participate in the follow-up study received separate debriefings at the end of the longitudinal study. Parents received points from the research company, which they could exchange for money, to compensate them for their participation.

3.4 Measures

All measures were pretested among a convenience sample of 42 children and 32 parents who visited the Nemo Science Museum in Amsterdam in the first half of July 2019 and had been approved by the Ethics Review Board of the Faculty of Social and Behavioral Science at the University of Amsterdam before its start. Based on this pre-test we made minor adjustments, but overall, the measures were found to be reliable and understandable for children and parents.

Unless indicated otherwise below, the response categories of the measures used in the present study consisted of a five-point Likert-scale ranging from "Does not apply at all" (1) to "Applies completely" (5). We analyzed the psychometric properties of the multiple-item scales (i.e., Spearman-Brown Coefficient for the two-item scales; [88]), which are reported,

[1] Families with more than one child in this age-range were excluded from participation due to practical constraints of the follow-up study.

Table 1 Descriptive statistics and confirmatory factor analysis (CFA) for all model variables

Variable	Descriptive statistics				Reliability	CFA[c]
	M	*SD*	Skew	Kurt	α/S-B*	Factor loadings
Adoption intention	4.01	0.98	−1.19	1.04	0.92	0.819–914
Hedonic attitude	3.97	0.91	−1.03	1.09	0.91	0.853–912
Ease of use	3.32	0.89	−0.15	0.19	0.91	0.869–877
Usefulness	3.86	0.89	−0.85	0.81	0.84	0.774–831
Injunctive norms	4.09	0.94	−1.14	1.28	0.90	0.892–922
Descriptive norms	3.37	1.05	−0.27	−0.60	0.82	0.759–903
Capacity	3.34	0.81	−0.27	0.56	0.73	0.568–783
Autonomy	3.91	0.85	−0.93	1.30	0.76	0.650–819
Openness	3.52	0.97	−0.39	−0.30	0.69	0.699–751
Agreeableness	3.77	0.58	−0.30	0.80	0.47	0.363–839
General attitude towards robots[a]	3.81	0.94	−0.59	0.33	–	–
Anxiety	2.50	0.87	0.17	−0.08	0.85	0.545–868
Technology density[b]	5.37	1.70	0.57	0.10	0.53	–
Real-life exposure[a]	1.29	1.42	0.87	−0.57	–	–
Media exposure	11.07	6.10	0.54	−0.02	0.81	0.473–654

[a]Single-items scale
[b]Manifest variable, constructed as a sum-score
[c]CFA standardized estimates derived from the full model
*Spearman-Brown Coefficient for the two-item scales

together with the descriptive statistics of all variables, in Table 1.

3.4.1 Intention to Adopt the Robot

Children's intention to adopt Cozmo was measured with a version of the 4-item intentional acceptance of social robots measure for children [35], adjusted to the pre-adoption phase (i.e., no prior interaction with the robot) (e.g., "I would like to use Cozmo at home"). This variable was placed directly after the video of Cozmo, to prevent any order effects.

3.4.2 Proximal Predictors

Hedonic Attitude Towards Adopting the Robot This concept was related to the experiential component of the attitude [50] and based upon recommendations by Ajzen [27] and on items used by Martin et al. [48, 49] and Hagger et al. [51], who all used semantic differentials. However, given that for children answering by means of a Likert-scale compared to semantic differentials showed to be easier [89], we used a three-item Likert-scale (i.e., "Using Cozmo at home is …, (1) nice, (2) enjoyable, (3) pleasant").

Utilitarian Attitude towards Adopting the Robot This concept reflected the instrumental component of the attitude. It consisted of two three-item scales measuring ease of use (e.g., "Using Cozmo at home is easy") and usefulness (e.g., "Using Cozmo at home is informative") [21] and was based upon recommendations by earlier research [21, 27, 48, 49, 51]. In contrast to [21], the ease of use items solely focused on using the robot at home, without referring to the capabilities of the user (e.g., "I can…" or "I will know…") to clearly differentiate between ease of use and self-efficacy [27].

Social Norms This concept was composed of a two-item scale of *injunctive norms* (e.g., "My family would approve of me using Cozmo at home") and a two-item scale of *descriptive norms* (e.g., "How many of your friends would use Cozmo at home?"), both based on recommendations by Fishbein and Ajzen [27] and in line with Rhodes et al. [89] and De Leeuw et al. [17]. For descriptive norms, children answered on a five-point Likert-scale ranging from "None" (1) to "All" (5).

Self-efficacy This concept is very similar to *perceived behavioral control* [44] and is, in line with the TPB, operationalized as *capacity* and *autonomy* [27]. Capacity was measured with a three-item scale inspired by Martin et al. [48, 49] and Hagger et al. [51] following the recommendation by Fishbein and Ajzen [27]. We adjusted the items according to a pre-adoption situation (e.g., "I can do all things necessary to use Cozmo at home"). Autonomy was measured with a three-item scale based on Fishbein and Ajzen [27], Rhodes et al. [89], and De Jong et al. [36]. The items mainly centered on external constraints to performing the behavior, but were positively formulated (e.g., "I have the space to use Cozmo at home").

3.4.3 Distal Predictors

Sex. Kantar Netherlands provided us with data on children's sex. The measure included two categories: boy (1) or girl (2) (see the Sample section for the descriptive statistics).

Personality This concept was assessed in the parent-questionnaire and was measured through *openness* (e.g., "My child likes to make up stories") and *agreeableness* (e.g., "My child trusts others"); two dimensions of the Big Five personality characteristics [90, 91]. These dimensions were measured with two-item scales (for a justification with adults see [92]) and were based on the Big Five Questionnaire for Children (BFQ-C; [90]. From the Dutch version of the BFC-Q [91] we chose those items that most closely resembled the items used by [92].

General Attitude towards Robots This concept consisted of one item asking children how much they like robots, with a five-point Likert-scale ranging from "Not at all" (1) to "Very much" (5). This one-item scale was based upon a general definition of attitudes as overall evaluations ranging from negative to positive [93].

Anxiety towards the Robot This concept consisted of a four-item scale measuring children's anxiety towards using the robot at home, which was partly based on Heerink et al. [21] and inspired by De Jong et al. [14, 36]. All our items focused on using the robot (e.g., "If I would use Cozmo at home I would be scared to make mistakes"), not on the user's perception of the robot itself.

3.4.4 Contextual Factors

Technology Density This concept was part of the parent-questionnaire. Parents were asked for several technologies (i.e., computer/ laptop, tablet, smartphone, gaming console, robot toys, voice assistant, drone, Internet of Things devices, smartwatch, wearables, and a robot vacuum cleaner), to indicate whether they had it at home (answering categories "yes" [1] and "no" [0]) (for a similar measure see [78]). As this measure deals with observable behavior and thus constitutes a manifest variable, we created an overall score by summing up the items.

Real-life Exposure to Robots This concept consisted of one item, which asked children whether they had ever seen a robot in real life outside of their homes (for example in a museum, in a store, or at an airport). As we expected children to have very limited real-life exposure to robots, the rating scale consisted of the following fixed options: "No, never" (0), "Yes, once" (1), "Yes, twice" (2), "Yes, three times" (3), and "Yes, more than three times" (4).

Mediated Exposure to Robots This concept was composed of two sub-scales: a five-item scale on fictional robots and a four-item scale on non-fictional robots. Children had to indicate for several images of either fictional or non-fictional robots how often they had seen this particular kind of robot, or robots that look like it, through different media channels including television, books, internet (e.g., YouTube), videogames, and magazines. Videogames was left out as a channel for the non-fictional robots, as—to our knowledge—no videogames exist with real robots. Children answered on the basis of a five-point Likert-scale, ranging from "Never" (0) to "Very often" (4).

3.4.5 Control Variables

Children's age (either eight or nine) was provided by Kantar Netherlands based on children's date of birth (reference date 19-08-2019). Information about the household size was also provided by Kantar Netherlands and ranged from 'One member' (1) to 'Six members or more' (6).

4 Results

4.1 Descriptive Statistics

Children's intention to adopt Cozmo was high ($M = 4.01$, $SD = 0.98$). The majority of children (82.1%; $n = 468$) reported an intention to adopt the robot (i.e., scoring above 3.00), whereas 17.9% ($n = 102$) were unsure or immediately rejected the robot (scoring 3.00 or lower).

4.2 Testing the Model

The model was tested with structural equation modelling (SEM) using Mplus (version 7.4) [94]. We employed the maximum likelihood estimator with Satorra-Bentler corrections (i.e., MLM), which is robust to non-normality. All multi-item concepts, except for technological density, were modelled as latent factors. Table 1 shows the factor loadings obtained in the Confirmatory Factor Analyses (CFA). We allowed the proximal factors to covary, modelled as correlations between the error terms of these factors. The model fit was assessed with the normed Chi-square (χ^2/df), the root mean square error of approximation (RMSEA), the comparative fit index (CFI), and standardized root mean square residual (SRMR). We assessed the normed Chi-square statistic rather than the simple Chi-square because it is sensitive to sample size and consequently tends to overreject models with a large sample size [95, 96]. The normed Chi-square [97] minimizes the effect of sample size on the model Chi-square [96].

Our model showed a relatively good fit of the data: χ^2/df ($N = 570$) = 2.114, RMSEA = 0.044 (90% CI: 0.041, 0.047; pClose = 1.00), CFI = 0.924, SRMR = 0.061. Except for the CFI—which should be above 0.95—the fit indices indicated a good fit of our model (for information on fit indices, see

Table 2 Zero-order correlations among all model variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Adoption intention																
2. Hedonic attitude	0.74***															
3. Ease of use	0.30***	0.42***														
4. Usefulness	0.61***	0.70***	0.36***													
5. Injunctive norms	0.63***	0.66***	0.38***	0.56***												
6. Descriptive norms	0.52***	0.45***	0.22***	0.41***	0.36***											
7. Capacity	0.40***	0.50***	0.51***	0.45***	0.42***	0.27***										
8. Autonomy	0.60***	0.66***	0.36***	0.62***	0.72***	0.36***	0.43***									
9. Sex[1]	−0.12**	−0.12**	−0.13**	−0.10*	−0.11**	−0.03	−0.09*	−0.10*								
10. Openness	0.05	0.03	−0.05	0.02	0.00	0.05	−0.02	−0.01	0.43***							
11. Agreeableness	0.09*	0.04	0.01	0.09*	0.07	0.08*	0.06	0.08	0.04	0.22***						
12. General attitude	0.56***	0.48***	0.24***	0.43***	0.41***	0.38***	0.34***	0.44***	−0.22***	−0.04	0.09*					
13. Anxiety	0.08	0.10*	0.01	0.13**	0.06	0.03	−0.03	0.08	0.08	0.10*	−0.05	0.03				
14. Technology density	0.10*	0.07	−0.00	0.07	0.13**	0.13**	0.01	0.11**	−0.11*	−0.01	0.06	0.15***	−0.03			
15. Real-life exposure	0.17***	0.09*	0.05	0.07	0.12*	0.12**	0.08	0.10*	−0.10*	0.01	−0.01	0.28***	−0.02	0.15***		
16. Media exposure	0.20***	0.14**	0.15***	0.22***	0.16***	0.19***	0.19***	0.16***	−0.19***	0.01	−0.01	0.28***	0.03	0.18***	0.20***	
Age	−0.11*	−0.02	0.01	−0.02	−0.03	−0.02	0.01	−0.03	0.11*	−0.05	−0.00	−0.08	−0.06	0.00	−0.03	0.01
Household Size	−0.06	−0.06	−0.01	−0.05	−0.05	−0.04	−0.02	−0.06	0.01	0.04	0.04	−0.08*	−0.01	−0.11**	−0.04	−0.09*

$p < 0.05$; $^{**}p < .001$; $^{***}p < .0001$; [1]Male = 1, Female = 2

[98, 99]. See Table 2 for zero-order correlations between all model variables.

4.2.1 Effect of Proximal Predictors on Adoption Intention

Hedonic attitude significantly predicted adoption intention (H1.1; $\beta = 0.47, p < 0.001$), but ease of use (H1.2; $\beta = -0.07$, $p = 0.062$) and usefulness (H1.3; $\beta = 0.03, p = 0.667$)—that is utilitarian attitude—did not. Given the results concerning H1.1, we thus partly accepted H1, which stated that attitude would positively predict the intention to adopt the robot. H2, which stated that social norms positively predicted adoption intention, was fully supported. Both injunctive (H2.1; $\beta = 0.17$, $p = 0.015$) and descriptive norms (H2.2; $\beta = 0.18$, $p < 0.001$) significantly predicted adoption intention, with higher perceived norms being associated with a higher intention to adopt the robot at home. Finally, H3, which posited that self-efficacy would predict adoption intention, was not supported: neither capacity (H3.1; $\beta = -0.01, p = 0.872$) nor autonomy (H3.2; $\beta = 0.06, p = 0.511$) significantly predicted intention to adopt the robot.

4.2.2 Effect of Distal Predictors on Adoption Intention

We expected various personal (i.e., sex, openness, agreeableness, general attitude towards robots and anxiety) and contextual factors (i.e., technology density in the household, real-life experience with robots, and media experience with robots) to directly predict adoption intention (H4a-H11a). Only general attitude towards robots (H6a) significantly predicted adoption intention ($\beta = 0.15$, $p < 0.001$): A more positive attitude towards robots in general was related to a higher intention to adopt the robot at home. All the other estimates were insignificant (see Table 3).

4.2.3 Effect of Distal on Proximal Predictors

Besides a direct effect of the distal predictors on adoption intention, we also expected that the distal predictors would be related to the proximal predictors attitudes (H4b-H11b), social norms (H4c–H11c), and self-efficacy (H4d-H11d). Overall, the relation between the distal predictors and adoption intention would thus be mediated by the proximal predictors. General attitude towards robots significantly predicted all proximal predictors (H7b–d; see Table 3). A more positive general attitude towards robots related to a more positive hedonic attitude (H7.b1; $\beta = 0.51, p < 0.001$), higher perceived ease of use (H7.b2; $\beta = 0.23, p < 0.001$), higher perceived usefulness (H7.b3; $\beta = 0.46, p < 0.001$), more positive injunctive (H7.c1; $\beta = 0.41, p < 0.001$) and descriptive norms (H7.c2; $\beta = 0.39$, $p < 0.001$), and capacity (H7.d1; $\beta = 0.38$, $p < 0.001$) and autonomy (H7.d2; $\beta = 0.48, p < 0.001$). Anxiety significantly predicted usefulness (H8.b3; $\beta = 0.10$, $p =$

Table 3 Standardized estimates (β) and probabilities (p) of distal predictors on proximal predictors

	Adoption Intention[a]		Hedonic attitude[b1]		Ease of use[b2]		Usefulness[b3]		Injunctive norms[c1]		Descriptive norms[c2]		Capacity[d1]		Autonomy[d2]	
	β	*p*	β	*p*	β	*p*	β	*p*	β	*p*	β	*p*	β	*p*	β	*p*
H4. Sex	−0.022	0.495	−0.056	0.207	−0.079	0.114	−0.029	0.550	−0.029	0.535	0.070	0.158	−0.001	0.990	−0.021	0.672
H5. Openness	0.038	0.376	0.083	0.154	0.001	0.987	0.027	0.663	0.002	0.978	0.038	0.541	−0.047	0.517	0.032	0.629
H6. Agreeableness	0.012	0.744	−0.010	0.838	−0.025	0.658	0.077	0.178	0.093	0.080	0.045	0.426	0.086	0.163	0.093	0.099
H7. General attitude	0.154	<0.001	0.511	<0.001	0.233	<0.001	0.460	<0.001	0.405	<0.001	0.393	<0.001	0.384	< 0.001	0.480	<0.001
H8. Anxiety	−0.010	0.709	0.063	0.120	−0.007	0.886	0.103	0.019	0.036	0.401	−0.007	0.882	−0.044	0.372	0.050	0.265
H9. Technology density	−0.025	0.346	0.001	0.976	−0.056	0.207	−0.001	0.981	0.064	0.125	0.080	0.063	−0.047	0.319	0.046	0.288
H10. Real-life exposure	0.038	0.166	−0.056	0.166	−0.031	0.491	−0.072	0.093	−0.001	0.975	−0.005	0.914	−0.037	0.440	−0.031	0.491
H11. Media exposure	0.011	0.736	−0.008	0.864	0.102	0.044	0.120	0.014	0.031	0.522	0.093	0.064	0.138	0.011	0.050	0.322

Note: Standardized estimates are derived from the full model; *Reading example:* Line 1 shows the relation between sex (as hypothesized in H4) with adoption intention (as hypothesized in H4a), hedonic attitude (as hypothesized in H4b1), ease of use (as hypothesized in H4b2) etc.

0.019), but none of the other proximal predictors (see Table 3). Finally, media exposure to social robots significantly predicted ease of use (H11.b2; β = 0.10, $p = 0.044$), usefulness (H11.b3; β = 0.12, $p = 0.014$), and capacity (H11.d1; β = 0.14, $p = 0.011$), but not the other proximal predictors (see Table 3). Sex, openness, agreeableness, technology density, and real-life exposure to robots were not significantly related to any of the proximal predictors (see Table 3).

Because we assumed a mediation effect, we additionally tested all indirect paths from distal predictors, through proximal predictors, on intention to adopt. For general attitude towards robots, we found significant mediated relations with adoption intention through hedonic attitude (β = 0.24, 95% bootstrap CI [0.16, 0.32]), injunctive norms (β = 0.07, 95% bootstrap CI [0.01, 0.12]), and descriptive norms (β = 0.07, 95% bootstrap CI [0.04, 0.11]). All the other mediation paths were insignificant (analyses are not provided for space reasons).

5 Discussion

To date, little is known about children's adoption of social robots at home. Against this background, we charted whether children intend to adopt or reject the social robot Cozmo at home. Most important, based on psychological models of human behavior, such as the TPB and substantiated by earlier research on adoption and acceptance of technology and robots (e.g., [26]) we developed and tested an initial model of children's intention to adopt a social robot at home. Many children intended to adopt the social robot Cozmo, which was largely related to their general attitude toward robots and mediated by their hedonic attitude towards and the social norms they perceived about adopting the social robot.

5.1 Intention to Adopt a Social Robot at Home

Before children have ever interacted with Cozmo in real-life, 82% of them indicated that they would like to use the robot at home. Only 18% of the children were unsure about adopting the robot or intended to reject it. This finding is in line with earlier findings on children's acceptance of social robots (for an overview see [14]). Generally, most children seem to be intrigued by the idea to have a social robot at home, regardless of the stage of acceptance. One reason for the overall positive approach of children to the adoption of social robots may be the novelty effect, which proposes that children show an initial enthusiasm towards a robot because it is new and unfamiliar (e.g., [8, 100, 101]).

Although our finding of children's overwhelming intention to adopt Cozmo merges with previous research, it is also somewhat surprising. In contrast to many previous studies, we focused on the *domestic* adoption of a social robot. Adopting a social robot at home differs from using it, for example, at school or during a therapy session, which previous research centered upon. We expected children to be hesitant when it comes to adopting domestic social robots, especially without real familiarity with them and after limited exposure [35]. However, even when children's beliefs about the social robot are mainly based upon indirect experiences, they largely seem to intend to adopt the robot at home. This is an interesting finding because without an initial intention to adopt the social robot at home, there is little chance of subsequent acceptance.

5.2 A Model of Children's Intended Social Robot Adoption

Our model of children's intention to adopt a social robot at home was based upon psychological models, and in particular the TPB. The model hypothesized that attitudes, social norms, and self-efficacy would directly predict intention to adopt the robot. Moreover, we hypothesized, again in line with the TPB, that various distal predictors (i.e., personal and contextual factors) would be related to adoption intention both directly and indirectly, through the proximal predictors. Hedonic attitude towards adopting the robot had, by far, the largest association with adoption intention in the model. This was in line with our expectations as social robots for children are typically designed for entertainment purposes, and children also approach them with hedonic goals in mind [45]. Our finding also dovetails with earlier findings on adults' acceptance of social robots, where perceived enjoyment was a direct predictor of robot use [47]. Moreover, a study on domestic use of voice-based agents, a technology related to social robots, showed that children focused on social and entertainment aspects when interacting with the agents [102]. Overall, the consistency of these results suggests that a better understanding of why children, but probably also adults, intend to adopt current domestic social robots hinges on a more detailed study of hedonic, entertainment-related aspects of using social robots. It seems that children see current domestic social robots primarily as advanced toys, which deserves more attention from research (see also [2]).

Utilitarian attitudes, in contrast, did not predict adoption intention in our model. This contradicted our expectations, which were based on the importance of utilitarian aspects in robot acceptance models for adults (e.g., [13, 21]), in the sense that "the decision to use a social robot is the same as evaluating whether a social robot is useful" [26, p. 41]. Our results suggest that what constitutes the rational, instrumental attitude component in the TPB does not play a major role in children's intended adoption of social robots, but note that the usefulness dimension of our measure may to some extent have assessed the usability of a robot and may need refinement and replication. At the theoretical level, this finding supports our choice of broader, psychologically oriented theoretical frameworks, such as the TPB [40], rather than more specific, technologically oriented frameworks, such as the TAM [38]. Earlier research on the acceptance of hedonic information systems has also shown that the applicability of TAM and UTAUT to hedonic systems is limited [44] and we believe that researchers need to consider the choice of their theoretical frameworks carefully when studying the adoption of social robots. Our results do not rule out that models such as the TAM may be useful for adults and/or more utilitarian robots (e.g., domestic service robots). At least at the pre-adoption stage, however, technologically oriented models may be somewhat limited to explain why children want to adopt current domestic social robots.

Our results also point to the importance of both injunctive and descriptive norms in predicting children's adoption intention. Adoption of a social robot at home seems not solely an individual choice, but also a social one, where children take into account the opinion of family members and the extent to which they perceive their peers to potentially use a social robot. The association of social norms with individual adoption and acceptance of technology has been well documented, not only in the TPB [40], but also in more general theories dealing with the diffusion of technology (e.g., the observability dimension in Rogers' [23] diffusion of innovations framework). In this context, it is important to realize that we cannot understand children's adoption of a technology as novel as social robots without zooming in on the social ramifications of its use.

Self-efficacy did not significantly contribute to children's intention to adopt the robot at home, which contradicted our expectations and earlier research on adults [29]. Three explanations are conceivable. First, children nowadays may become technologically savvy at a very young age [103] and may feel confident using a technology such as a social robot. Second, at the pre-adoption stage self-efficacy may not yet play a role because it requires a deeper knowledge of a technology that children lack at this stage. Third, the children in our study, who were eight and nine years old, are not yet cognitively sufficiently advanced to realize the challenges of operating an advanced device like a social robot and equate it with a toy. As a result, TPB-based research on children's adoption of social robots should study the potential contribution of self-efficacy also at different stages in the adoption process and with older children.

Children's general attitude towards robots was strongly associated with children's intention to adopt the social robot. At the pre-adoption stage, when children have not yet interacted with the robot in real-life, their beliefs about a specific robot seem to be largely based upon a general conception of robots. Practically speaking, this finding is useful because it suggests that knowing children's general attitude towards social robots will allow for decent predictions of whether they intend to adopt a robot. None of the other distal factors proved to be influential, although their selection was both theoretically and empirically motivated. Personal factors such as children's sex, openness and agreeableness, and anxiety towards using the robot, as well as contextual factors, such as technology density in the household and real-life and media exposure to social robots, were all unrelated to the intention to adopt a social robot.

Albeit unexpected, the many non-associations of our distal predictors with the key variables may support the 'assumption of sufficiency,' which posits that, according to the TPB, the only necessary predictors of intention are attitude, social norms, and self-efficacy, and that no additional constructs are needed to accurately predict this intention ([27, 43] Still, we recommend that future researchers may include distal factors into their models. According to Ajzen [43], it is possible to include additional predictors if several assumptions are met, for example that the predictors should be applicable to a wide range of behavior. The TPB itself assumes that demographic characteristics and personality can play a role as they may influence intention indirectly [43].

A statistical explanation of the non-associations of our distal predictors with the key variables is that the inclusion of general attitude towards robots in the model has eliminated some of the variance of the other distal predictors (see Table 2). Most of the distal predictors that we included in the model are considered background factors, which are theorized to affect behavioral, normative, and control beliefs, which, in turn, affect attitudes, social norms, and self-efficacy. As beliefs, compared to background factors, are thus more proximally related to intention and behavior, it might be fruitful for future research to focus on children's beliefs or cognitive schemata of social robots as these may drive their intention to adopt.

In sum, our non-findings about distal factors (except general attitudes) should not be seen as a refutation of the potential influence of these factors on children's adoption of social robots, nor do they suggest that such factors are irrelevant in the TPB. The TPB does not specify a fixed set of distal factors. Given the novelty of the topic, we therefore had to select personal and contextual distal factors based on related research, which typically did not focus on social robots and children. As a result, several of the factors we studied may not have been precise enough to predict children's adoption of social robots. Our study thus also calls for fundamental research on children and social robots. A promising starting point may be to focus on the role of the only significant distal predictor, general attitudes toward robots, and identify other factors that are theoretically related to these attitudes (e.g., neuroticism and robot-human likeness [58]). In so doing, we may be able to better understand the role of general attitudes in predicting children's adoption of social robots but also the theoretical ramifications of these attitudes and, by extension, the composition of distal factors.

5.3 Limitations and Conclusion

Our study has at least four limitations. First, our correlational, cross-sectional design does not allow for internally valid conclusions about the causality of the variables in our model. Our model was based on theoretical predictions from the TPB [40] and many of the hypothesized relationships have theoretically a clear causal direction. Still, some caution is warranted in terms of causal interpretations of our findings. To validate the causality of our model, future research should focus on both the pre-adoption and adoption stage. Second, our study is based on children aged eight to nine, that is, children from middle childhood. Given the huge developmental differences in childhood, our findings can probably not be generalized to other developmental groups. In this context, research that compares between different developmental groups, notably between children and adults, may greatly enrich our understanding of the adoption of social robots. Third, we conducted our study in a technologically advanced, rich Western country, in which many children are confronted early on with advanced technology both at home and in school. We need more research from diverse countries to see whether our results also hold in other cultures and countries. Nevertheless, these limitations hold for the TPB in general, given that the model is population-specific (e.g., [41]). Fourth, in our study, we focused on a behavioral *intention* rather than the behavior itself. Given a potential gap between children's intention and behavior, we should be cautious in extending our findings to *actual* adoption of the social robot [43].

To conclude, the intention to adopt a social robot seems to be mainly determined by hedonic, normative and attitudinal considerations. With social robots increasingly entering children's homes and daily lives, it is essential to further study their adoption, as well as their acceptance in the long run. Our model may be an initial step into disentangling the complex process of domestic social robot acceptance for children.

Acknowledgements We would like to thank Kantar Netherlands and all the families that participated in our study.

Funding This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (Grant agreement No. [682733]) to the second author.

Availability of Data and Material The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of interest The authors have no conflicts of interest to declare that are relevant to the content of this article. Anki® and Cozmo® are registered trademarks of Anki, Inc. This research project is not sponsored by, supported by, or affiliated in any manner with Anki.

Consent to Participate Informed consent was obtained from all individual participants included in the study.

Ethics Approval The Ethics Review Board of the Faculty of Social and Behavioral Science at the University of Amsterdam approved the study. The procedures of this study were in accordance with the Dutch national code of ethics for research in the Social and Behavioural Sciences involving human participants.

References

1. Broadbent E (2017) Interactions with robots : The truths we reveal about ourselves. Annu Rev Psychol 68:627–652. https://doi.org/10.1146/annurev-psych-010416-043958
2. Peter J, Kühne R, Barco A, De Jong C, Van Straten CL (2019) Asking today the crucial questions of tomorrow: Social robots and the Internet of Toys. In: Mascheroni G, Holloway D (eds) The Internet of Toys. Practices, Affordances and the Political Economy of Children's Smart Play. Palgrave MacMillan, Cham, Switzerland, pp 25–46. https://doi.org/10.1007/978-3-030-10898-4
3. Fernaeus Y, Håkansson M, Jacobsson M, Ljungblad S (2010) How do you play with a robot toy animal? In: Proc 9th International Conference on Interaction Design and Children. Barcelona, pp 39–48 . https://doi.org/10.1145/1810543.1810549
4. International Federation of Robotics (2020) Executive Summary WR Service Robots. https://ifr.org/img/worldrobotics/Executive_Summary_WR_2020_Service_Robots.pdf
5. Belpaeme T, Kennedy J, Ramachandran A, Scassellati B, Tanaka F (2018) Social robots for education: A review. Sci Robot 3:1–10. https://doi.org/10.1126/scirobotics.aat595410.1126/scirobotics.aat5954
6. Vogt P, De Haas M, De Jong C, Baxter P, Krahmer E (2017) Child-robot interactions for second language tutoring to preschool children. Front Hum Neurosci 11:497–505. https://doi.org/10.3389/fnhum.2017.00073
7. Malik NA, Hanapiah FA, Rahman RAA, Yussof H (2016) Emergence of socially assistive robotics in rehabilitation for children with Cerebral Palsy: A review. Int J Adv Robot Syst 13:1–7. https://doi.org/10.5772/64163
8. Baxter P, Ashurst E, Read R, Kennedy J, Belpaeme T (2017) Robot education peers in a situated primary school study: Personalisation

promotes child learning. PLoS ONE 12:1–23. https://doi.org/10.1371/journal.pone.0178126

9. Breazeal C, Harris PL, DeSteno D, Kory JM (2016) Young children treat robots as informants. Top Cogn Sci 8:481–491. https://doi.org/10.1111/tops.12192
10. Westlund JMK, Martinez M, Archie M, Das M, Breazeal C (2016) Effects of framing a robot as a social agent or as a machine on children's social behavior. In: Proceedings of the 25th International Symposium on Robot and Human Interactive Communication. New York, pp 688–693. https://doi.org/10.1109/ROMAN.2016.7745193
11. Park HW, Gelsomini M, Lee JJ, Breazeal C (2017) Telling Stories to Robots: The Effect of Backchanneling on a Child's Storytelling. Proc 2017 ACM/IEEE Int Conf Human-Robot Interact 100–108. https://doi.org/10.1145/2909824.3020245
12. Sung JY, Grinter RE, Christensen HI (2010) Domestic robot ecology: An initial framework to unpack long-term acceptance of robots at home. Int J Soc Robot 2:417–429. https://doi.org/10.1007/s12369-010-0065-8
13. De Graaf MMA, Ben Allouch S, Van Dijk JAGM (2017) A phased framework for long-term user acceptance of interactive technology in domestic environments. New Media Soc 20:2582–2603. https://doi.org/10.1177/1461444817727264
14. De Jong C, Peter J, Kühne R, Barco A (2019) Children's acceptance of social robots: A narrative review of the research 2000–2017. Interact Stud 20:393–425. https://doi.org/10.1075/is.18071.jon
15. Akimana B-T, Bonnaerens M, Wilder J Van, Vuylsteker B (2017) A survey of human-robot interaction in the Internet of Things. https://www.researchgate.net/profile/Bjorn_Vuylsteker/publication/318722691_A_Survey_of_Human-Robot_Interaction_in_the_Internet_of_Things/links/5979adbdaca272177c1f4abc/A-Survey-of-Human-Robot-Interaction-in-the-Internet-of-Things.pdf
16. Michaelis JE, Mutlu B (2017) Someone to read with: Design of and experiences with an in-home learning companion robot for reading. In: Proc Conference on Human Factors in Computing Systems. Denver, pp 301–312. https://doi.org/10.1145/3025453.3025499
17. De Leeuw E, Borgers N, Smits A (2004) Pretesting questionnaires for children and adolescents. In: Presser S, Rothgeb JM, Couper MP, Lessler JT, Martin E, Martin J, Singer E (eds) Methods for testing and evaluating survey questionnaires. Wiley, New York, pp 409–429. https://doi.org/10.1002/0471654728.ch20
18. Read JC, MacFarlane S (2006) Using the fun toolkit and other survey methods to gather opinions in child computer interaction. In: Proceedings of 2006 conference on interaction design and children, pp 81–88. https://doi.org/10.1145/1139073.1139096
19. Cole M, Cole SR, Lightfoot C (2005) The development of children, 5th edn. Worth Publishers, New York
20. De Leeuw ED, Otter ME (1995) The reliability of children's responses to questionnaire items; question effects in children's questionnaire data. In: Hox JJ, Van der Meulen BF, Janssens JMAM, Ter Laak JJF, Tavecchio LWC (eds) Hearing children's voices. Thesis Publishers, Amsterdam, pp 251–257
21. Heerink M, Kröse BJA, Evers V, Wielinga BJ (2010) Assessing acceptance of assistive social agent technology by older adults: The Almere model. Int J Soc Robot 2:361–375. https://doi.org/10.1007/s12369-010-0068-5
22. Davis FD (1986) A technology acceptance model for emperically testing new end-user information systems: Theory and results. Doctoral Dissertation. Massachusetts Institute of Technology. https://doi.org/10.1016/S0378-7206(01)00143-4
23. Rogers EM (1995) Diffusion of innovations. The Free Press, New York
24. De Graaf MMA, Ben Allouch S, Van Dijk JAGM (2016) Long-term evaluation of a social robot in real homes. Interact Stud 17:461–491. https://doi.org/10.1075/is.17.3.08deg
25. Ruijten P, Cuijpers R (2017) Dynamic perceptions of human-likeness while interacting with a social robot. In: ACM/IEEE International Conf on Human-Robot Interaction. pp 273–274. https://doi.org/10.1145/3029798.3038361
26. De Graaf MMA, Ben Allouch S, van Dijk JAGM (2019) Why would I use this in my home? A model of domestic social robot acceptance. Human-Computer Interact 34:115–173. https://doi.org/10.1080/07370024.2017.1312406
27. Fishbein M, Ajzen I (2010) Predicting and Changing Behavior: The Reasoned Action Approach. Psychology Press, New York
28. Lohse M (2011) Bridging the gap between users' expectations and system evaluations. In: Proceedings of IEEE International Workshop on Robot and Human Interactive Communication, pp 485–490. https://doi.org/10.1109/ROMAN.2011.6005252
29. De Graaf MMA, Ben Allouch S, Van Dijk JAGM (2016) Long-term acceptance of social robots in domestic environments: Insights from a user's perspective. In: AAAI Spring Symposium Series. Palo Alto, pp 96–103. https://doi.org/10.1075/is.17.3.08deg
30. Forlizzi J, DiSalvo C (2006) Service robots in the domestic environment: A study of the roomba vacuum in the home. In: Proceedings of 2006 ACM Conference on Human-Robot Interaction, pp 258–265. https://doi.org/10.1145/1121241.1121286
31. Ghazali AS, Ham J, Barakova E, Markopoulos P (2020) Persuasive Robots Acceptance Model (PRAM): Roles of social responses within the acceptance model of persuasive robots. Int J Soc Robot 12:1075–1092. https://doi.org/10.1007/s12369-019-00611-1
32. Ferraz M, Câmara A, O'Neill A (2016) Increasing children's physical activity levels through biosymtic robotic devices. In: Proceedings of 13th International Conference on Advances in Computer Entertainment Technology. Osaka, no. 2. https://doi.org/10.1145/3001773.3001781
33. Cha E, Dragan A, Srinivasa SS (2014) Pre-school children's first encounter with a robot. In: ACM/IEEE International conference on Human-Robot Interaction, pp 136–137. https://doi.org/10.1145/2559636.2559852
34. Robert D, Van Den Bergh V (2014) Children's Openness to Interacting with a Robot Scale (COIRS). In: Proceedings of IEEE International Work on Robot Hum Interact Communication, pp 930–935. https://doi.org/10.1109/ROMAN.2014.6926372
35. De Jong C, Kühne R, Peter J, van Straten CL, Barco A (2020) Intentional acceptance of social robots: Development and validation of a self-report measure for children. Int J Hum Comput Stud 139:102426. https://doi.org/10.1016/j.ijhcs.2020.102426
36. De Jong C, Peter J, Kühne R, van Straten CL, Barco A (2021) Exploring children's beliefs for adoption or rejection of domestic social robots. In: 30th International Conference on Robot and Human Interactive Communication, Vancouver. https://doi.org/10.1109/ROMAN50785.2021.9515438
37. Shin D-H, Choo H (2011) Modeling the acceptance of socially interactive robotics: Social presence in human–robot interaction. Interact Stud 12:430–460. https://doi.org/10.1075/is.12.3.04shi
38. Davis FD (1989) Perceived usefulness, perceived ease of use, and user acceptance of social robots. MIS Q 13:319–340. https://doi.org/10.2307/249008
39. Venkatesh V, Morris MG, Davis GB, Davis FD (2003) User acceptance of information technology: Toward a unified view. MIS Q 27:425–478. https://doi.org/10.2307/30036540
40. Ajzen I (1991) The theory of planned behavior. Orgnizational Behav Hum Decis Process 50:179–211. https://doi.org/10.1016/0749-5978(91)90020-T

41. Fishbein M (2000) The role of theory in HIV prevention. AIDS Care Psychol Socio-Medical Asp AIDS/HIV 12:273–278. https://doi.org/10.1080/09540120050042918
42. Taylor S, Todd PA (1995) Understanding information technology usage: A test of competing models. Inf Syst Res 6:144–176. https://doi.org/10.1287/isre.6.2.144
43. Ajzen I (2020) The theory of planned behavior: Frequently asked questions. Hum Behav Emerg Technol 2:314–324. https://doi.org/10.1002/hbe2.195
44. Van der Heijden H (2004) User acceptance of hedonic information systems. MIS Q 28:695–704. https://doi.org/10.2307/25148660
45. De Jong C, Kühne R, Peter J, Van Straten CL, Barco A (2019) What do children want from a social robot? Toward gratifications measures for child-robot interaction. In: Proceedings os 28th IEEE International Conference on Robot and Human Interactive Communication. New Delhi, India, pp 512–519. https://doi.org/10.1109/RO-MAN46459.2019.8956319
46. Yzer M (2012) The integrative model of behavioral prediction as a tool for designing health messages. In: Cho H (ed) Health communication message design: Theory and practice, pp 21–40. https://in.sagepub.com/sites/default/files/upm-binaries/43568_2.pdf
47. De Graaf MMA, Ben Allouch S (2013) Exploring influencing variables for the acceptance of social robots. Rob Auton Syst 61:1476–1486. https://doi.org/10.1016/j.robot.2013.07.007
48. Martin JJ, Kulinna PH, Mccaughtry N, Cothran D, Dake J, Fahoome G (2005) The theory of planned behavior: Predicting physical activity and cardiorespiratory fitness in African American children. J Sport Exerc Psyschol 27:456–469. https://doi.org/10.1123/jsep.27.4.456
49. Martin JJ, Oliver K, McCaughtry N (2007) The theory of planned behavior: Predicting physical activity in Mexican American children. J Sport Exerc Psychol 29:225–238. https://doi.org/10.1123/jsep.29.2.225
50. Ajzen I (2002) Constructing a TPB questionnaire: Conceptual and methodological considerations . http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.601.956&rep=rep1&type=pdf
51. Hagger MS, Chatzisarantis N, Biddle SJH, Orbell S (2001) Antecedents of children's physical activity intentions and behaviour: predictive validity and longitudinal effects. Psychol Heal 16:391–407. https://doi.org/10.1080/08870440108405515
52. Lin C, MacDorman KF, Šabanović S, Miller AD, Brady E (2020) Parental expectations, concerns, and acceptance of storytelling robots for children. In: ACM/IEEE Int Conf Human-Robot Interact. pp 346–348. https://doi.org/10.1145/3371382.3378376
53. Rivis A, Sheeran P (2003) Descriptive norms as an additional predictor in the theory of planned behaviour: a meta-analysis. Curr Psychol 22:218–233. https://doi.org/10.1007/s12144-003-1018-2
54. Bandura A (1977) Self-efficacy: toward a unifying theory of behavioral change. Psychol Rev 84:191–215. https://doi.org/10.1037/0033-295X.84.2.191
55. Ajzen I (2002) Perceived behavioral control, self-efficacy, locus of control, and the theory of planned behavior. J Appl Soc Psychol 32:665–683. https://doi.org/10.1111/j.1559-1816.2002.tb00236.x
56. Bandura A (1991) Social cognitive theory of self-regulation. Organ Behav Hum Decis Process 50:248–287. https://doi.org/10.1016/0749-5978(91)90022-L
57. Shibata T, Wada K, Ikeda Y, Sabanovic S (2009) Cross-cultural studies on subjective evaluation of a seal robot. Adv Robot 23:443–458. https://doi.org/10.1163/156855309X408826
58. Mays, KK Krongard, S, Katz, JE (2019). Robots revisited: Cyberdystopia, Robotphobia, and social perceptions of robots in the evolving AI landscape. Paper presented at the Human-Machine Communication preconference, International Communication Association, Washington DC
59. De Graaf MMA, Ben Allouch S, Klamer T (2015) Sharing a life with Harvey: exploring the acceptance of and relationship-building with a social robot. Comput Human Behav 43:1–14. https://doi.org/10.1016/j.chb.2014.10.030
60. Walters ML, Syrdal DS, Dautenhahn K, Te Boekhorst R, Koay KL (2008) Avoiding the uncanny valley: robot appearance, personality and consistency of behavior in an attention-seeking home scenario for a robot companion. Auton Robots 24:159–178. https://doi.org/10.1007/s10514-007-9058-3
61. Tung FW (2011) Influence of gender and age on the attitudes of children towards humanoid robots. In: Jacko JA (ed) Human-computer interaction. Users and applications. Springer, Heidelberg, pp 637–646. https://doi.org/10.1007/978-3-642-21619-0_76
62. Hughes RM, Nzekwe B, Molyneaux KJ (2013) The single sex debate for girls in science: a comparison between two informal science programs on middle school students' STEM identity formation. Res Sci Educ 43:1979–2007. https://doi.org/10.1007/s11165-012-9345-7
63. Sullivan A, Bers MU (2016) Girls, boys, and bots: Gender differences in young children's performance on robotics and programming tasks. J Inf Technol Educ Innov Pract 15:145–165. https://doi.org/10.28945/3547
64. Nourbakhsh IR, Hamner E, Crowley K, Wilkinson K (2004) Formal measures of learning in a secondary school mobile robotics course. In: Proc IEEE Int Conf Robot Autom, pp 1831–1836. https://doi.org/10.1109/robot.2004.1308090
65. McCrae RR, Costa PT (1999) A five-factor theory of personality. In: Pervin LA, John OP (eds) Handbook of personality: Theory and research, 2nd ed. Guilford Publications, pp 139–153
66. Graziano WG, Eisenberg N (1997) Agreableness: a dimension of personality. In: Hogan R, Jhonson J, Briggs S (eds) Handbook of Personality Psychology. Academic Press, pp 795–824
67. Kędzierski J, Muszyński R, Zoll C, Oleksy A, Frontkiewicz M (2013) EMYS-Emotive head of a social robot. Int J Soc Robot 5:237–249. https://doi.org/10.1007/s12369-013-0183-1
68. Devaraj US, Easley RF, Michael Crant J (2008) How does personality matter? Relating the five-factor model to technology acceptance and use. Inf Syst Res 19:93–105. https://doi.org/10.1287/isre.1070.0153
69. Robins RW, Tracy JL, Trzesniewski K, Potter J, Gosling SD (2001) Personality correlates of self-esteem. J Res Pers 35:463–482. https://doi.org/10.1006/jrpe.2001.2324
70. Lane J, Lane AM, Kyprianou A (2004) Self-efficacy, self-esteem and their impact on academic performance. Soc Behav Pers 32:247–256. https://doi.org/10.2224/sbp.2004.32.3.247
71. Stephen C, Stevenson O, Adey C (2013) Young children engaging with technologies at home: the influence of family context. J Early Child Res 11:149–164. https://doi.org/10.1177/1476718X12466215
72. Brosnan MJ (1998) The impact of computer anxiety and self-efficacy upon performance. J Comput Assist Learn 14:223–234. https://doi.org/10.1046/j.1365-2729.1998.143059.x
73. Saade R, Kira D (2006) The emotional state of technology acceptance. In: Proc 2006 InSITE Conf. https://doi.org/10.28945/2945
74. Yi MY, Hwang Y (2003) Predicting the use of web-based information systems: self-efficacy, enjoyment, learning goal orientation, and the technology acceptance model. Int J Hum Comput Stud 59:431–449. https://doi.org/10.1016/S1071-5819(03)00114-9
75. Ross L, Greene D, House P (1977) The "false consensus effect": an egocentric bias in social perception and attribution processes. J Exp Soc Psychol 13:279–301. https://doi.org/10.1016/0022-1031(77)90049-X
76. Ezer N (2008) Is a robot an appliance, teammate, or friend? Age-related differences in expectations of and attitudes towards

personal home-based robots. Doctoral Dissertation. Georgia Institute of Technology . http://hdl.handle.net/1853/26567
77. Heerink M (2011) Exploring the influence of age, gender, education and computer experience on robot acceptance by older adults. In: Proceedings of the 6th international conference on human-robot interaction. Lausanne, pp 147–148. https://doi.org/10.1145/1957656.1957704
78. Van RV, Roe K, Struys K (2002) Children's influence on internet access at home: adoption and use in the family context. Information Commun Soc 5:189–206. https://doi.org/10.1080/13691180210130770
79. Bronfenbrenner U (1979) The ecology of human development. Harvard University Press
80. Bernstein D, Crowley K (2008) Searching for signs of intelligent life: an investigation of young children's beliefs about robot intelligence. J Learn Sci 17:225–247. https://doi.org/10.1080/10508400801986116
81. Fortunati L, Esposito A, Ferrin G, Viel M (2014) Approaching social robots through playfulness and doing-it-yourself: children in action. Cognit Comput 6:789–801. https://doi.org/10.1007/s12559-014-9303-y
82. Sundar SS, Waddell TF, Jung EH (2016) The Hollywood robot syndrome: media effects on older adults' attitudes toward robots and adoption intentions. In: International conference on human-robot interaction. pp 343–350. https://doi.org/10.1109/HRI.2016.7451771
83. Broadbent E, Stafford R, MacDonald B (2009) Acceptance of healthcare robots for the older population: Review and future directions. Int J Soc Robot 1:319–330. https://doi.org/10.1007/s12369-009-0030-6
84. Lapinski MK, Rimal RN (2005) An explication of social norms. Commun Theory 15:127–147. https://doi.org/10.1093/ct/15.2.127
85. Jeong SH, Cho H, Hwang Y (2012) Media literacy interventions: a meta-analytic review. J Commun 62:454–472. https://doi.org/10.1111/j.1460-2466.2012.01643.x
86. Pelikan HRM, Broth M, Keevallik L (2020) "Are you sad, Cozmo?" How humans make sense of a home robot's emotion displays. In: Proc. ACM/IEEE Int Conf Human-Robot Interact 461–470. https://doi.org/10.1145/3319502.3374814
87. Leite I, Pereira A, Lehman JF (2017) Persistent memory in repeated child-robot conversations. In: Proceedings of the 2017 Conference on Interaction Design and Children. pp 238–247. https://doi.org/10.1145/3078072.3079728
88. Eisinga R, Te Grotenhuis M, Pelzer B (2013) The reliability of a two-item scale: Pearson, Cronbach, or Spearman-Brown? Int J Public Health 58:637–642. https://doi.org/10.1007/s00038-012-0416-3
89. Rhodes RE, Macdonald HM, McKay HA (2006) Predicting physical activity intention and behaviour among children in a longitudinal sample. Soc Sci Med 62:3146–3156. https://doi.org/10.1016/j.socscimed.2005.11.051
90. Barbaranelli C, Caprara GV, Rabasca A, Pastorelli C (2003) A questionnaire for measuring the Big Five in late childhood. Pers Individ Dif 34:645–664. https://doi.org/10.1016/S0191-8869(02)00051-X
91. Muris P, Meesters C, Diederen R (2005) Psychometric properties of the Big Five Questionnaire for Children (BFQ-C) in a Dutch sample of young adolescents. Pers Individ Dif 38:1757–1769. https://doi.org/10.1016/j.paid.2004.11.018
92. Rammstedt B, John OP (2007) Measuring personality in one minute or less: a 10-item short version of the Big Five Inventory in English and German. J Res Pers 41:203–212. https://doi.org/10.1016/j.jrp.2006.02.001
93. Petty RE, Wegener DT, Fabrigar LR (1997) Attitudes and attitude change. Annu Rev Psychol 48:609–647. https://doi.org/10.1146/annurev.psych.48.1.609
94. Muthén LK, Muthén BO (2012) Mplus user's guide, 7th edn. Muthén & Muthén, Los Angeles
95. Bentler PM, Bonett DG (1980) Significance tests and goodness of fit in the analysis of covariance structures. Psychol Bull 88:588–606. https://doi.org/10.1037/0033-2909.88.3.588
96. Hooper D, Coughlan J, Mullen MR (2008) Evaluating model fit: A synthesis of the Structural Equation Modelling literature. In: Brown A (ed) Proceedings of the 7th European conference on research methods for business and management studies. Academic Publishing Limited, pp 195–200. https://doi.org/10.21427/D79B73
97. Wheaton B, Muthén BO, Alwin DF, Summers GF (1977) Assessing reliability and stability in panel models. Sociol Methodol 8:84–136. https://doi.org/10.2307/270754
98. Hu LT, Bentler PM (1999) Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. Struct Equ Model 6:1–55. https://doi.org/10.1080/10705519909540118
99. Schermelleh-Engel K, Moosbrugger H, Müller H (2003) Evaluating the fit of structural equation models: tests of significance and descriptive goodness-of-fit measures. Methods Psychol Res Online 8:23–74. https://doi.org/10.1002/0470010940
100. Kanda T, Hirano T, Eaton D, Ishiguro H (2004) Interactive robots as social partners and peer tutors for children: a field trial. Human-Computer Interact 19:61–84. https://doi.org/10.1207/s15327051hci1901&2_4
101. Sung JY, Christensen HI, Grinter RE (2009) Robots in the wild: Understanding long-term use. In: Proceedings of the 4th International conference on human-robot interaction. La Jolla, pp 45–52. https://doi.org/10.1145/1514095.1514106
102. Singh N (2018) Talking machines: democratizing the design of voice-based agents for the home. Master Dissertation. Massachusetts Institute of Technology. http://hdl.handle.net/1721.1/119089
103. Mawson WB (2013) Emergent technological literacy: what do children bring to school? Int J Technol Des Educ 23:443–453. https://doi.org/10.1007/s10798-011-9188-y

Chiara de Jong (MA, 2017, Tilburg University) is a PhD candidate in the Amsterdam School of Communication Research (ASCoR) at the University of Amsterdam. Her research focuses on child development and the interaction between children and (digital) technology. She is currently studying children's acceptance of robots in the domestic environment.

Jochen Peter (PhD 2003, University of Amsterdam) is a Professor in the Amsterdam School of Communication Research (ASCoR) at the University of Amsterdam, the Netherlands. His current research interests focus on the consequences of new technologies for young people's psychosocial development.

Rinaldo Kühne (Ph.D, 2015, University of Zürich) is an Assistant Professor in the Amsterdam School of Communication Research (ASCoR) at the University of Amsterdam. Prior to joining ASCoR, he worked as a Research and Teaching Associate at the Institute of Mass Communication and Media Research at the University of Zürich. His research focuses on cognitive and emotional effects of media and communication technologies.

Alex Barco earned his PhD in electrical engineering at La Salle – Universitat Ramon Llull where he worked as a researcher and lecturer in the Electronics Department. His research focused on interdisciplinary research in social robots for children with disabilities. During his post-doc in the Amsterdam School of Communication Research (ASCoR) at the University of Amsterdam he studied the potential effects of the interaction between children and social robots.