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Exploring Children's Beliefs for Adoption or Rejection of Domestic Social Robots*

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***Abstract*— With social robots entering the consumer market, there is a growing need to study child-robot interaction in a domestic environment. Therefore, the aim of this study was to explore children's beliefs that underlie their intended adoption or rejection of a social robot for use in their homes. Based on a content analysis of data from 87 children, we found that hedonic beliefs (i.e., the belief that having a robot at home is pleasurable) were the most mentioned beliefs for domestic adoption of a social robot. More specifically, companionship was an often-mentioned hedonic belief. Social beliefs were rarely mentioned. If children mentioned beliefs for rejecting the robot, they often referred to family members and family composition. The findings of this exploratory study thus suggest that children's hedonic beliefs play a central role in their intended adoption of a social robot in a domestic environment.**

I. Introduction

Given the recent technological developments and evidence from various fields of the successful use of social robots among children (e.g., [1]–[4]), social robots have recently entered the consumer market, often in the form of smart/ connected toys [5], and are expected to increasingly be used in different roles in more natural environments [6]. A social robot can be defined as a robot capable of approaching interpersonal interaction [7]. To date, most research on child-robot interaction (CRI) has focused on social robots for specific educational goals, such as tutoring [8]–[11] or learning social skills [12], [13]. Little research, however, has been conducted on the – often playful – interactions between children and social robots in a domestic environment. Such interactions differ from interactions in a school or therapy setting because stakeholders (e.g., teachers or therapists versus family members) as well as goals (e.g., education/ health vs. play) vary. Additionally, research with adults has shown that more practical considerations come into play when deciding to use a technology or a social robot at home, such as the costs [14], [15] or privacy issues [14], [16], [17]. Finally, social robots for domestic use seem to centre more on playful interactions, especially when targeted at children [5], [6] and are often not designed for utilitarian purposes (i.e., not meant for a specific task or service [18], [19]). Given the limited knowledge about domestic social robots for children, the main goal of this study thus was to gain more insight into why children would want to adopt such a social robot at home.

Research on domestic social robots is still a small field, with only a few studies having dealt exclusively with children (e.g., [20], [21]). However, these studies typically focused on teaching children certain skills and did not study children's adoption of the robot, which can be defined as the initial decision to start using the robot at home [22]. Adoption is essentially different from acceptance, which is the longitudinal process of repeated use behavior [22]–[24]. Other studies on adoption or acceptance of domestic (social) robots have sometimes included children in their sample, but analysed the family as a whole, instead of children as the specific user group (e.g., [5], [14], [25], [26]). With the prospect that social robots are increasingly used in children's homes, it is thus timely and important to gain more insights into children's intended adoption or rejection of a social robot in a domestic context. After all, there is little chance of subsequent, longitudinal acceptance, without an initial intention to adopt the social robot (e.g., [14], [27]–[29]).

Several models have aimed at predicting user's intended adoption of technology. An influential model in explaining the adoption of technology in a domestic context is the Model of Adoption of Technology in the Household (MATH) [15], [30]. The MATH proposes – consistent with the Theory of Planned Behavior (TPB)[31] – that attitudinal, normative, and control beliefs predict the intention to adopt a technology. Attitudinal beliefs are comprised of utilitarian (i.e., task-related), hedonic (i.e., pleasure-related), and social beliefs (i.e., status-related). Normative beliefs refer to what the user believes others (e.g., friends and family) think of adopting the technology. Finally, control beliefs are perceived constraints that might prevent the user from adopting the technology [15], [30]. Thus, to gain more insight into children's intended adoption of social robots in the domestic context, it is imperative to first study children's beliefs that may underlie this initial decision to start using the social robot.

Although adults present a different user group than children, their beliefs for adopting or rejecting a technology in their home can be informative for the current study. Previous research on adults' intention to use a social robot has shown that in particular perceived enjoyment, which is an aspect of hedonic beliefs, predicted use intention. However, perceived usefulness (i.e., utilitarian beliefs) was also a fundamental requirement for robot acceptance [32]. Privacy and self-efficacy (i.e., the idea that one is capable of using the social

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robot; [33]) also played important roles in predicting the intention to use a social robot [32]. A similar picture emerged in an in-home study with a social robot, in which hedonic and social interactions with the social robot seemed to be the primary predictor of use, provided that there was a clear function for the robot (i.e., that the robot was useful) [17]. A study on persuasive social robots found attitude towards using the robot to be the only direct predictor of use intention, with perceived usefulness of the robot in turn being the strongest predictor of attitude [29]. However, looking at the phases of *long*-term use of social robots at home, another study showed that, before adoption (i.e., pre-adoption), users mainly focused on control beliefs, whereas, after adoption, they shifted towards utilitarian and hedonic beliefs [14].

As our previous research has shown that children mainly gain hedonic gratifications from *use* of a social robot [34], we expected them to also focus on hedonic beliefs when *deciding to adopt or reject* a social robot at home. Additionally, as we focus on the intention to adopt a social robot at home (i.e., pre-adoption), we also expected children to mention control beliefs as a reason for adopting or rejecting a social robot. In the current paper, we focus on the pre-adoption stage, which often includes a first encounter of the user with the technology, *outside* the domestic environment (e.g., at school or at a museum), before deciding to adopt it at home [22]. This initial encounter took place at children's schools and centred around a playful interaction with the robot. In this study, we targeted children in middle childhood (i.e., 7 to 11 years old) [35], as they generally have the language ability to process surveys [36], [37], and master various social and relation skills relevant for studying CRI, which is not the case with younger children (e.g., [35]). The study uses a qualitative approach, given that it is the first to analyze children's beliefs for adoption of social robots at home.

II. Method

This study was approved by the Ethics Review Board of the Faculty of Social and Behavioural Sciences at the University of Amsterdam (2018-YME-8706). The data used in this study are part of a larger study, which focused mainly on measure development for CRI [38]. Data from the larger study have been used in earlier publications [34], [39]–[41]. Before conducting the study, we received active written consent from the schools and from children's parents or legal caretakers.

A. Sample

Our sample consisted of 88 children from two elementary schools in the Netherlands. As one child did not finish the interaction, we collected data from 87 children (48 female, 39 male). Their age ranged from 7 to 11 years old (M = 9.17, SD = 0.85).

B. Procedure

Before we conducted the study, we introduced all children simultaneously to the study and to the robot in the classroom, as this could promote a more successful, comfortable interaction [9]. As participation was voluntary, we explained, in child-appropriate language, that children could withdraw from the study at any moment without giving a reason. We also explained that no personal information would be published. At the end of the introduction, children could ask questions, but – to prevent a potential influence on the study outcomes – robot-related questions were not answered at this point. Next, children were invited to individually interact with the robot.

Before the interaction between the child and the robot took place, we explained children again that they could stop their participation anytime without giving any reason. We explicitly asked them whether they wanted to participate. When children verbally consented to participation, the interaction was started.

Children interacted with the social robot NAO (Softbank) for approximately eight minutes in a quiet room. The robot was teleoperated from a laptop by a female researcher in the same room (i.e., Wizard-of-Oz). Children sat in front of the robot at a distance they deemed comfortable. To prevent any feelings of deception in the children (for an elaborate discussion, see [7]), we refrained as much as possible from programming the robot in a way that would induce a perception of humanness in the children (e.g., by the robot claiming to have feelings or consciousness).

The interaction centered around a guessing game and started with the robot asking the child several questions (e.g., "How are you doing?") to make the child feel comfortable. The guessing game was a 'True or False' game during which the robot made various statements about its functioning (e.g., "I speak many different languages"). The child had to guess whether the statement was true or false. After each guess, the robot revealed whether the child answered correctly and elaborated a bit on the specific function, sometimes also showing some of its functions (e.g., dancing and playing air guitar). To prevent children from getting distracted or bored, the robot asked several questions in-between (e.g., "What is your favorite color?"). To end the interaction, the robot and the child said goodbye and shook hands if the child wanted to.

After the interaction between the child and the robot, a female researcher administered a questionnaire in an interview room. The questions or statements were read aloud to the children, after which children indicated on a five-point scale – ranging from "Does not apply at all" to "Applies completely" – whether they agreed with the statement or not. The answering scale was visualized by means of a bar-chart which we adapted from [42]. As this bar chart does not use colours and/ or smileys, it avoids the elicitation of socially desirable answers as much as possible. We explained the answering scale to children and presented them with several practice items (e.g., "I like Brussels sprouts") (for a similar approach see [43]). Finally, we stressed the fact that there were no right and wrong answers.

The questionnaire consisted mainly of closed-ended questions on children's perception of the robot and the interaction with the robot, their psychological states during the interaction, and their cognitive development and personality [34], [38]–[41]. For some closed-ended questions, we included a follow-up open-ended question so children could elaborate on their answers and to gain a more detailed insight into their motivations for certain answers. For this study, we focused on the open-ended question that followed the item "I would like to take NAO home" of the variable *adoption intention* (The other items to measure that variable were "I would like to play again with NAO," "I would like to see NAO again," "It would be nice if NAO and I could meet again"). In its closed-ended

form, this variable has been analyzed in a study on the development and validation of a measure of intentional acceptance of social robots [41]. For detailed information on specific variables in the questionnaire (e.g., adoption intention or trust) see [38], [40].

At the end of the study, after all children had participated, we debriefed all children simultaneously in the classroom (for a similar approach, see [44]). Through a presentation with pictures, the researchers explained the mechanical nature and functioning of the robot, that the interaction was scripted, and that the robot was programmed to say and do the same things during each interaction. Finally, main differences between robots and humans were outlined. Any remaining questions were answered, and all children received a small present to thank them for their participation.

C. Data Analysis

To explore children's beliefs underlying their intended adoption or rejection of a social robot at home, we analyzed their responses to the open-ended question (i.e., "Why would you/ wouldn't you like that?"), which followed the closed-ended question on children's intention to adopt the robot at home (i.e., "I would like to take NAO home"). As we focus on adoption in this study, which is the initial decision to start using the robot, we did not mention a potential longitudinal use of the robot. As children could give a negative, positive, or neutral answer to the closed-ended question, analyzing the open-ended follow-up question enabled us to analyze beliefs that underlie both the intended adoption and rejection of the social robot for use at home.

Children's answers were analyzed with a directed content analysis (i.e., guided by theoretically defined concepts) [45]. We first coded the data based on the categories defined by the MATH [15], [30] (see below for a specification per category). If data did not match these categories, they were analyzed to identify a potential novel category [45]. Children often expressed multiple beliefs and thus, per child, multiple categories of beliefs could be coded (e.g., both hedonic and utilitarian beliefs). Accordingly, the total number of beliefs across all categories is higher than the total number of children. When a child mentioned multiple beliefs of the *same* category, it was coded as one occurrence of the particular belief. We, therefore, also present the percentage of children mentioning a given category. Two propositions were not coded as they referred to the interaction that children had had with the robot, rather than to beliefs for adopting or rejecting it.

The categories that we used in our analysis came from the MATH: attitudinal beliefs, which are categorized into utilitarian beliefs, hedonic beliefs, and social beliefs; normative beliefs; and control beliefs [15], [30] (see Table I). For coding the data, the beliefs were specified as follows: Attitudinal beliefs are personal beliefs about adopting the social robot. These were split into utilitarian beliefs, which are task-related beliefs and beliefs related to the functional purpose and practical features of the robot [17], [30]; hedonic beliefs, which are pleasure-related beliefs and beliefs related to (not) having fun with the robot [30], [32]; and social beliefs, which are beliefs related to a certain status or public recognition that one can gain when adopting the social robot [15], [30]. Normative beliefs are beliefs related to the (expected) attitude of others (e.g., friends, family, or a secondary source, such as television) that influence adopting the social robot [15], [30]. Control beliefs are beliefs about knowledge and source factors that may facilitate or hinder adoption of the social robot [30], [32]. These constraints can be, for example, fear of the social robot, the costs of adopting the social robot, the ease or difficulty of using it, or the required knowledge for adopting the social robot. We also added a residual category for beliefs that could not be coded in any of the other categories.

To check the reliability of the coding procedure, a second coder coded 10% of the semantic propositions (n = 12). There was substantial agreement (n = 11; Cohen's Kappa = .90) between the two coders and thus the procedure was considered reliable.

TABLE I. CATEGORIES OF BELIEFS, OCCURRENCE, PERCENTAGE OF CHILDREN THAT MENTIONED THE BELIEFS AND EXAMPLE PROPOSITIONS

Category (times mentioned)	% of children*	Example
Attitudinal beliefs		
Utilitarian beliefs (n = 13)	14.9	"It can help me with my math"
Hedonic beliefs (n = 69)	79.3	"I can do fun stuff with Nao"
Social beliefs (n = 4)	4.6	"Robots are cool"
Normative beliefs (n = 7)	8	"My friend also loves robots"
Control beliefs (n = 13)	14.9	"I have a dog, so it is not possible"
Other beliefs (n = 10)	11.5	"It is big"

*Per child, multiple categories of different beliefs could be coded, thus percentages do not sum up to 100.

III. RESULTS

Of the 87 children, a majority of 73.6% (n = 64) indicated that they really wanted to take NAO home ("Applies completely"). Eight children (9.2%) answered "Applies" and eleven children (12.6%) gave a neutral answer. Only four children (4.6%) answered negatively to the question: One child answered "Does not apply at all" and three children "Does not apply". It is important to note that a positive answer to the closed-ended question did not necessarily lead to a belief for accepting the social robot, and vice versa, and that a neutral answer to the closed-ended question could be followed by a belief for accepting or rejecting the robot, or both.

When analysing children's answers to the question why they did or did not want to take the social robot NAO home, three general findings emerged. First, even when children indicated that they wanted to take the robot home (i.e., a positive answer to the closed-ended question; n = 72, 82.8%), they sometimes explained why it would be difficult or impossible to do so (e.g., because they have a dog or because the robot is too expensive). Children thus entertain certain beliefs as a reason for rejecting a robot although they may want to adopt it. Second, when children indicated that they did not want to take the robot home, they always referred to family members or friends, either emphasizing that others would not like it (i.e., normative beliefs) or that they already had enough people to play with (i.e., control beliefs). Third, when

comparing the various beliefs, hedonic beliefs were mentioned by far most frequently, namely by 79.3% (n = 69) of the children.

A. Attitudinal beliefs

1) Utilitarian beliefs

As Table I shows, 13 children (14.9%) referred to utilitarian beliefs, only once using it as a reason for rejecting the social robot (i.e., the belief followed a neutral answer to the closed-ended question). Rather than referring to the ease of use, usefulness, or adaptability of the robot, children mainly mentioned specific functions of the robot that they appreciated or envisioned. These functions included, for example, dancing; teaching them jokes; and helping them with homework, math, or specific chores. One child also mentioned how the robot could 'replace' his/ her parents in helping him/ her with homework. The child who referred to utilitarian beliefs in the context of rejecting the robot expected it to wake him/ her up when he/ she was asleep.

2) Hedonic beliefs

Hedonic beliefs were mentioned by 69 of the 87 children (79.3%). Children often mentioned that they liked the social robot and, more specifically, playing with it. They also thought it was kind and enjoyed its jokes. More specifically, several children (n = 24, 27.6%) referred to the companionship they expected to get from the robot (not shown in Table I). For example, they mentioned how the robot could cheer them up when they are angry or feel lonely and how they can play and talk with the robot when they have no-one or nothing else around.

3) Social beliefs

Only four children (4.6%) mentioned social beliefs, all as a reason for adopting the social robot at home. Three of these children referred to the robot as 'cool,' whereas the fourth one mentioned that he/ she would be the only one in their class to have a humanlike robot.

B. Normative beliefs

Seven children (8%) mentioned normative beliefs as a reason for adopting (n = 2) or rejecting (n = 5) the social robot. One of these children wanted to take the robot home but gave a normative belief for rejecting the social robot. The children who mentioned normative beliefs as a reason for *adopting* NAO expected their family members or one of their friends to like the robot and to be curious to see the robot. The other children who mentioned normative beliefs as a reason for *rejecting* the robot solely mentioned their family members and expected them to disagree with, or dislike, having the robot at home. One child also expected his or her younger sibling to be scared of the robot.

C. Control beliefs

Thirteen children (14.9%) mentioned control beliefs, with almost all using it as a reason for rejecting the social robot (n = 12). For three of these children, the negative control belief contrasted with their wish to take the robot home. Control beliefs that were mentioned were the costs of the robot or of charging it; having a dog at home; and space and/ or time constraints because of a large family or many friends. Some children also mentioned that they did not know what the robot could or would do and whether it was properly tested to be used in a family. Only one child used a control belief as a reason to adopt the robot, namely because it would make him/ her less scared of the robot.

D. Other beliefs

There were ten beliefs that could not be coded into the previously defined categories. Four of those beliefs had to do with the novelty or exclusiveness of the robot. Children mentioned that they had never had a robot at home; that one cannot just make a social robot oneself; that it is something different; and that one does not see a robot daily. Three beliefs referred to family members and how they could interact with the robot, but without mentioning family members' expected attitude or affective opinion and without using the robot to gain public recognition or status. Showing the robot to others and being able to share the experience with family members seems to be an additional belief underlying the intended adoption of social robots. The three remaining beliefs could not be meaningfully categorized and referred to specifics, such as the size of the robot (but without giving an attitude or evaluative judgement); how it would be strange to live with a robot; and the fact that the child already had a robot before but wanted a new one.

IV. Discussion

The goal of our study was to explore children's beliefs that underlie their intention to adopt or reject a social robot at home. Given our small sample size and non-representative sample, the results should be regarded as an initial exploration of the topic and should be interpreted and generalized with caution. We found that children mainly refer to hedonic beliefs, but that utilitarian beliefs also seem to play a role in adopting a social robot. Children thus seem to focus on their own attitude towards adopting the robot (i.e., attitudinal beliefs) rather than on the attitude of others (i.e., normative beliefs) or on other factors, such as their own knowledge or external factors (i.e., control beliefs). In contrast, when it comes to rejecting a social robot, children seem to focus especially on control beliefs.

These findings merge with studies on adults' adoption and acceptance of social robots, which found that especially enjoyment of the interaction and sociality of the social robot played a central role, but that utilitarian beliefs were also important for adopting and accepting the robot [17], [32]. Additionally, when looking at the temporal aspect of adoption, the results dovetail with the earlier finding that adult users tend to focus on control beliefs prior to adoption [14]. Finally, the findings also largely merge with the MATH [15], [30], except for the low prevalence of social beliefs (i.e., beliefs referring to status). Children seem to care less about public recognition and more about enjoyment compared to adults when it comes to social robots (for a similar finding concerning the same children's gratifications from social robots *use*, see [34]).

Besides control beliefs, normative beliefs also seemed to be at play in children's *rejection* of a social robot. In the context of rejection, the normative beliefs exclusively referred to children's family members. Similarly, the control beliefs often focused on constraints related to the family situation (e.g., number of siblings; dog ownership). Occasionally, there seemed to be a discrepancy between what children want and what they consider possible: Various children who mentioned

family when referring to control and normative beliefs indicated that they wanted to take the social robot home, but gave a reason for why that would not be possible. Moreover, some children referred to a belief that overlapped with social and normative beliefs, but focused on simply being able to show the robot to family members as a reason for adopting it. The decision to adopt or reject a social robot at home seems less of a personal decision for children, but rather a social one, in which they consider other members of their family.

A. Limitations and Future Research

Next to its non-representative and small sample, our study has at least four more limitations. First, during the interaction children were not made aware of the fact that the robot was pre-programmed and tele-operated by a researcher (i.e., Wizard-of-Oz) and we did not ask children whether they thought the robot was operating autonomously. This may have influenced children's beliefs about the robot and may have resulted in high expectations about the robot. Moreover, NAO is not a typical commercially available robot. The social robot's type and functioning in our study are thus probably not a realistic reflection of how a social robot would function in a domestic environment. Second and related to the first limitation, the interaction mainly consisted of a guessing game. The robot did show some of its (utilitarian) functions, but the interaction was mainly playful. This may have influenced children's perception of the robot as a hedonic technology and may have elicited mainly hedonic beliefs. The type of interaction may also explain the similarity with the dominance of hedonic considerations in children's gratifications from robot *use* that we found in an earlier study based on the same data [34]. Third, we focused on self-reported data on adoption and beliefs and asked children about their intention to adopt the robot. As a result, our data may have been affected by children's tendency to answer in a socially desirable way, for example by stating that they wanted to take the robot home or liked it. Nevertheless, children's positive responses in our study merge with earlier research in CRI (for a review see [46]). Fourth and finally, the intention to adopt a robot, may not always reflect actual behaviour (i.e., the intention-behaviour gap, see e.g., [47]).

As robot adoption is the initial decision to use the robot at home, it can meaningfully be studied cross-sectionally. Still, future research may also benefit from a longitudinal approach and a focus on children's *acceptance* of the social robot beyond initial adoption, notably given earlier findings on adults' robot acceptance, which showed that different beliefs surface during pre- and post-adoption [14]. Additionally, given the small sample size and the exploratory nature of our study, future research should analyse children's beliefs with a larger sample size and, to increase ecological validity, study different robots and interaction types.

B. Conclusion

Despite its limitations, our study offers some first novel insights into children's thoughts and beliefs about adopting or rejecting a social robot in the domestic environment, which is an essential step in the longitudinal acceptance process of robots at home. It seems that, when designing and trying to understand social robots for use at home, the focus should be on hedonic aspects of the robot and the interaction, which has been suggested before [48]. This focus on hedonic beliefs, and the robot as a toy, may also extend to other, less playful domains, such as education or therapy. Moreover, and more specific to the domestic context, control beliefs, such as costs of the robot and the 'co-existence' with other family members, should be taken into account when we want to grasp better what children do – and what they do not do – with a social robot in a domestic environment. Finally, a unique aspect of domestic social robots, compared to other technologies such as smartphones, surfaced in hedonic beliefs, with many children mentioning the companionship of the robot as a reason for adopting it. Against this background, our study may contribute to conceptualizing children's adoption of domestic social robots in the broader context of hedonically oriented technologies.

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