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Research Paper

"You" versus "children": A repeated-measures experiment on the effects of social robots' use of (im)personal address forms when talking to children

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ABSTRACT

Address forms are an important element of communication and can both reflect and affect how social robots are responded to. However, their effects on children's responses to social robots remain understudied. To fill this gap initially, we conducted an online repeated-measures experiment to investigate the effects of a robot's use of personal ("you") versus impersonal ("children") address forms on children's involvement in the interaction, their perception of the robot (in terms of cognitive and affective perspective-taking and social support) and their relationship with it (i.e., feelings of closeness and trust). Children ($N = 282$, age 8–9) watched two videos of a Nao robot with one week in between, in which the robot addressed them either personally or impersonally. We expected that children would respond more positively to a robot that always used personal address forms than to a robot that always used impersonal address forms, resulting in higher scores on all aforementioned variables. In addition, we expected that a change from impersonal to personal address forms over encounters would positively influence children's involvement, perception of the robot, and relationship with it, and vice versa for a change from personal to impersonal address forms. However, we did not find any significant effects of address form. We discuss the lack of significant findings in light of the differences between communication with humans versus machines.

1. Introduction

Over the past years, studies on children's interactions with social robots – or robots made for interactions with people (Breazeal et al., 2016) – have aimed to elucidate how communication processes that facilitate the emergence of interpersonal relationships affect child-robot relationship formation (see van Stratenet al., 2020b). In this context, the effects of robots' self-disclosure on children's feelings of companionship with social robots have attracted ample research attention (e.g., Kory Westlund & Breazeal, 2019a; Ligthart et al., 2019; van Straten et al., 2022a). However, a communication process that remains understudied in the literature on child-robot interaction (CRI) is the manner in which robots address children. This research gap is surprising because the way in which we refer to others, for instance using personal pronouns, forms a central element of relational communication (see Smolík & Chroma, 2022; Zhao, 2006).

Another shortcoming in current research on CRI in general, and studies on child-robot relationship formation in particular, refers to the dominance of singular, one-time exposures of children to social robots in research designs (see, e.g., van Straten et al., 2020b). Communication, however, is not static: The way in which we address others and expect to be addressed in return develops over encounters (e.g., Burleson, 2010). The dynamic character of communication applies particularly to relationship *formation*. Little research, however, has investigated the emergence of child-robot relationships over time, some notable exceptions notwithstanding (Calvo-Barajas & Castellano, 2022; Kruijff-Korbayová et al., 2015; Leite et al., 2014; Ligthart et al., 2022). As a result, it is unclear whether and how *changes* in a robot's use of address forms over time affect children's perceptions of, and relationship formation with, social robots.

Investigating how robots' use of different kinds of address forms affects children's responses to social robots over time is especially important in light of the ongoing ethical debate on child-robot relationship formation (Constantinescu et al., 2022). This debate centers on the concepts of 'authenticity' and 'deception' (Sharkey & Sharkey, 2021; Turkle, 2007), asking whether social robots should more clearly signal their machine nature to children instead of encouraging them to perceive robots as humanlike potential friends (see also van Straten

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et al., 2023). Importantly, scholars have emphasized that deception about social robots does not always happen intentionally: The design of a robot and/or its interaction style can also *unintentionally* cause children to form robot perceptions that are not in line with social robots' current capacities (e.g., Sharkey & Sharkey, 2021). This, in turn, may lead children to think of robots as potential friends based on unjust expectations of these new communication partners.

A robot's use of personal, pronominal address may invoke in children the feeling that the robot is aware of them as a unique individual (Lewis, 2022). As this awareness does not exist in current social robots, pronominal address is one element of CRI that may unintentionally mislead children about a robot's capacities. While this issue may appear negligible to some, the increasing importance being attached to responsible, transparent robotics (Boden et al., 2017; Sharkey & Sharkey, 2021) may soon necessitate us to rethink current standards in child-robot interaction design. To date, however, pronominal address remains an often-overlooked element of social robots' interaction styles.

Against this background, the present study investigated whether a social robot's use of personal, pronominal address ("you") versus impersonal, generic address ("children"), as well as its change over time, would influence children's interaction involvement, their perceptions of the robot, and their relationship with it. We conducted an online, repeated-measures experiment among children aged 8 to 9, who watched videos in which a social robot addressed them either personally or impersonally at two timepoints. At this age, children are becoming increasingly sensitive to discourse flexibilities (e.g., Stafford and Vangelisti, 2004), and begin to develop friendships on the basis of increasingly meaningful considerations (e.g., Bernath & Feshbach, 1995). Therefore, the effects of different forms of pronominal address on the emergence of child-robot relationships can meaningfully be assessed with children in this age range.

2. Theoretical framework

2.1. (Im)personal address forms in interpersonal communication

One theoretical framework that deals with (changes in) the way people address each other is the developmental perspective on interpersonal communication (see, e.g., Burleson, 2010). According to this perspective, all communication is *im*personal at first: People relate to each other by taking social roles rather than by being distinct persons. Over time and encounters, interactions and relationships become *inter*personal and are increasingly based on unique psychological information that people have about each other (Burleson, 2010; Miller & Steinberg, 1975). Next to differences in conversation content, the more or less (inter)personal nature of an interaction becomes apparent in how people choose to address their interlocutor (e.g., Keshavarz, 2001). Accordingly, the manner in which people address each other changes as their relationship evolves (Jorgenson, 1994).

Besides calling others by their names, people can also address them through personal pronouns. Pronominal address makes interactions time-, place-, and person-specific (Vizcaíno Ortega, 1996) and thus specifies the relationship between interlocutors at a given point in time (Clyne, 2009). In addition, the specific pronouns can reflect the *nature* of our relationship with another person (Papapavlou & Sophocleous, 2009). For instance, many languages have a familiar and a deferential second-person pronoun (e.g., "tu" and "vous" in French), the second being used "when the addressee is in a superior social position or when the speaker does not have a sufficiently close personal relationship with the addressee" (Keshavarz, 2001, p. 6). However, pronominal address forms can also be used to actively manage interpersonal relationships by choosing formal versus friendly, or inclusive versus exclusive forms, such as "we" vs "you" (Moyna et al., 2019).

Next to choosing different kinds of address forms, people can also refrain from directly addressing their interlocutor by using generic noun phrases, such as "Children have to go to bed early". Such statements convey only generic information. This information is unrelated to time and context (DeJesus et al., 2021) and generally concerns members of a certain group, which may or may not include the addressee (Moty & Rhodes, 2021). As described by Sugamoto (Sugamoto, 1989, p. 270, emphasis added), "[n]ouns are a lexical category whose primary function is to *name* an entity, whereas the primary function of pronouns is to *refer* to an entity." By excluding any direct reference to the addressee, the use of generic statements thus renders communication impersonal.

In mediated communication, address forms can have similar effects as in face-to-face communication. Maslowska et al. (2011), for example, found that newsletters that mentioned participants' names were evaluated more positively than generic ones. In addition, Wagner et al., (1998) found that the use of informed consent forms with first- and second-person pronouns increased patients' evaluations of a therapist's attractiveness. In television content, the use of second-person pronouns is one way of "breaking the fourth wall" (Auter, 1992, p. 176) and can facilitate the emergence of a parasocial relationship between the media character and the viewer by making the presence of the audience explicit (see, e.g., Auter, 1992; Cohen et al., 2019; Coimbra de Rezende Filho, 2019). In educational programs for children, direct address can also improve learning (Krcmar & Cingel, 2019; Tamborini & Zillmann, 1985). Finally, song lyrics in which the listener is directly addressed in the second person create a more intimate atmosphere than those written from a third person perspective (see, Bailey-Shea, 2014). Together, these findings illustrate that address forms can alter people's responses to 'others' regardless of whether the communication between them is face-to-face or mediated and interactive or one-directional.

2.2. Address forms in human-machine communication

As address forms influence human-human communication both in interpersonal and (computer-)mediated settings, the question arises whether their effects also transfer to human-machine communication (HMC) and children's encounters with robots more specifically.

2.2.1. Address forms in CRI and related research

To the best of our knowledge, only two studies to date have investigated address forms in CRI. First, Baxter et al. (2017) assessed the effects of personalization, operationalized as a robot's use of children's (age 7–8) name to address them; a more friendly communication style with more frequent second-person pronoun use; and more responsive non-verbal behavior. However, children's perceptions of the personalized and non-personalized robots did not differ in terms of social presence, social support, or competence. Their enjoyment of, and interest in, the interaction with the robots were equally comparable across the conditions (Baxter et al., 2017). A second study (van Straten et al., 2022b) has investigated how children aged 7–10 responded to a robot that referred to itself using the personal pronouns "I" and "my," or only talked about robots in general. Self-reference decreased children's view of the robot's similarity to themselves, but otherwise did not affect children's perception of, and relationship with, the robot. The authors argued that the robot's acknowledgement of its lack of human likeness may explain their findings: Saying "I" may have emphasized how *this* particular robot was unlike the children in many ways, while the robot's avoidance of the first-person perspective may not have surprised children given its machine status (van Straten et al., 2022b).

Either way, the effect of a robot saying "I" on children's perception of the robot's similarity to themselves suggests that children are susceptible to a robot's pronoun use. Additional support for this idea comes from related research. For example, a study on children's interaction with virtual agents found that children aged 5 to 12 preferred an agent that used first-person pronouns, and referred to them through second-person pronouns, to an agent that did not do this. However, children did not prefer an agent that also knew their name and age to an agent that only used first- and second-person pronouns (Yuan et al., 2019). Comparable findings were obtained among adults, who liked a robot better that addressed them using second-person pronouns – without additionally using their name – than one that addressed them as a "user" without using second-person pronouns (Chung et al., 2022). While robots' use of personal pronouns may thus influence children's responses to them, the effects of a robot's use of pronouns to refer to itself need to be further disentangled from the effects of a robot's use of pronouns to refer to others.

2.2.2. How (im)personal address may impact children's responses to robots

For a relationship to emerge, both entities involved in it should know at least that the possibility for a relationship exists (Roloff, 1976). In a CRI context, a robot's use of personal address forms shows that it is aware of this possibility. By contrast, generic noun phrases, such as "Children have to go to bed early", do not acknowledge the existence of a specific addressee. If a robot solely speaks in generics, this might thus signal the robot's unawareness of the child as a potential "friend". Research has shown that from the age of 4, children interpret generic noun phrases in much the same way as adults do (Brandone et al., 2015). Moreover, in Dutch – the language in which the present study was conducted – different pronouns are used for the second-person singular (i.e., "jij/je") and plural (i.e., "jullie; de Vogelaer, 2007). Personal address – operationalized through second-person *singular* pronoun use – is thus unlikely to be interpreted as referring to a larger group of individuals. Taken together, primary school children can thus be expected to notice, and potentially be influenced by, a robot's use of generic versus pronominal address.

While, as mentioned above, the effects of robots' self-reference using personal pronouns may depend upon children's general robot perceptions (see van Straten et al., 2022b), a robot's use of pronouns to refer to children should not. As Stawarska (2019, p. 4) argues: "[T]he first-person pronoun is necessarily taken up by the speaker as she addresses another in the second-person mode. 'I use *I* only when I am speaking to someone who will be a *you* in my address'". Thus, when the robot refers to itself as an "I" but does not address the child as a "you", an impersonal situation emerges regardless of how the robot is perceived. As previous research has found children to be susceptible to machines' pronoun use (van Straten et al., 2022b; Yuan et al., 2019), a social robot's use of personal versus impersonal address forms may thus influence children's experience of the interaction; their perception of the robot; and their relationship to it.

This expectation is, first, supported by research among adults: Three studies on adults' interactions with agents, chatbots, or computers suggest that the personal address of a human partner can facilitate the emergence of friendly relationships with machines. First, a virtual agent was perceived as more friendly and helpful when it used the personal pronouns *I* and *you* instead of the impersonal third-person perspective (Moreno & Mayer, 2004). Second, students evaluated a computer as more friendly and trusted it more when its narration style included first- and second-person pronouns as well as direct comments and cues regarding the identity of the "narrator" (Liew et al., 2014). Third, people experienced a stronger social connection with a chatbot when it directly addressed them by name than when it did not (Candello et al., 2019).

Although the reasoning of children in our age range differs from that of adults (Belpaeme et al., 2013), children are sensitive to pronominal and generic address (Brandone et al., 2015) as well as to discourse flexibilities more generally (Stafford & Vangelisti, 2004). Therefore, effects similar to the ones found among adults may emerge in the context of child-robot relationship formation. Three concepts that are central to the development of social relationships, and child-robot relationships more specifically (see van Straten et al., 2020), are closeness, trust, and perceived social support. Closeness can be defined as a sense of intimacy or connectedness that may develop into friendship (Sternberg, 1987), and thus mirrors the concepts of friendliness and social connection that were affected in the above discussed studies among adults (Candello et al., 2019; Liew et al., 2014; Moreno & Mayer, 2004). Trust, which was impacted in (Liew et al., 2014), refers to the belief that someone is benevolent and honest (Larzelere & Huston, 1980). Finally, perceived social support can be defined as "perceived [...] instrumental and/or expressive provisions supplied by the community, social networks, and confiding partners" (Lin et al., 1986, p. 18), and as such relates to the concept of helpfulness as investigated in (Moreno & Mayer, 2004).

Prior research has shown that children's trust in a robot was related to their perception of the robot's ability to take their cognitive perspective, or, in other words, to understand their thoughts (van Straten et al., 2022a). But to be able to take someone's perspective, one should first be aware of the other as a unique individual: otherwise, there would be no perspective to take. Perspective-taking can happen on a cognitive level, but also on an affective level: It is both about the ability to understand the thoughts and the emotions of others (Eisenberg et al., 1998). As mentioned previously, the use of personal pronouns acknowledges someone as an individual rather than an indistinct member of a group. We thus also expected the robot's use of pronominal address to increase children's perception of the robot's cognitive and affective perspective-taking abilities.

Finally, we expected that the robot's use of personal address forms would increase children's involvement in the interaction. When children are directly addressed by the robot, a sense of being part of an interaction emerges (see Mildorf, 2016). Assessing children's involvement is particularly relevant in the context of the present study: Children observe rather than interact with a social robot and involvement may be particularly prone to variations in the robot's interaction style. In sum, we hypothesized:

Hypothesis 1a-c. **(H1a-c).** When a social robot consistently uses personal rather than impersonal address forms, children will experience more (a) closeness toward, (b) trust in, and (c) social support from the robot.

Hypothesis 1d-f. **(H1d-f).** When a social robot consistently uses personal rather than impersonal address forms, children will (d) be more involved, and more strongly believe in the robot's ability to take their (e) cognitive and (f) affective perspective.

2.3. Changes in address forms over time and their effect on relationship formation

Relationships change over time, and changes in a relationship are reflected in how those involved in the relationship communicate with and address each other (e.g., Burleson, 2010). According to Stewart and Koenig Kellas (2020), people aim to 'co-construct uniqueness' in any interaction after the first encounter: Then, interaction partners no longer see each other as interchangeable entities but as distinctive others, which allows them to express themselves and learn about the other. A requirement is that both interaction partners are engaged in the construction of uniqueness, such that both develop an understanding of each other's distinct (personality) characteristics (Stewart & Koenig Kellas, 2020). One way of showing that one conceptualizes another person as a unique individual is by directly referring to this person using second-person pronouns (see, e.g., Wolf, 2016). As a relationship progresses and uniqueness is being constructed, it becomes increasingly uncommon to exclusively use generic, impersonal formulations.

The development of affection and rapport that changes the nature of interactions from impersonal in first encounters to more personal in subsequent encounters occurs in all human interaction, regardless of whether it is mediated or not (Walther, 1996). While relationships may become more personal over time, they can also become more impersonal again when (one of) those involved wish(es) to take their distance. Communication patterns can reflect both of these developments (e.g., Roloff, 1976). Thus, when someone addresses us more personally in a second encounter, we may interpret this as a sign that they wish to intensify the relationship. Conversely, address forms that become increasingly impersonal may be received as a wish to weaken or terminate the relationship.

Against this backdrop, we expected that changes in a social robot's use of address forms would affect how children perceive and relate to a robot over time. More specifically, when the robot addresses children impersonally in the first encounter but personally in the second, this signals an increase in familiarity expressed by the robot, which will positively influence child-robot relationship formation. Conversely, when the robot addresses children personally in the first encounter but impersonally in the second, this signals the robot's attempt to create distance, which will negatively influence children's relationship to the robot. In addition, we expected that a change from impersonal to personal address would increase children's involvement and perception of the robot's perspective-taking abilities over encounters, whereas a change from personal to impersonal address would have the opposite effect. We hypothesized:

Hypothesis 2a-c. **(H2a-c).** When a robot uses impersonal address forms in the first encounter and personal address forms in the second, children's (a) closeness toward, (b) trust in, and (c) perceived social support from the robot will increase over encounters. In contrast, when a robot uses personal address forms in the first encounter and impersonal address forms in the second, children's (a) closeness, (b) trust, and (c) perceived social support will decrease over time.

Hypothesis 2d-f. **(H2d-f).** When a robot uses impersonal address forms in the first encounter and personal address forms in the second, children's (d) involvement as well as their perception of the robot's (e) cognitive and (f) affective perspective-taking abilities will increase over encounters. In contrast, when a robot uses personal address forms in the first encounter and impersonal address forms in the second, children's (d) involvement as well as their perception of the robot's (e) cognitive and (f) affective perspective-taking abilities will decrease over time.

3. Method

Data collection took place in July 2021, during the Covid-19 pandemic. Therefore, the study was conducted as an online experiment. The study was conducted using survey software and children could participate in the study independently at their own time, using their home computer. All questions and instructions were provided in written form. During the study, children watched videos in which a social robot addressed them either personally or impersonally at two timepoints (T1 and T2). The experiment thus had a 2 (address form T1: personal/impersonal) x 2 (address form T2: personal/impersonal) x 2 (time: T1/T2) mixed design, with address form in T1 and T2 as between-subject factors and time as a within-subject factor. In line with other studies on repeated CRI (e.g., Ahmad et al., 2022; Ligthart et al., 2022; Ros et al., 2016), there was a one-week interval in between the timepoints. We considered this a reasonable interval to guarantee that children still had the previous video in mind without overburdening them in a shorter timeframe. The ethics review board of the Faculty of Social and Behavioral Sciences of the University of Amsterdam had approved the study (project number: 2020-YME-12448) before the start of the study.

3.1. Participants

Participant recruitment and data collection were done by DVJ Insights. An invitation email was sent to parents of Dutch children aged 8 to 9 who were part of DVJ's online database. A link in the email took parents to a screening page. On this page, they were asked to confirm their child's age and to indicate whether their child had participated in robot-related research of the University of Amsterdam before. In addition, parents were asked whether their child was diagnosed with autism spectrum disorder (ASD). Children with this diagnosis experience difficulties with social interactions (American Psychological Association, 2013) and relationships (e.g.,Eisenmajer et al., 1996). In addition, individuals with ASD may differ in their anthropomorphic tendencies (Epley et al., 2007). Therefore, this medical indication could influence our analyses. In total, our selection procedure thus involved three exclusion criteria: age, participation in robot-related research of the University of Amsterdam, and ASD diagnosis.

We asked for active consent from both parents and children, meaning that both parent and child had to explicitly indicate that they agreed with the child's participation in the study. If their child fit the screening criteria, parents were first taken to a page with information on the goal and procedure of the study. After reading this information, they were asked to proceed to a consent form, which contained information about the voluntariness of participation, privacy matters, and data management. After parents had provided consent, they were prompted to ask their child to join them as the next page would contain a consent form for children. A text written in age-appropriate language informed children that the researchers would not be able to see who gave what answers to the questionnaire, and that participation could be stopped at any time without providing a reason.

As the consent form was highly similar to the forms that children read in earlier studies we conducted in-person (e.g., van Straten et al., 2022a; van Straten et al., 2023), we were confident that children would be able to understand its content without further explanation. Still, parents were asked to provide their child with additional explanations about this information if needed. When the child indicated to understand the information and to be willing to participate by clicking a button, the study began. At the start of T2, the information that children had received at T1 was reiterated on the first page they encountered. After reading this information, children were once more asked for their consent.

To the best of our knowledge, power tests for three-way interactions between within- and between-subjects factors (as they are tested in H2a-f) are currently not adequately implemented in existing software such as G*Power (Faul et al., 2007). However, to get a rough indication of the sample size needed to test H2a-f, we ran a power analysis in G*Power in which we specified a small effect size ($f = 0.10$) with an alpha level of 0.05 and a conservative power level of 0.90 (F-Test, ANOVA, repeated measures, within-between interaction). To obtain the correct number (i.e., 1 for our expected interaction) of the numerator degrees of freedom, we specified the number of both groups and measurements as two, setting the correlation between repeated measures to 0.5 and the sphericity correction to 1. This resulted in a required sample size of 266. As we considered this number only indicative of the required sample size and wanted to take into account potential missing data, we upped the number by 5% to 280 respondents as our final targeted sample size. The testing of H1a-f required a smaller sample size.

Children were oversampled in T1 to account for participant attrition between T1 and T2. In total, 384 children completed T1, and 287 of these children also completed their participation in T2. Due to missing data, five children were excluded from analyses because DVJ could not guarantee that they met our screening criteria. We thus analyzed the data of 282 children aged 8 to 9 (143 boys, 139 girls, $M_{age} = 8.52$, $SD_{age} = 0.50$). Participants were randomly assigned to the experimental conditions (personal vs. impersonal address) at both T1 and T2. There were no significant differences in children's age ($t\ (280) = -1.787$, $p = 0.08$ for T1; $t\ (280) = 0.725$, $p = 4.69$ for T2) or gender ($\chi2\ (1, N = 282) = 1.423$, $p = 0.233$ for T1; $\chi2\ (1, N = 282) = 0.125$, $p = 0.723$ for T2) between the conditions. Thus, the randomization procedure was successful.

3.2. Stimuli and manipulation

At both T1 and T2, children watched a short video of the Nao robot (Softbank; for a screenshot taken during one of the videos, which all looked exactly the same, see Fig. 1). The duration of the videos was kept constant over timepoints and across the conditions (i.e., about 4 minutes, with a difference of max. 10 seconds). The robot made expressive gestures and body movements while speaking. Face tracking was activated such that the robot automatically redirected its gaze at the camera

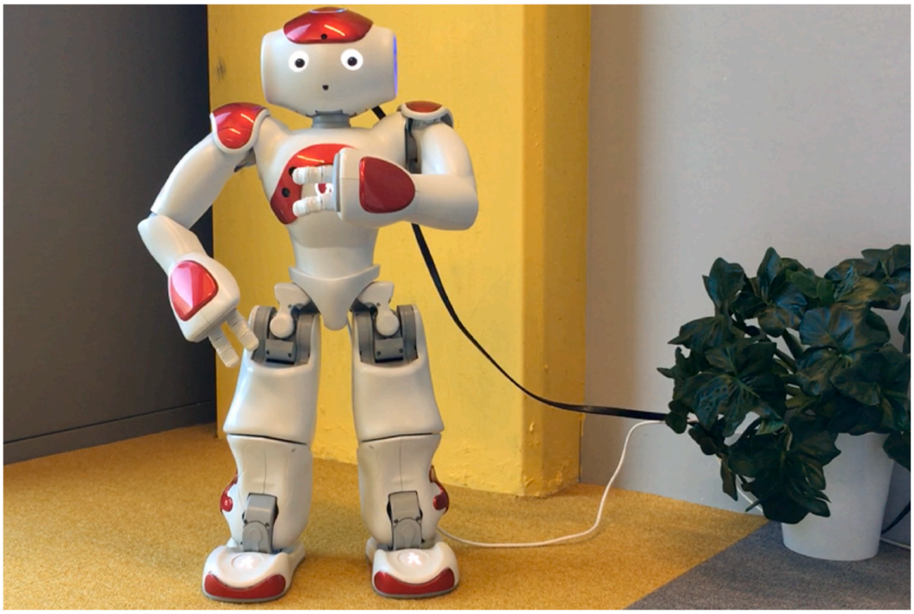

Fig. 1. Screenshot of one of the video stimuli.

(which was operated by a researcher sitting right behind it) after looking elsewhere. We aimed to make the content of the videos shown in T1 and T2 equally engaging. To minimize any form of deception, the robot never claimed to have any humanlike capacities and openly addressed its machine nature and working.

The T1 video started with Nao introducing itself and the survey to the children. Then, Nao talked about topics appealing to children in this age range (e.g., school, hobbies). The appeal of these and similar topics was based on our observations of children's engagement in similar CRI scenarios in previous studies (e.g., van Straten et al., 2020b,c) as well as by their prominence in, for instance, children's friendship books (Ligthart et al., 2019). During the video, Nao also showed children that it could change its eye color and demonstrated its ability to play air guitar. At the end of the video, Nao referred to the questionnaire that would follow. At T2, Nao told the children that the researchers wanted to know more about their opinion of robots, such that a second questionnaire would follow. Then, Nao told an animated, fairytale-like story and talked to children about topics related to its content. The demonstrations that the robot engaged in (i.e., changing eye colors; air guitar demonstration; animated storytelling) were also part of the interaction scripts used in our earlier studies (e.g., van Straten et al., 2020a,b), in which we observed that children particularly enjoyed these demonstrations in spite of their non-interactive nature. Therefore, we considered these demonstrations suitable to maintain children's engagement during the videos. At the end of this video, the robot reminded children that they would next be presented with a questionnaire (see section 3.3 for a description of the questionnaire procedure).

In the personal address conditions, Nao addressed children by using second-person pronouns "you" and "your" (e.g., "*You probably* had swimming lessons, so *you* can enjoy swimming in the sea"). In the impersonal address condition, Nao did not address children personally (e.g., "*Most children* had swimming lessons, so *they* can enjoy swimming in the sea"). We made minor adaptations to the robot's formulations whenever the change of address forms required this (see example). Apart from these adaptations, the robot said exactly the same across the experimental conditions. The video stimuli used in the different conditions have been added to this publication as online supplementary material. As the videos are in Dutch, we provide English translations of the transcripts in Appendix A. The translations follow the Dutch original as closely as possible.

3.3. Procedure

At T1, after children had indicated to be willing to participate in the study, they filled in two survey questions about their age and gender. Subsequently, they were asked to test their computer sound volume before the answer format of the questionnaire was explained. As in Leite et al. (2017), children were presented with several practice items, such as "I like candy" and "I like Brussels sprouts", to practice the questionnaire procedure. They could go through both the explanation and the practice items multiple times if they wished, and were encouraged to ask their parents for help in case anything was unclear. The explanations and practice items used were identical to the ones we have used in earlier studies that were conducted in-person with children in the same age range (e.g., van Straten et al., 2020a,b) and children usually understand these quickly. At T2, the demographics questions were skipped, and children could choose whether they wanted to go through the explanation and practice items again. Otherwise, the procedure was identical at both timepoints.

Once children indicated to understand the questionnaire procedure, they were presented with a video of Nao. After the video, the questionnaire started automatically. Children were instructed to fill in the questionnaire directly after watching the video. It was not possible to continue to the questionnaire before the video had finished or to watch the video more than once. The questionnaire was administered in written form, without researcher supervision. Each question was presented on a separate screen. The order of the *items* of each scale was randomized. However, the order of the scales themselves was the same for each child. Short introductory texts were included before the first item of each scale to clarify their meaning and to keep children engaged.

At the end of the T1 questionnaire, children were presented with a short video in which one of the researchers thanked them for participating and mentioned that she hoped they would also be willing to participate in T2. At the end of the T2 questionnaire, a debriefing video was presented to the children in which the same researcher explained the mechanical workings of the robot; some differences between humans and robots; the preprogrammed nature of the robot's behavior; and the experimental set-up, goals, and manipulation. The debriefing video was similar to videos we have used in earlier studies (e.g., van Straten et al., 2023; van Straten et al., 2022a) and children always easily understood the content of these videos.

3.4. Measures

The questionnaire consisted of closed-ended items that were answered on a five-point Likert scale running from "does not apply at all" to "applies completely". The questionnaire started with 4-item measures of perceived cognitive and affective perspective-taking (based on measures presented in Leite et al., 2014; Plank et al., 1996), followed by a 5-item measure of closeness (van Straten et al., 2020a); a 4-item measure of trust (adapted from Larzelere & Huston, 1980); a 4-item scale of perceived social support (based on Gordon-Hollingsworth et al., 2016; Leite et al., 2014); and measure of involvement that was based on the Interaction Involvement Scale (IIS; Cegala et al., 1982). We selected four items based on their applicability to the current study. As the IIS is a trait measure, we adapted the items to form a state measure. In addition, we ensured that all items had an identical item introduction (i.e., "While Nao was talking, I …). The questionnaire ended with a two-item treatment check (i.e., "In the video, Nao talked about children" and "In the video, Nao said 'you' to me"; the second item was reverse coded such that children in the impersonal conditions would be expected to score higher on both items).

The answer scale and all measures except the measure for involvement and the treatment check were successfully used in earlier studies similar to the present one, in which children in similar age ranges interacted with the same social robot that was used in the present study (e.g., van Straten et al., 2020; van Straten et al., 2022a,b). The measures of closeness and trust, in particular, were extensively validated among children in this age range (see van Straten et al., 2020a). This strengthened our confidence that children would be able to understand the questionnaire independently – which was important given the online, unsupervised nature of the current experiment. Table 1 provides an overview of the psychometric properties of all measures at T1 and T2, which corroborate this expectation. In all factor analyses, we used principal axis factoring and direct oblimin rotation.

3.5. Analytical approach

We analyzed the data using SPSS Statistics (v. 28). The data can be considered to follow a normal distribution if skewness and kurtosis range between −2 and 2 (George & Mallery, 2010). The assumptions of normality and homoskedasticity were met for all variables. The treatment checks were performed by conducting two univariate ANOVAs with either address form in T1 or address form in T2 as the between-subject factor, and the index variable of the treatment check administered at the same timepoint as the outcome variable. In the treatment check for T2, we controlled for the condition children were exposed to in T1.

As H1 addresses the effect of a robot's *consistent* use of either personal or impersonal address forms on children's responses to the robot, we tested this hypothesis on a subsample of the data containing only the data of children who were addressed by the robot in the same way over encounters (i.e., either personally or impersonally at both timepoints). The hypothesis was tested with a series of univariate ANOVAs with address form in T2 as the between-subjects factor and closeness, trust, perceived social support, perceived cognitive and affective perspective-taking, and involvement (as measured in T2) as the dependent variables.

To test H2, we conducted a series of repeated-measures ANOVAs on the entire sample, with address form in T1 and address form in T2 as between-subject factors, time as the within-subject factor, and closeness, trust, perceived social support, perceived cognitive and affective perspective-taking, and involvement (as measured at T1 as well as T2) as dependent variables. Box's tests were non-significant for each of the models, indicating equality of covariances.

4. Results

4.1. Treatment checks

In T1, children in the impersonal condition ($M = 3.41$, $SD = 0.77$) indicated more often that the robot had talked about "children" and less often that the robot had said "you" than children in the personal condition ($M = 2.62$, $SD = 0.71$), $F(1, 280) = 80.853$, $p < 0.001$, part. $\eta^2 = 0.22$. The same pattern occurred for T2 (impersonal condition: $M = 3.69$, $SD = 0.75$; personal condition: $M = 2.48$, $SD = 0.76$; $F(1, 279) = 179.226$, $p < 0.001$, part. $\eta^2 = 0.39$). The treatment checks were thus successful at both measurement points.

4.2. Tests of hypotheses

H1 stated that a social robot's consistent use of personal, as opposed to impersonal, address forms would lead to more closeness, trust, and perceived social support, as well as greater involvement and higher ratings of the robot's cognitive and affective perspective-taking abilities. In contrast to our expectations, we found no effects of the robot's consistent use of personal versus impersonal address in T1 and T2 on closeness, $F(1, 153) = 0.234$, $p = 0.630$, part. $\eta^2 = 0.00$, trust, $F(1, 153) = 0.186$, $p = 0.667$, part. $\eta^2 = 0.00$, perceived social support, $F(1, 153) = 2.378$, $p = 0.125$, part. $\eta^2 = 0.02$, involvement, $F(1, 153) = 0.425$, $p = 0.516$, part. $\eta^2 = 0.00$, perceived cognitive perspective-taking, $F(1, 153) = 0.160$, $p = 0.690$, part. $\eta^2 = 0.00$, or perceived affective perspective-taking, $F(1, 153) = 1.507$, $p = 0.221$, part. $\eta^2 = 0.01$. Therefore, H1 was rejected.

H2 stated that when the address forms used by robot change from impersonal to personal over time, this increases closeness, trust, and

Table 1
Psychometric properties.

	%VE		α*		*M; SD*		Skew.; Kurt.	
	T1	T2	T1	T2	T1	T2	T1	T2
PCPT	63	69	.80	.85	2.66; 0.81	2.60; 0.82	0.112; −0.559	0.031; −0.176
PAPT	73	77	.87	.90	2.57; 0.90	2.56; 0.87	0.100; −0.606	0.029; −0.440
Closeness	72	76	.90	.92	3.28; 0.85	3.26; 0.91	−0.214; −0.285	−0.248; −0.284
Trust	75	76	.88	.89	3.63; 0.80	3.54; 0.84	0.588; −0.544	−0.530; −0.448
PSS	70	79	.85	.91	3.30; 0.82	3.20; 0.93	−0.295; −0.065	−0.307; −0.155
Involvement	61	69	.84	.88	3.76; 0.73	3.76; 0.75	−0.051; −0.578	0.155; −0.078
TC	64	70	.44	.58	3.02; 0.84	3.10; 0.97	0.152; 0.420	0.027; −0.204

Note. PCPT = perceived cognitive perspective-taking; PAPT = perceived affective perspective-taking; PSS = perceived social support; TC = treatment check; VE = variance explained. *For the treatment check, instead of Cronbach's alpha, we report the Spearman-Brown co-efficient for two-item scales.

perceived social support, whereas a change from personal to impersonal address has the opposite effect. The same pattern was expected to occur for involvement and perceived cognitive and affective perspective-taking. Technically speaking, the hypothesized effect of address form at T2 not only depends on the address form in T1, but in its focus on the impact of the change inaddress forms, also on the within-subject time factor. Support for any of the sub-hypotheses would thus be found in a significant three-way interaction effect between address form in T1, address form in T2, and time on the outcome variables. No significant three-way interactions emerged for any of the outcome variables: closeness: $F(1, 278) = 0.023$, $p = 0.880$, part. $\eta^2 = 0.00$; trust: $F(1, 278) = 0.815$, $p = 0.367$, part. $\eta^2 = 0.00$; perceived social support: $F(1, 278) = 0.000$, $p = 0.993$, part. $\eta^2 = 0.00$; involvement: $F(1, 278) = 0.160$, $p = 0.689$, part. $\eta^2 = 0.00$; perceived cognitive perspective-taking: $F(1, 278) = 0.017$, $p = 0.896$, part. $\eta^2 = 0.00$; perceived affective perspective-taking: $F(1, 278) = 1.202$, $p = 0.274$, part. $\eta^2 = 0.00$. H2 was thus rejected.

5. Discussion

We investigated the effects of a social robot's use of personal versus impersonal address forms on children's perceptions of the robot and their relationship with it. Contrary to our predictions, we did not find significant influences of the robot's address forms on children's relationship with the robot in terms of their self-reported closeness toward, trust in, and perceived social support from the robot. Similarly, there were no effects of (changes in) address forms on children's involvement or perceptions of the robot's cognitive and affective perspective-taking abilities.

Due to Covid-19 related restrictions, our study relied on pre-recorded video stimuli of a robot. Children's average involvement scores for both timepoints suggest that they were paying attention to the videos, but we cannot preclude that social desirability effects influenced the outcomes of this measure. In any case, children could not interact with the robot but just watched it talking to them. This may, at least partially, explain why (changes in) the robot's use of (im)personal address forms did not have the expected effects. Given children's experience with recorded material, they may have concluded that the video was also shown to other participants. Therefore, children may not have interpreted the robot's personal address as personally directed to them. At the same time, the literature on mediated interpersonal communication shows that address forms can also affect people's responses to others when interaction is not possible, for instance in the context of television (Auter, 1992; Cohen et al., 2019). Moreover, related research has demonstrated that video stimuli of robots can be successfully used to assess children's responses to robots (see, e.g., Nijssen et al., 2021a,b).

A more convincing explanation for our unexpected findings may lie in the different expectations we have of social robots and traditional media. When we watch television, it may at times feel as if a television personality addresses us personally, leading to experiences of parasocial interaction (see, e.g., Cohen et al., 2019; Hartmann & Goldhoorn, 2011). Still, we do not actually believe this, nor do we expect to be able to interact with the television personality. In contrast, such expectations do exist when we encounter social robots, which are explicitly made for *interactions* with people (Breazeal et al., 2016). When we encounter a robot, we may thus expect that we will be able to interact with it – which marks an important difference between our study and studies on television viewing. An interaction, however, was not possible in our study and children may have inferred that the robot did not know more about them in the second encounter than in the first. As communicative behavior depends on the amount of knowledge interactants have about each other (Miller & Steinberg, 1975), and assuming that children conceived of the robot as an intended interactant, they may consequently not have responded to changes in the robot's use of (im)personal address forms over encounters as we expected.

Yet another alternative explanation for the unexpected findings may lie in our operationalization of (im)personal address. After all, the only difference between the conditions was the robot's use of second-person pronouns, which constitutes a rather subtle manipulation. However, the treatment check showed that children were aware of the manner in which the robot had addressed them during the experiment. Moreover, the manipulation of (im)personal address could not have been less subtle while also remaining precise: For instance, if the robot had also used children's names during the interaction, this would have resulted in a *personalized* rather than a *personal* communication style. In fact, disentangling the effects of a robot's pronominal address from the effects of a robot using participants' name constitutes one of the contributions of this study to existing research on the effects of address forms in HMC.

Despite the centrality of pronominal address to communication and relationship formation (Smolík & Chroma, 2022; Zhao, 2006), no studies had yet specifically studied how this communication feature influences children's interactions and relationship formation with robots. Our lack of findings may reflect a meaningful difference between communication with humans and machines, rather than an artifact of how the experiment was conducted: We may hold robots to different standards than our human interlocutors (see Fox & Gambino, 2021). More specifically, while we may expect robots to be more interactive than traditional media, we may not expect them to interact according to human standards (see also Dautenhahn, 2007).

Communication with machines may by default be seen as less 'personal' than interpersonal communication. Accordingly, we may accept that social robots' communication styles do not adhere to communication processes that govern conversations between humans. As pointed out by Fox and Gambino (2021), interpersonal theories may not always transfer to human-robot interaction (HRI) because robots typically do not fulfill the requirements of these theories. Instead of assuming that principles of interpersonal communication apply to HRI, it is crucial to empirically study how these principles manifest themselves in HRI and whether interpersonal theories may require adjustment to fit this new communication context (see also Guzman & Lewis, 2020; Krämer et al., 2011; Lombard & Xu, 2021; Westerman et al., 2020).

Children, in particular, may expect differences in how robots and humans communicate. According to children, robots can both have a mind and be built by humans (Bhamjee et al., 2010). Similarly, children see robots as potential friends despite their lack of animacy (Severson & Carlson, 2010). If robots do not need to be alive to be friends, then they also do not have to follow human communication principles to function as interaction partners. Generally, it is important to keep in mind that "children are not just small adults" (Belpaeme et al., 2013, p. 453) and that their reasoning about robots may deviate from that of adults (see also van Straten et al., 2022b). Moreover, interpersonal processes have been studied more extensively among adults than among children. As a result, we may run the risk of an adult-bias when generalizing the effects of interpersonal processes to children's responses to others, regardless of whether they are humans or machines. Research on CRI may therefore benefit from a more child-oriented perspective in which findings like the ones of this study may be less puzzling than in an adult-oriented perspective.

6. Limitations and implications for future research

The online set-up of our study with its indirect form of CRI may not have been an ideal setting for the testing of our hypotheses. Future work should therefore investigate the effects of robots' use of address forms in the context of real child-robot interactions before clear conclusions about their (lack of) effects on children's responses to robots can be drawn. If, however, such studies confirmed our findings, this may be some further evidence of a fundamental difference between human-human and human-machine communication, which, in turn, may have important implications for ethical discussions about child-robot relationship formation and responsible robotics more generally (see, e.g., Constantinescu et al., 2022). If children do not expect robots to address them personally and are not less likely to engage in social relationships with robots that interact with them in an impersonal, machinelike fashion, efforts to make CRI ever more humanlike may not be useful. By extension, our results imply that unintentional deception through robots' humanlike interaction style can be avoided by making robots communicate with children in a manner that more accurately reflects their machine nature.

Moreover, our study also suggests that a more machinelike style of communication does not necessarily harm child-robot relationship formation. As societal robot applications often seem to benefit from a certain degree of bonding between a child and robot (e.g., Kory Westlund et al., 2019b; Sinoo et al., 2018), this finding implies that avoiding deception by decreasing robots' human likeness does not necessarily come at the cost of social robots' potential to be used efficiently in practice.

Our findings do not imply that social robots' communication with children can, without consequence, be stripped from any form of personalization without decreasing children's engagement. However, we encourage scholars to reconsider which communication features are central to creating a satisfactory CRI application, and which may be omitted to allow for an interaction setting that minimally deceives children – whether intended or not.

Comparative research that assesses the effects of robots' use of different address forms in conversations with adults versus children may inform us about differences in children's and adults' responses to social robots' use of communicative processes. In studies with children, adding open questions to the questionnaire or having post-hoc conversations with participants may help to clarify the meaning of children's responses. As the current study was already quite resource-intensive, this was not feasible for us. Yet, such more qualitative approaches may contextualize quantitative findings and thus be a valuable addition to future work. Finally, it may be worth investigating whether a robot's complete avoidance of the pronouns "I" and "you" – and thus a particularly machinelike communication style – affects children's responses to it. This kind of future research may help us understand better whether the lack of effects of address forms on children's responses to social robots signals a fundamental difference between interactions with humans or machines.

7. Conclusion

In contrast to our expectations, personal address, and a change from impersonal to personal address over time, did not affect children's interaction involvement, nor their perception of the robot and their relationship to it. Our lack of findings may signal that robots may not always be held to the standards of interpersonal communication. However, future research should investigate the effects of address forms further in offline settings, preferably also comparing child and adult samples, before such conclusions can be drawn with confidence. More generally, we encourage scholars to further explore to what extent interpersonal communication principles hold in interactions with social robots, in order to elucidate the potentially fundamental differences between interpersonal and human-machine communication.

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Selection and participation

For this study, we collaborated with a survey company (DVJ Insights). DVJ contacted all parents of children in the right age range (i.e., 8–9 years old) who were part of their research participant database. We followed a two-step informed consent procedure. Parents were informed about the study goals and procedures and were subsequently asked for active parental consent. In case parents consented to the participation of their child, children themselves were asked for active consent. That is, the survey started with an information sheet in which we explained, in age-appropriate language, that participation was voluntary; that children could stop their participation at any point in time if they did not wish to continue; and that their data would be analyzed in anonymized form only. Parents were asked to provide further explanations about this information if their child did not understand it. As the study consisted of a repeated measures experiment, all children participated in the research at two timepoints. At the start of the second timepoint, we reiterated the information that was provided at the first timepoint and once more asked children for their active consent. At the end of the study, children were fully debriefed about the goals and procedure of the research; the workings of the robot; and some key differences between humans and robots.

CRediT authorship contribution statement

Caroline L. van Straten: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Jochen Peter:** Writing – review & editing, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Rinaldo Kühne:** Writing – review & editing, Methodology, Investigation, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare no competing interests to declare.

Data availability

Data will be made available on request.

Appendix A. English translations of video transcripts

T1 – Impersonal address

I'm a robot of the University of Amsterdam, and my name is NAO. Many children have seen a robot before, and some children even got a robot to play with themselves. I'm used by researchers from the university to study how children think about robots. The researchers find this very interesting! That's why a questionnaire will follow later. In school, children sometimes have to make tests. Then they should give the correct answer to as many questions as possible. In this questionnaire, that's different: the researchers just want to know what children think of robots, so there are no right or wrong answers. That's different than in school!

Most children like to go to school because in school they get to do all kinds of fun things like arts and crafts and gymnastics. Some children are very creative and like to make things themselves. Other children are very sporty and prefer playing a soccer game. And yet other children like both arts and crafts and soccer!

I'm a robot and there are many things that children can do that I cannot. But then again, I can do things that children cannot! For instance, children have the same eye color for their entire life, while my eyes can switch colors all the time. Let me demonstrate: [*eye colors*]. Something else that I can do while children cannot, is playing music through my ears. Children can only hear with their ears, yet my ears can also make sounds! For instance, I can play guitar music while I pretend to play the guitar myself. It goes like this: [*air guitar movements, with guitar sounds*].

Some children can actually play the guitar, and other children play another musical instrument. And yet other children can sing very well. There are many English songs, which children can perhaps not always fully understand. But if they often sing in English, children will automatically learn the language. And some children already learn English in school. Luckily, children only have to really start to learn different languages in high school, so they can now still play outside a lot.

Of course, robots don't go to school, nor on holiday. But I've got many different languages stored in my computer. That means I don't have to learn these languages like children do, because they are simply saved in my computer program. Perhaps the researchers can let me speak a different language once. Then they can investigate how well children can understand me. But for now, it's time for the questionnaire, which luckily will be in Dutch today!

T1 – Personal address

I'm a robot of the University of Amsterdam, and my name is NAO. Perhaps you have seen a robot before, and perhaps you've even got a robot to play with yourself. I'm used by researchers from the university to study how you think about robots. The researchers find this very interesting! That's why a questionnaire will follow later. In school, you sometimes have to make tests. Then you should give the correct answer to as many questions as possible. In this questionnaire, that's different: the researchers just want to know what you think of robots, so there are no right or wrong answers. That's different than in school!

You probably like to go to school because in school you get to do all kinds of fun things like arts and crafts and gymnastics. Perhaps you are very creative and like to make things yourself. Or perhaps you are very sporty and prefer playing a soccer game. And perhaps you like both arts and crafts and soccer!

I'm a robot and there are many things that you can do that I cannot. But then again, I can do things that you cannot! For instance, you have the same eye color for your entire life, while my eyes can switch colors all the time. Let me demonstrate: [*eye colors*]. Something else that I can do while you cannot, is playing music through my ears. You can only hear with your ears, yet my ears can also make sounds! For instance, I can play guitar music while I pretend to play the guitar myself. It goes like this: [*air guitar movements, with guitar sounds*].

Perhaps you can actually play the guitar, or perhaps you play another musical instrument. Or perhaps you can sing very well. There are many English songs, which you can perhaps not always fully understand. But if you often sing in English, you will automatically learn the language. And perhaps you already learn English in school. Luckily, you only have to really start to learn different languages in high school, so you can now still play outside a lot.

Of course, robots don't go to school, nor on holiday. But I've got many different languages stored in my computer. That means I don't have to learn these languages like you do, because they are simply saved in my computer program. Perhaps the researchers can let me speak a different language once. Then they can investigate how well you can understand me. But for now, it's time for the questionnaire, which luckily will be in Dutch today!

T2 – Impersonal address

The researchers would like to know a bit more about what children think of robots. Therefore, a second questionnaire will follow. But first I'm going to tell a story! I don't know whether children read a lot of books, but children who don't like to read probably watch a movie every now and then. And movies are, in fact, stories too! Children probably know many more stories than I do. Children may find some of them a bit childish, but there are also stories that are quite exiting. Like the following story:

[*tells Three Musketeers story; animated*]: "[*imitates trumpet player, with sound*] Long ago, a king was making a secret plan in his castle. He wanted to conquer an island! [*imitates king plotting; evil laughter*] But on the island lived a knight. He rushed to the castle on his horse! [*imitates horseback riding, with sounds*] They ended up in a sword fight [*imitates sword fight, with sounds*], until the knight won against the king. The island was safe, and the knight was applauded [*cheering movements and sounds*] as he headed back home and lived happily ever after [*imitates horseback riding, with sounds*]."

This story is stored in my computer. Children can make up stories themselves, but I can't. Robots can only do what is in their computer program, while children can actually do anything they can think of. Children can also remember lots of things – if they really try perhaps infinitely many things. But children may find some things boring, and if they think something is boring, children usually forget about it quickly.

The knight in the story lived on an island. Many children have also been to an island! Some children may have taken a plane to an island very far away, while other children may have gone by ferry to a Dutch island. Most children had swimming lessons, so they can enjoy swimming in the sea. But some children may prefer to build castles out of sand when they are at the beach.

I cannot swim in the sea like children, of course, because I am a robot. I actually can't do sports at all. Luckily, children break much less easily than I do, so they can do real sports. Because if children fall, they can hurt themselves, but if they get a bruise, it will disappear automatically. That's very fortunate, otherwise children would be all covered in bruises once they have grown up!

Children probably like swimming, reading, or watching tv better than answering questions, but for now it's time to fill in the researchers' questionnaire.

T2 – Personal address

The researchers would like to know a bit more about what you think of robots. Therefore, a second questionnaire will follow. But first I'm going to tell a story! I don't know whether you read a lot of books, but if you don't like to read, you probably watch a movie every now and then. And movies are, in fact, stories too! You probably know many more stories than I do. You may find some of them a bit childish, but there are also stories that are quite exiting. Like the following:

[*tells Three Musketeers story; animated*]: "[*imitates trumpet player, with sound*] Long ago, a king was making a secret plan in his castle. He wanted to conquer an island! [*imitates king plotting; evil laughter*] But on the island lived a knight. He rushed to the castle on his horse! [*imitates horseback riding, with sounds*] They ended up in a sword fight [*imitates sword fight, with sounds*], until the knight won against the king. The island was safe, and the knight was applauded [*cheering movements and sounds*] as he headed back home and lived happily ever after [*imitates horseback riding, with sounds*]."

This story is stored in my computer. You can make up stories yourself, but I can't. Robots can only do what is in their computer program, while you can actually do anything you can think of. You can also remember lots of things – if you really try perhaps infinitely many things. But you may find some things boring, and if you think something is boring, you usually forget about it quickly.

The knight in the story lived on an island. Perhaps you have also been to an island! You may have taken a plane to an island very far away, or you may have gone by ferry to a Dutch island. You probably had swimming lessons, so you can enjoy swimming in the sea. Or perhaps you prefer to build castles out of sand when you're at the beach.

I cannot swim in the sea like you, of course, because I am a robot. I actually can't do sports at all. Luckily, you break much less easily than I do, so you can do real sports. Because if you fall, you can hurt yourself, but if you get a bruise, it will disappear automatically. That's very fortunate, otherwise you would be all covered in bruises once you have grown up!

You probably like swimming, reading, or watching tv better than answering questions, but for now it's time to fill in the researchers' questionnaire.

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijcci.2024.100682.

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