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“No, I Won’t Do That.” Assertive Behavior of Robots and its Perception by Children

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Abstract

This paper contributes to the understanding of child-robot interaction through the investigation of child interactions with and anthropomorphization of humanoid robots when manipulating robot-related variables such as behavior and gender. In this study, children observe a robot demonstration in a classroom setting, during which the robot showcases either assertive or submissive behavior and is attributed a gender, either robot-female or robot-male. Afterwards, participant anthropomorphization is measured using the Attributed Mental States Questionnaire (AMS-Q). Results suggest that when prompted to select a response directed at the robot, children used significantly more commanding phrases when addressing the assertively behaving robot when compared to the submissively behaving robot. Further, younger children ages 7–9 anthropomorphize robots at a higher degree than older children 10–12 and assertive behavior from the robot lead to higher rates of anthropomorphization. Results also suggest that children are more likely to respond to female robots in an imperative way than male robots. This widened understanding of child perception of and interaction with humanoid robots can contribute to the design of acceptable robot interaction patterns in various settings.

Keywords Human–robot interaction · Child-robot interaction · Anthropomorphism · Assertive behavior · AMS-Q

1 Introduction

As the integration of social robotics into our daily lives continues to grow, it is increasingly important to understand the social and psychological impact that these technologies have on humans. The implementation of robots in fields such as therapy, work, and education raises questions about how humans perceive and interact with them. It’s especially important to explore this phenomenon in our youngest generations, who are raised and come of age with such technology [1].

Humanoid robots have already been used for education research and implemented into classrooms as helpful tools [2–10]. These applications require more complex patterns of interaction, including, for example, robot teaching strategies and conflict resolution tactics in various scenarios. In order to effectively develop and implement such tools across these various contexts, we must have a thorough understanding of how children think, feel, and behave in the presence of humanoid social robots. We wish to contribute to this understanding by exploring how children respond to assertive robot behaviors, as well as attributed robot gender, and how these factors impact their anthropomorphization of robots. Understanding the dynamics of child-robot interactions can be helpful in creating comfortable, beneficial interactions that help children with educational, cognitive, emotional, and social development [11–13].

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1.1 Child Robot Interaction

The field of child-robot interaction (CRI), which explores the relationships and engagements between children and robots, offers a unique exploration of human interaction with robots, because children’s limited experience and still developing cognitive abilities have a significant impact on shaping their perceptions, behaviors, and emotional responses in the presence of these technologies. This is especially evident when discussing the concept of anthropomorphism, defined as the attribution of human qualities, characteristics, and behaviors to nonhuman entities, a process that allows individuals to best make sense of and react to what they witness.

When humans interact with something non-human and unfamiliar, such as a robot, they tend to project their understanding of the familiar onto it—human mental states, behaviors, and characteristics [14]. This becomes particularly evident when the actions and behaviors of non-human entities resemble what we are accustomed to, as is the case with humanoid, social robots. The process of anthropomorphization involves inferring the mental processes underlying the observed behaviors. The Theory of Mind posits that humans possess an innate capacity to do this, to understand that others have minds and mental states separate from their own [15]. This capacity allows humans to attribute mental states to others, including thoughts and beliefs about the world, oneself, and others; having intentions and purposes in carrying out actions; experiencing emotions and feelings; possessing desires and motivations; and being perceptive and aware [16, 17]. The Theory of Mind extends to non-human entities as well: through anthropomorphization, we often attribute mental states to animals, as well as entities that walk the line between alive and inanimate, like humanoid robots [2].

Anthropomorphization is significantly impacted by the age of the human user, and thus children tend to anthropomorphize robots more than adults do [18, 19]. This tendency is particularly prominent among younger children due to their less developed cognitive capabilities [18, 20]**.** They have a limited understanding of the world and less experience to draw from. When considering this, and the fact that children often exhibit egocentric thinking that makes them prone to perceiving the world from their own perspective [21] it is easy to see why children are prone to projecting their own limited human experience onto non-human entities. When in one study, children aged 7–8 who were watching e-puck robots were asked a few questions ("What do you think the robots are doing?", "Why are they doing these things?" and "What is going on inside the robot?") it turned out that they have a strong tendency to attribute animate characteristics to robots [22] Further, in a study by Kahn et al. 15-year-olds were shown to conceptualize a robot named Robovie as a mental, social, and partly moral other to a lesser degree than the 9- and 12-year-olds [23].

Alongside age, child robot interaction is influenced by various other factors, including a child's individual characteristics such as their gender [2, 18, 24], cultural background [25], and technological experience [25–28], which all work to alter their internal representation of the robot [29] and their ability to attribute mental states to it. An individual's prior experiences with technology play a particularly large role in their interactions. The so-called novelty effect, well studied in the field of HRI, indicates that levels of anthropomorphization are generally higher during the initial interaction with a new robot, especially if the human user has limited prior experiences with robots [2, 14]. Children specifically have been proven to anthropomorphize more when they first interact with a robot, and when their technological experience levels are lower [20, 30].

Of course, such interactions also vary depending on the contextual setting in which the robot is being utilized. This is investigated by Kuchenbrandt et al. in their study, which explored how the social categorization of robots impacts their anthropomorphization. The results reveal that robots with "in-group" membership were anthropomorphized to a higher degree than those with "out-group" membership [31]. The use of linguistic framing is another prime example of this: using language to frame robots as if they were human, such as assigning them human names, backstories, and even genders, can influence our relationships with robots. [23, 32–37]

Robot-centered factors, such as its physical design and behaviors play a large role in human robot interaction as well, especially with children. A robot's physical embodiment [38, 39], movements, gestures [40–43] and language used [23] have all proven to influence the degree of robot anthropomorphization, as well as overall perception of and interactions with robots.

1.2 Robot Behaviors

Of particular importance is the impact of robot behaviors, unsurprising considering how crucial the role of social behaviors is in human interaction. The way we behave socially —through our speech, body language, gestures, facial expressions, and listening —enhances our ability to communicate, collaborate, build relationships, and resolve conflict [44–46]. Understanding the social norms tied to these behaviors, and displaying these appropriate social cues in different contexts, enhances social cohesion in human interactions [46].

Research suggests that this phenomenon can be transferred to the realm of human robot interactions. There is an expectation for both humans and robots to behave according to accepted social norms when interacting, a kind of human computer interaction etiquette explored by Miller and Frank in their studies [47]. This is largely related to the The Computers-Are-Social-Actors (CASA) paradigm, introduced by Reeves and Nass, which posits that people's interactions with technology are inherently social, like human–human interactions [48], as well as The Media Equation Theory, also developed by Reeves and Nass, which states that humans respond to technology as they do to humans, treating them as social actors [48]. Taking this into account, it is to be expected that the behaviors robots exhibit substantially influence how humans perceive and respond to them.

1.2.1 The Impact of Robot Behavior on Human Perceptions

For example, interacting with robots that display human-like behaviors can shape the impression humans form about them. Polite behavior in robots has proven to encourage user trust and compliance in a variety of settings [49–53], including healthcare [54, 55] and domestic environments [51, 56, 57]. Such behaviors and communications have also resulted in higher ratings of robot likeability and goodwill [57, 58], along with higher degrees of social acceptance or willingness of users to adopt various technologies [59–63]. On the other hand, making mistakes or cheating during interactions can also negatively impact trust, as shown in studies involving children conducted by Zguda [64], Geiskkovitch et al. [65], and Short et al. [66].

Robot behaviors also have the power to influence how humans attribute mental states towards robots. Acts of politeness, persuasion, or even disruption may indicate to human observers that a robot possesses more complex cognitive processes. This in turn can increase levels of robot social presence and anthropomorphization [14, 67]. For instance, scenarios in which robots behave in a way that is unexpected, such as not complying or disregarding social norms, have been linked to increased levels of anthropomorphization among human users [14, 68–70]. Short et al. found that cheating behavior from a robot during a game results in human participants perceiving the robot as having more intentionality [66].

1.2.2 The Impact of Robot Behavior on Human Reactions and Actions

Apart from influencing human perceptions of robots, robot behaviors have also been shown to impact human actions and reactions directed at them. As previously noted, the CASA paradigm highlights how humans almost unconsciously apply the same rules, norms, and expectations towards robots as they do in interpersonal interactions. This effect has been demonstrated when examining polite behaviors. There are various accepted models of politeness in human behaviors, including Brown and Levinson's Politeness theory, which posits that individuals utilize communication strategies to minimize potential threats to face, emphasizing the importance of politeness and face-saving in social interactions [71]. These notions have been observed in human robot interactions [72, 73].

This unconscious application of social rules towards non-human entities is frequently attributed to anthropomorphization, as well as, according to Elen Langer, mindlessness—a state in which humans excessively rely on familiar categories and distinctions. This leads to the automatic transfer of reactions and behaviors reserved for humans, to various tech entities, almost out of habit [74].

Robot behaviors can also impact human behaviors and decision making. Persuasive robots have successfully encouraged various human behaviors, as demonstrated in a study conducted by Ham et al., during which a robot used persuasive strategies as a store clerk to sell clothing [75], and in another study, where robots were used to influence energy-consumption behavior [76]. Polite robot behavior has proven to increase compliance, exemplified in Lee et al.'s study where a polite robot improved patients' adherence to healthcare guidelines [54]. Similarly, robots displaying polite behavior improved child learning outcomes during a Wang et al. study [77]. Machine behaviors have not only influenced reciprocal behaviors in humans [72] but have also been used to obtain sensitive information from them [78]. And educational robots, similar to human tutors, must be able to adapt behaviors in response to student's cognitive loads and engagement in order to be effective educational agents. This has a direct impact on their involvement and distractions, which impacts their learning. [79]

1.3 Assertive Behavior

Amidst this behavioral research, there has been little exploration of assertive behavior and its impact on human robot interaction, especially within children. Assertiveness is defined as communicating one's thoughts or beliefs in a direct, honest manner that is not hostile or coercive [80]. It is considered one of three known styles of interacting, also including submissive behaviors, characterized by lack of self-assertion and avoidance of conflict; and aggressive behaviors, characterized by self-serving behaviors with no regard for others' feelings [81]. In a world where robots engage in increasingly complex behavioral patterns with a variety of people, it's important to understand the dynamics of various human robot interactions, including assertive behaviors in robots.

There are several studies that showcase robot assertive behavior during human interactions. Babel et al. presented participants with a range of assertive robot conflict resolution strategies, then instructed them to assess the robot's behavior and express their likelihood of compliance. Results suggest that positive and neutral assertion strategies were more effective than negative ones, such as threats and commands, which sometimes lead to reactance and fear [56]. In a study by Thomas et al., a doorway negotiation task was designed involving a robot negotiating the right of way at a doorway. The findings indicate the behavior was successful in resolving the doorway deadlock between humans and robots [82]. This is similar in nature to a hallway navigation task study conducted by Warta in all, during which participants navigated through a hallway alongside a robot displaying various behaviors. The more human-like and assertive the behaviors, the more socially present the robot was perceived to be [67]. Studies have also explored how human perception of robots is influenced by their assertive behavior, though the results produced were mixed regarding trust and compliance [83–85].

To the best of the author's knowledge, there are few studies exploring the anthropomorphization of assertively behaving robots, and there has not been any comprehensive investigations into the extent to which commonly observed responses to assertion in human human interactions transfer to human robot interactions.

There is a range of recognized responses to assertion in human interactions, including respect and admiration, as well as compliance from the interaction partner, since clear, direct communication and self-assuredness can create the image of a capable individual deserving of respect and compliance [86, 87]. On the other hand, assertive behavior can sometimes be met with a degree of intimidation and resistance [88].

Perception of and responses to assertive behavior seems to be at least somewhat related to gender. Deluty et al. conducted an experiment where 4th–6th graders were asked to judge aggressive, assertive, and submissive behaviors. It was shown that boys regarded aggressive behaviors more favorably in comparison to assertive and submissive behaviors [81], which may be linked to the general association of masculinity with assertive behaviors [89]. In a study conducted by Eisler et al. exploring various assertive situations, it was found that males elicited different responses than females in all assertive situations, both negative and positive. For example, men were more assertive than women when asked to stand up for their rights, as well as when asked to offer praise and appreciation, likely due to sociocultural norms that make assertions towards women more permissible [90]. Men also use assertive speech more than women, who use more affiliative speech, according to a study by Leaper at et al. [89]. Through various structures present within our society, men and boys are more often encouraged and conditioned to be assertive, confident, and direct while expressing their opinions and desires, while women and girls tend to be taught to be more accommodating, nurturing, and thus, less assertive [91].

But ultimately, it seems a person's behavior in a particular situation is largely linked to the way they cognitively perceive the situation, which will vary highly based on their backgrounds and lived experiences [90]. It is unclear how much of what is understood about human assertiveness transfers to the field of HRI; a further exploration is needed.

We wish to widen the exploration of assertive behavior in human–robot interaction and how it impacts human interaction with and anthropomorphization of robots by extending this research to include children. Our study will explore how children anthropomorphize robots and respond (commanding vs. polite) to a robot's behavior (assertive v. submissive) in a classroom setting, in which the robot and instructor are giving a demonstration.

Due to what we understand about the role of gender norms in assertive behavior, as well as our broader understanding of the role of gender in human–robot interactions, we also wish to explore how the ascribed gender of the robot in such interactions will impact how the assertive behavior is perceived and responded to. Further, we wish to explore the relationship between these factors and anthropomorphization, to see if there are any patterns.

In order to explore these topics, we propose the following hypotheses:

H1 Stronger anthropomorphization of the humanoid robot will occur in children younger than older children.

Current literature supports the claim that younger children tend to anthropomorphize more than older children. We seek to confirm this in our study.

H2 Assertive behavior from the robot will increase children's perception of the robot's mental state and rights compared to submissive behavior.

Based on what we know about robot behavior impact on anthropomorphization, assertive behavior from the robot should increase the mental states attributed due to the more complex cognitive processes needed to express desires and intentions, such as a refusal. Further, disruptive behaviors, in which a robot refuses to comply, have been shown to increase anthropomorphization.

However, when it comes to child participants' responses to assertive behavior, we feel there is not sufficient literature concerning assertive behavior in children or assertive behavior with robots to draw any assumptions. We thus propose the following research question to explore whether children will respond to the robot in a more imperative or polite manner during the procedure:

RQ1: How will assertive and submissive behaviors on the part of the robot affect the type of response (polite, commanding) children choose to refer to the robot with?

Furthermore, because our interactions with robots play a fundamental role in shaping our degree of anthropomorphism, we are interested in what the child's response indicates about their degree of anthropomorphism toward the robot. Again, because the literature on this topic is insufficient, we raise the following question:

RQ2: What is the relationship between the way children choose to refer to the robot (commanding vs. polite) and the degree to which they anthropomorphize the robot?

When considering the role of gender in HRI, we have reason to believe that existing gender norms are likely to influence the perception of a robot's assertive behavior. While certain behavioral patterns associated with gender and assertion have been acknowledged, we hesitate to formulate a hypothesis based on these findings due to their antiquity, which raises concerns about their current relevance and accuracy in reflecting contemporary perspectives. The perception and impact of assertive behavior also appears to be heavily influenced by context. Thus, we formulated the following research question:

RQ3: What is the relationship between the gender attributed to the robot and the way children choose to refer to the robot (commanding vs. polite)?

The findings of this study indicated that children tend to use significantly more commanding phrases during interactions with an assertive robot. Moreover, it appears children anthropomorphize robots to a higher degree when they themselves are younger, and the robot behaves assertively. These findings contribute to our comprehension of how established notions of assertive conduct translate into Human–Robot Interaction (HRI) and can assist in the development of robots that adhere to human social norms and contribute to harmonious social interactions with people.

2 Methods and Materials

2.1 Participants

Studies in the field of Child-Robot Interaction can involve a wide range of age groups, from very young children to adolescents. In our study, we focus on grade school children between the ages of 8 and 12, which are typically described as being pre-adolescent, indicating a period of development before the teenage years.

There were 191 participants between 8 and 12 years old recruited for this study, including 99 girls, 92 males, and 4 participants who identified otherwise or were not willing to provide their gender identity. After cleaning the data, 185 participants had valid data: 95 girls, 86 boys, and 4 participants that identified otherwise. Participants were students from various Warsaw elementary schools enrolled in free workshops at the Central House of Technology (Centralny Dom Technologii—CDT) in Warsaw, Poland. An invitation to participate in the study along with a consent form were sent out to the parents and guardians of potential participants. This consent form described the study and its objectives, and requested that parents not share the goal of the study to their children. All participants were required to have the informed consent of their parents or guardians before the study. This recruitment process was aided by our project partner, CDT.

2.2 Experimental Design

A 2 (person-sex: female, male) × 2 (robot-sex: robot-female, robot-male) × 2 (robot-behavior: assertive, non-assertive) between-participants study was conducted in which, after a quick robot demonstration, child participants were asked to choose from a variety of possible responses to the robot and then fill out the Attribution of Mental States (AMS) Questionnaire. The robot's demonstration was either assertive, in which it rejected the researcher's request to mimic a cat, and instead mimicked a dog, or non-assertive, in which it complied and demonstrated a cat.

2.3 Materials

2.3.1 Pepper the Robot

The robot used in this study was Pepper from Aldebaran Robotics. that is owned by SWPS university. This is a humanoid robot standing 1.20 m tall, with a 10.1 inch tablet embedded on its chest. The robot was programmed by our research team using QiSDK and Android Studio. The application was deployed on the robot and remotely controlled by the experimenter.

2.3.2 Android Application

An Android application developed by our research team was used to collect survey data from the participants during the study. This application was tested on children 8–12 during a pilot study and presented no problems in accessibility. The application first collected demographic information, asking each participant for their age and gender. Then, the application prompted them to choose from a variety of messages directed toward the robot, half of them in the form of a polite request, and the other half in the form of a command ("Can you show…." / "Show…"/ "Please show…"/ "You must show…."). After they selected the message, on the next screen the participants were prompted to select the photo of the animal they wished to see the robot mimic (dog, lion, gorilla, elephant), thus completing the message (see Fig. 5 in Appendix). The application then displayed the 25 AMS yes-or-no survey questions, one by one, in a randomized order (see Figs. 6 and 7 in Appendix).

The full application sequence is illustrated in Fig. 1.

The data collecting application was uploaded onto Samsung Galaxy Tab Active 2 tablets, property of CDT, which were then used to collect data from each child. The data on the tablets was anonymized, downloaded on the experimenter's computer, and then later deleted from each tablet.

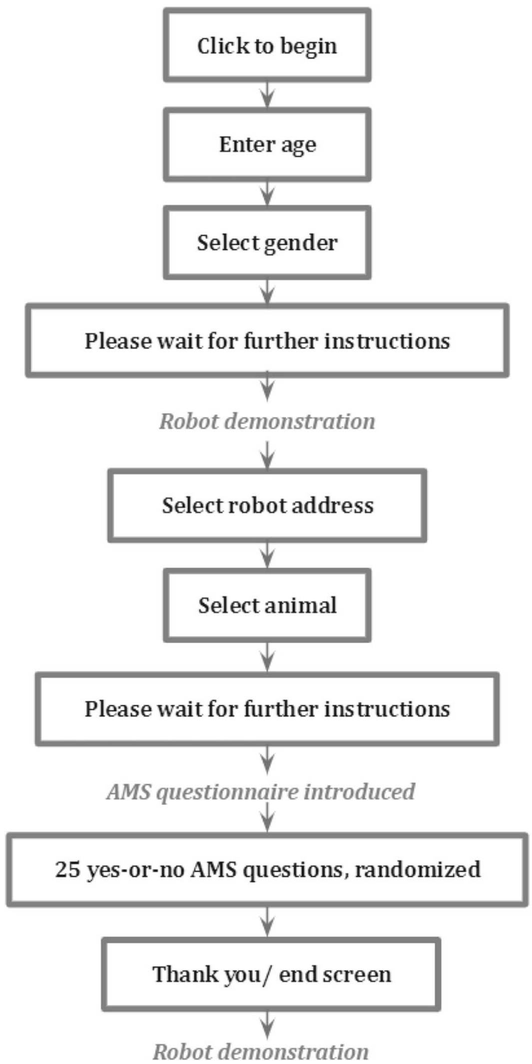

Fig. 1 Flowchart illustrating the sequence of screens within application

2.3.3 The AMS Questionnaire

The AMS questionnaire that each participant was asked to fill out works to measure the mental states that participants attribute to the humanoid robot. It was developed to assess the level of mental anthropomorphization of nonhuman agents. The questions fall into five categories: Perceptive, which involves attributing senses such as seeing, hearing, smelling, tasting, and touching; Emotive, which involves attributing emotions and feelings; Desires and Intentions, which involves attributing desires, wants, and intentions; Imaginative, which involves attributing the ability to imagine, lie, and dream; and Epistemic, which involves attributing beliefs, knowledge, and awareness to others.each allowing for an analysis of different psychological processes. Originally inspired an Martini et al. study on how increasing the human-like appearance of non-human agents impacts the mental states attributed to them [92], this questionnaire was developed and tested by Miraglia et al. [93] and has been used in several child robot interaction studies [39, 94]. The reliability of the AMS questionnaire in the presented study is $\alpha = 0.85$, which should be considered a very good result.

This is one of two popular questionnaires used to measure user perception of robots, the other being the Godspeed questionnaire [95]. This alternative survey employs 5-point scales to assess various aspects of a user's perception, including anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety. We decided to move forward with the AMS questionnaire because we felt it was better suited for young children. The yes-or-no format offered an easier navigation for children using the application compared to the complexity of a 5-point scale system.

2.4 Procedure

A preliminary test of the experiment was conducted before commencing data collection in order to validate our procedure. Every aspect of the procedure was tested in the target environment with target participants to ensure children understood instructions, were able to use the application effectively, and everything worked properly. After the pilot, all necessary adjustments were made to the software, experimental setup, and procedure timing to ensure this was the case.

The experiments took place at the CDT, 15 min before the educational workshops participants were scheduled to attend. They were carried out in the classroom where the workshop was to be held. Notably, the researcher interacting with the child participants has experience working with children, positioning them effectively to lead studies involving this demographic. The set up of the room was as follows: Pepper was positioned at the front of the room, with the first researcher standing beside it. The second researcher sat in the back of the classroom, out of sight, in order to remotely control the robot. Chairs were set up in front of the robot for the children, and tablets used for data collection were passed out and placed in front of each seat before the children entered the room.

When children arrived at CDT on the day of their workshops, those with signed consent forms were introduced to the research team and escorted into the classroom where Pepper stood, turned on. Children were instructed to sit down in front of a tablet and to wait for further instructions.

Once children were seated and settled, the researcher standing next to Pepper introduced the robot to them, using either the female name "*Ada*" or the male name "*Adam*". Pepper then greeted the children and again, introduced itself using the appropriately gendered name.

The researcher then requested that the robot showcase its abilities by mimicking a cat. In the submissive condition, the robot agrees and proceeds to demonstrate the cat (*Okay, I will show a cat*). In the assertive condition, the robot refuses, and instead offers to mimic a dog (*No, I won't show a cat! But I can show a dog).* In both conditions, the participants have the opportunity to see the robot's abilities. During both the cat and dog imitations, the robot combines similar body movements with animal sound bites to mimic the animal in a brief and friendly manner. This introduction and demonstration took no more than 5 min.

After this demonstration, the children were asked to decide how they would like to communicate with the robot using the tablet. Upon entering their age and gender, they were prompted to select from a list of various cues instructing the robot to demonstrate another animal. They chose one out of five potential prompts and one out of four potential animal demonstrations. The list of prompts included two in the form of polite requests and two in the form of commands (see Fig. 5 in Appendix). This process took no more than a few minutes.

After this, the children were instructed by the experimenter to fill out the AMS questionnaire displayed on their tablets. It was emphasized that the questionnaire was not a test, and that there were no incorrect answers. Additionally, they were directed to complete the survey in silence and not discuss the questions with one another. On average, this step took approximately 10 min.

Once the children finished filling out the questionnaire, the study concluded. The children then observed the final robot demonstration, and the researchers provided more detailed information on the robot and the research study. This phase of the procedure took no more than 5 min, bringing the total experiment time to around 15 to 20 min.

3 Results

In order to answer the research questions, statistical analyses were carried out using the IBM SPSS Statistics 26 package. This software was employed to analyze basic descriptive statistics in addition to performing the Shapiro–Wilk test, the Mann–Whitney test, the chi-square test of independence in and the Student's t test for independent samples. The level of significance in this chapter was considered to be $\alpha = 0.05$.

In the first step of the analysis, the distributions of quantitative variables were checked. For this purpose, basic descriptive statistics were calculated together with the Shapiro–Wilk test examining the normality of distribution.

The result for all introduced variables were found to be statistically significant (at $p < 0.001$), indicating that their distributions significantly deviate from the normal distribution. Nevertheless, it's important to highlight that the skewness of the distribution of these variables does not exceed the absolute value of 2, which means that their distributions are slightly asymmetric. Therefore, it is reasonable to conduct an analysis based on parametric tests, provided that their other assumptions are met.

3.1 The Relationship Between the Age of Participants and the Extent to Which they Anthropomorphize the Robot

In the next stage of the analysis, H1 was tested, which posited that younger children would anthropomorphize the humanoid robot Pepper more significantly than older children. For this purpose, the Mann–Whitney test was employed to compare the indicated groups in terms of both the overall degree of anthropomorphization and in its individual dimensions. The results of the analysis are presented in Fig. 2.

The analysis revealed statistically significant differences between the compared groups concerning the degree of anthropomorphization in general and within the perceptive, emotive, and imaginative dimensions. Younger children assessed the anthropomorphization of the robot in the indicated areas significantly higher than their older counterparts (M = 18.05, SD = 4.36 vs M = 15.61, SD = 5.37). The difference was statistically significant, $z = -2.92$; $p < 0.005$, with a small effect size, $\eta^2 = 0.05$.

The results showed significant differences between younger and older children in terms of the perceptive dimension (M = 2.96, SD = 1.22 vs. M = 2.39, SD = 1.26, $z = -2.61$; p = 0.009; $\eta^2 = 0.04$), emotive (M = 4.10, SD = 1.13 vs. M = 3.17, SD = 1.77;, $z = -3.45$; $p < 0.001$; $\eta^2 = 0.07$) and imaginative (M = 3.27, SD = 1.22 vs. M = 2.92, SD = 1.03;, $z = -2.08$; $p = 0.038$; $\eta^2 = 0.02$). Thus only the effect observed for anthropomorphization in the emotive dimension turned out to be moderately strong.

In the case of the intentions and desires, as well as the epistemic dimension, no statistically significant distinctions were observed. This suggests that, regardless of age, the examined children assessed the anthropomorphization of the robot in the indicated areas to a similar extent.

3.2 The Relationship Between the Robot's Behavior and the Degree of its Anthropomorphization

Subsequently, H2 was tested, assuming that assertive behavior on the part of the robot will increase children's belief that robots have mental states and rights when compared to the behavior of a more submissive robot. To investigate this, the Student's t test for independent samples was used to compare robot behaviors (assertive vs. submissive) based on the degree of anthropomorphization following the experiment. In the case of calculations for general anthropomorphization, as well as anthropomorphization in the Perceptive and Imaginative dimensions, the results were reported with Welch's

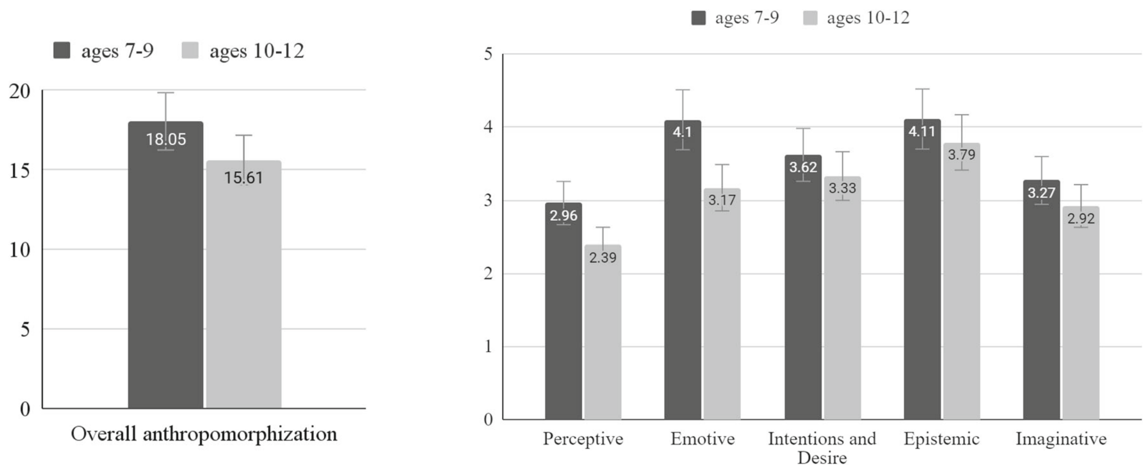

Fig. 2 Relationship between age of child participants and their degree of anthropomorphization

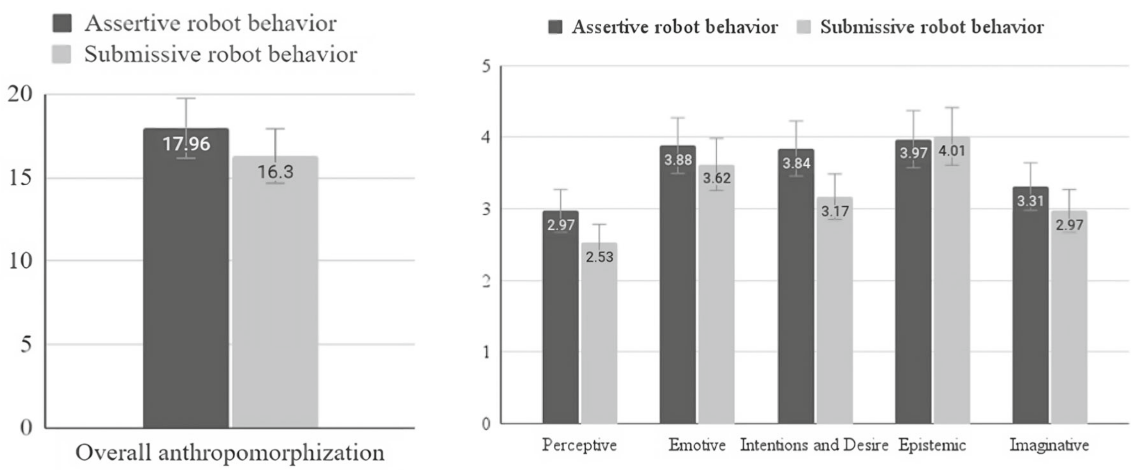

Fig. 3 The relationship between the robot's behavior and the degree of its anthropomorphization

correction due to the fact that the result of Leven's test turned out to be significant.

The results of the analysis are presented in Fig. 3.

The analysis showed statistically significant differences between the test conditions. In general, in the assertive robot variant, children anthropomorphized it more strongly than in the submissive robot variant (M = 17.96, SD = 5.37 vs M = 16.30, SD = 4.19). A t-test revealed a significant difference between the two conditions, t(169.20) = 2.30; p = 0.023, with a medium effect size, Cohen's d = 0.34.

The analysis of individual dimensions, however, revealed that the difference concerns only the perceptive dimension (M = 2.97, SD = 1.39 vs. M = 2.53, SD = 1.08)—t(168.64) = 2.35; p = 0.020; Cohen's d = 0.35; Intentions and Desire (M = 3.84, SD = 1.29 vs. M = 3.17, SD = 1.25)—t(176) = 3.47; $p < 0.001$, Cohen's d = 0.52, and Imaginative (M = 3.31, SD = 1.23 vs. M = 2.97, SD = 1.06)—t(174.30) = 1.99; p = 0.048, Cohen's d = 0.30). However, only in the case of Intentions and Desire we can talk about a large effect (d > 0,50).

In the case of the emotive and epistemic dimensions, no statistically significant differences were observed. This implies that regardless of the robot's behavior, the examined children assessed its anthropomorphization in the indicated areas to a similar extent.

3.3 Relationship Between the Behavior of the Robot and the Response Type From the Child Participant

RQ1 was then examined, exploring the relationship between assertive behavior on the part of the robot and the selection of responses by children directed at the robot in the next task. For this purpose, the chi-square test of independence was utilized to compare two types of robot behavior (assertive vs.

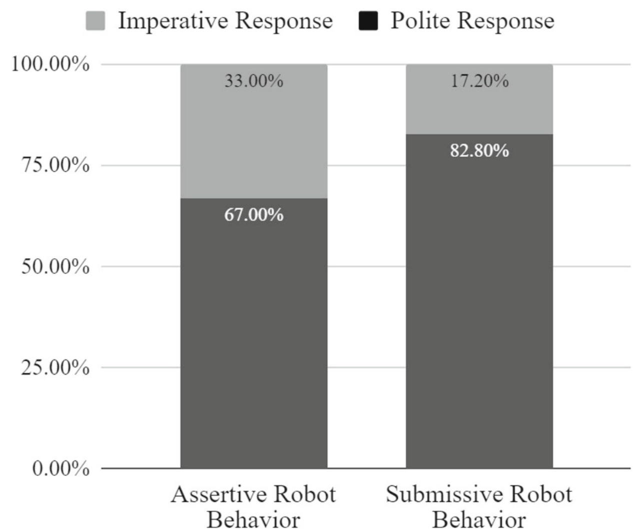

Fig. 4 Child Response Type to Robot Behavior Types

submissive) in relation to the frequency of individual reactions to this behavior (polite vs. commanding). The results of the analysis are presented in Fig. 4.

When comparing the impact of the robot's behavior (assertive vs submissive) on children's message choices, statistically significant differences were observed. While polite messages dominated in both experimental conditions, when the robot displayed assertive behavior, (compared to submissive behavior), the use of imperative form directed towards the robot was significantly increased (33% vs 17.2%)–$\chi^2(1) = 5.82$, $p = 0.024$. However, the strength of this effect was not large, $\phi = 0.18$.

3.4 The Relationship Between the Response Type From the Child Participant and the Degree of Anthropomorphization of the Robot

Then, in regards to RQ2, it was examined whether the frequency of using particular types of phrases (polite vs commanding) influenced the level of anthropomorphization of the robot (lower vs higher). To address this, the chi-square test of independence was used to compare children who anthropomorphized the robot to a lower degree with those who anthropomorphized to a higher degree, in terms of the frequency of using particular types of phrases. The results of the analysis are presented in Table 1.

The analysis showed a statistically significant difference between children assessing the anthropomorphization of the robot at a lower level and children assessing the anthropomorphization of the robot at a higher level in terms of the frequency of using particular types of response messages. It turned out that children who rated the degree of anthropomorphization of the robot lower, used commanding phrases significantly more often than children who rated the degree of anthropomorphization of the robot higher. Thus, children who rated the degree of robot anthropomorphization higher significantly more often used requesting phrases, compared to children who rated the degree of robot anthropomorphization lower. However, it should be noted that the observed effect turned out to be weak ($\phi < 0.30$).

3.5 The Relationship Between the Gender of the Robot and the Type of Phrase Used

In the next stage of the analysis, RQ3 was tested, exploring whether the responses towards the robot are influenced by framing the robot's gender as female or male.For this purpose, the chi-square test of independence was employed to compare a robot framed as female with one framed as male, in terms of the frequency of response phrases used by children (polite vs. commanding) The results of the analysis are presented in Table 2.

The analysis unveiled a statistically significant distinction between a male robot and a female robot with regards to the frequency of response phrases used**.** It turned out that when the robot was characterized as female, children employed commanding phrases significantly more frequently than when the robot was framed as male. Conversely, when the robot was portrayed as a male, the children selected polite phrases more than when the robot was female. However, it should be noted that the observed effect turned out to be weak ($\phi < 0.30$).

It is also worth mentioning that the relationship between the type of phrase used by the children and their ages was also explored. However, no differences were noted. 75% of children choose the polite message instead of the imperative one, regardless of age.

4 Discussion

Our study results contribute to the understanding of robot behavior in child robot interactions by examining the effects of assertive behavior and gender on interaction type and anthropomorphization during child interactions with robots.

In line with our first hypothesis (H1), we found that younger children (7–9) anthropomorphized the robot at a higher degree overall than older children (10–12). This aligns with the current literature on the topic, specifically the Theory of Mind, which suggests that younger childrens' less developed cognitive skills and limited experience make them more likely to project human-like features onto robots. The data obtained is consistent with the results of previous studies revealing the tendency of children to think magically and create a world of various illusions [96]. This phenomenon extends to their perceptions of robots as well [97], which are

Table 1 Comparison of the frequency of using individual phrases among children, differentiated by the degree of anthropomorphization of the robot

	Lower degree of anthropomorphization		Higher degree of anthropomorphization		$\chi^2(1)$	*p*	ϕ
	N	%	*N*	%			
Child response to the robot's behavior							
Polite response	59	67.0	74	82.2	5.43	**0.025**	0,17
Commanding response	29	33.0	16	17.8			

Key. *N*—number of participants; χ^2—chi square test result; *p*—statistical significance; ϕ—effect strength indicator

Table 2 Comparison of robot gender in terms of the frequency of response phrases used by children

	Robot -female ("Ada")		Robot-male ("Adam")		$\chi^2(1)$	*p*	ϕ
	N	%	*N*	%			
Child response to the robot's behavior							
Requesting phrase	56	65.1	77	83.7	8.12	0.006	0,21
Commanding phrase	30	34.9	15	16.3			

Key. *N*—number of participants; χ^2—chi square test result; *p*—statistical significance; ϕ—effect strength indicator

often seen as causative entities that have their own subjectivity and mental worlds [98, 99] Such animistic tendencies can be observed even among adults [100].

Interestingly, regardless of age, there was a similarity in mental state attribution concerning the Desires and Intentions and Epistemic categories: children of both age groups anthropomorphized relatively high in these categories. This trend is potentially due to the complexity of these AMS-Q categories. An older child's mental model of robots may be advanced enough to recognize a robot cannot smell, hear, or be happy (mental states from the Perceptive and Emotive categories), but not mature enough to answer questions regarding a robot's willingness to act or capacity to learn (mental states from the Intentions and Desires as well as the Epistemic categories).

When considering H2, our results suggest that assertive behavior from the robot did in fact increase children's perception of a robot's mental state when compared to submissive robot behavior. This is consistent with the present-day literature pertaining to the subject. Lemaignan et al. explore this concept and found any unexpected, disruptive behaviors affect how much rationality a user ascribes to the robot and results in local increases of anthropomorphic effects. [69] Found that a robot whose behavior was characterized by low predictability demonstrated increases in anthropomorphic inferences among users.Unpredictable actions from a robot that are incompatible with our expectations for robot behavior may indicate more complex cognitive processes, which in turn, increase its perceived mental states and participant anthropomorphization of the robot.

An assertive refusal like this, paired with a proposed alternative also contributes to a longer and more intricate interaction. Being able to invent a substitute demonstration could also portray greater, more human-like, cognitive abilities. Therefore, this issue requires resolution in further research.

When exploring our first research question (RQ1), our results indicate that assertive behavior from the robot leads to children using significantly more imperative phrases than when the robot showed more compliant, submissive behavior in the demonstration. On the other hand, submissive behavior encouraged more polite phrases from children.

There are several possible reasons for this trend. Many researchers have put a larger emphasis on the role of a child's parents and peers in determining their behavior patterns. Studies by Bandura et al., for example, showcase how aggressive and submissive behaviors in children are largely attributed to a child's copying or modeling of adult and peer social agents [101–103]. Further, Sears et al. and McCord et al. all highlight the critical role of parental reinforcement in shaping children's behavior [104, 105]. It is possible that assertive behavior from the robot encouraged children to choose a more assertive, commanding response, mimicking the behavior witnessed from the robot.

Additionally, aligning with the CASA paradigm, children may be behaving in a way that is consistent with social norms observed in human human interactions. For example, it's possible that children are interpreting assertive behavior as a rejection, compelling them to respond imperatively with increased assertiveness in order to see their desired outcomes. On the other hand, when the robot has already demonstrated compliance, the children may not feel a need for a more commanding approach, as a polite request yielded compliant behavior during the demonstration.

It's important to note that in both the assertive and submissive robot behavioral conditions, polite responses from the children dominated. This outcome also aligns with what is understood about the Politeness Theory and CASA paradigm. A general trend of politeness coincides with the idea that humans typically adhere to polite social norms in order to avoid uncomfortable situations and achieve desired outcomes. This line of thinking may extend to our interactions with robots.

It already seems to extend to voice assistants, as shown in a study by Schneider and Hagmann, which observed the CASA paradigm in action during coaching sessions, where assistance from a voice assistant during a coaching session resulted in increased reciprocal behavior towards the assistant by participants [73]. Further, in their studies, Nass and Moon demonstrated that people mindlessly apply social rules, including politeness, to technological devices [74].

In regards to RQ2, it seems there is a relationship between the degree of anthropomorphism and the manner in which children choose to refer to the robot. Results show that children who anthropomorphized to a lower degree used more commanding phrases with the robot, while children who anthropomorphized to a higher degree seemed to use polite phrases more commonly. This suggests that children who attribute mental states to the robot, and see it as more human-like, may be more conscious of the robot's emotions when making the request, therefore choosing a more polite request instead of a more commanding one. Again, this result is also in accordance with the principles established by the Politeness Theory and the CASA paradigm.

Finally, we consider our last research question (RQ3) which aimed to explore how the type of message selected by child participants, directed at the robot, would be influenced by attributed robot gender. The results suggest that introducing the robot as female led to the children selecting more imperative phrases than when the robot was introduced as male.

It is difficult to make broad assumptions on why this is. It may be related to structures surrounding gender in Western society: for example, women, who are traditionally more compliant and nurturing, may be an easier target for more assertive, imperative approaches for children, in contrast to men, who may be seen as more intimidating [106]. This pattern may also be related to participant family backgrounds. The Family Communication Patterns theory suggests that the family system is the primary socialization agent for children, influencing how they perceive their social environment and communicate within it [107, 108]. Perhaps, therefore, the choice of the form of communication with robots of different genders by children reflects the pattern of communication that prevails in the children's home environment. If women within their families are referred to in a commanding nature, children may mimic this observed behavior in external environments [109]. This issue certainly requires further research.

4.1 Significance

This exploration of robot behavior has provided insight on how our established ideas of assertive behavior in human interaction transfer into the world of HRI, including important information about responses and communication patterns that emerge during these interactions, especially when it comes to child robot interactions.

Our work contributes to the discussion on the adaptability of social robots, which, according to many researchers, should understand user behavior, respond to it appropriately [110] and model correct, prosocial behavior patterns [111]. Children, who are still in the process of cognitive development, can be substantially influenced by robot behaviors. It's therefore crucial that robots display appropriate social cues and behaviors in different contexts in order to ensure comfort, efficiency, and engagement in their interactions with them. Perhaps intelligent machines (robots or digital assistants) should even note when children refer to them in too direct or aggressive of a tone, as research suggests there is a transfer of patterns of behavior acquired by children to people [112]. Allowing such behavior to go unchecked might promote similar impolite behavior within their interpersonal communication.

As discussed, a common viewpoint among researchers is that robots ought to be programmed to adhere to fundamental social norms, such as exhibiting kindness during human interactions. This approach underscores the pivotal role of robots in not only fulfilling specific tasks but also contributing positively to human experiences, fostering smoother and more harmonious interactions between technology and people.

4.2 Limitations and Future Work

There are several limitations to our study, and many avenues for refining the exploration of assertive robot behavior in future studies.

Firstly, our investigation was centered around the humanoid robot Pepper, and it is difficult to make wider inferences regarding robots with varying physical forms from our findings. Future investigations could explore the reproducibility of these findings using a variety of robot types and sizes, including both humanoid and non-humanoid designs.

Other factors that could potentially offer more comprehensive insights include exploring spontaneous reactions to robots as opposed to predetermined text-based responses, which could also provide a richer understanding of children's authentic interactions with assertive robots in future studies. Additionally, our study was conducted at the Centralny Dom Technologii, a technology education center in Warsaw. Future research should be expanded to various environments, such as public spaces like shopping malls, in order to test the interactions in a variety of contexts. Yet another variation includes investigating children's perceptions when a robot does not comply with their individual requests, in an individual scenario, in contrast to the researcher's requests demonstrated to the entire group.

Another interesting avenue for future exploration involves the effect of researcher-related factors on CRI. The interaction pattern between our researcher and robot may significantly influence children's future interactions with and perceptions of the robot. The researcher could partake in several styles of interaction with the robot, such as assertive and polite behaviors. Additionally, given our results indicate children selected more imperative phrases with the robot introduced as female compared to male, investigating the role of researcher gender could offer deeper insights on how children's interactions with robots are influenced by the gender dynamics and communication styles they observe in their social environments."

Related to this, another extension of this research could be an exploration of children's mimicking of assertive behaviors. Do the robot's assertive behaviors with humans have an impact on the child's communication in similar, future contexts? An exploration of how family communication patterns influence children's imitation of assertive behaviors should also be explored.

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Data Availability The data presented in this study are openly available in FigShare at https://doi.org/10.6084/m9.figshare.24031839.

Declarations

Conflict of Interest The author declares that they have no conflict of interest.

Ethical Approval This study was approved by the Research Ethics Committee of the Faculty of Psychology in Warsaw of SWPS University (protocol code 15/2022 and date of approval 08.03.2022).

Informed Consent Written informed consent was obtained from the parents of all subjects involved in the study.

Appendix

Figures 5, 6 and 7.

Fig. 5 Survey Questions

	AMS-Q	AMS-Q-PL
Perceptive	*Do you think she/he/it can smell?*	*Czy myślisz, że ten robot potrafi wąchać?*
	Do you think she/he/it can see?	*Czy myślisz, że ten robot widzi?*
	Do you think she/he/it can taste?	*Czy myślisz, że ten robot może czuć smak?*
	Do you think she/he/it can hear?	*Czy myślisz, że ten robot słyszy?*
	Do you think she/he/it can feel hot or cold?	*Czy myślisz, że ten robot może odczuwać ciepło lub zimno?*
Emotive	*Do you think she/he/it can get angry?*	*Czy myślisz, że ten robot może się złościć?*
	Do you think she/he/it can be scared?	*Czy myślisz, że ten robot może się bać?*
	Do you think she/he/it can be happy?	*Czy myślisz, że ten robot może być szczęśliwy?*
	Do you think she/he/it can be surprised?	*Czy myślisz, że ten robot może być zaskoczony?*
	Do you think she/he/it can be sad?	*Czy myślisz, że ten robot może być smutny?*
Intentions and Desire	*Do you think she/he/it may have the intention to do something?*	*Czy myślisz, że ten robot planuje to co robi?*
	Do you think she/he/it might want to do something?	*Czy myślisz, że ten robot może mieć ochotę coś zrobić?*
	Do you think she/he/it might be willing to do something?	*Czy myślisz, że ten robot ma swoje potrzeby?*
	Do you think she/he/it can make a wish?	*Czy myślisz, że ten robot może mieć własne życzenie?*
	Do you think she/he/it might prefer one thing over another?	*Czy myślisz, że ten robot może preferować jedną rzecz od drugiej?*
Epistemic	*Do you think she/he/it can understand?*	*Czy myślisz, że ten robot rozumie?*
	Do you think she/he/it can make a decision?	*Czy myślisz, że ten robot może podejmować decyzję?*
	Do you think she/he/it can learn?	*Czy myślisz, że ten robot potrafi się uczyć?*
	Do you think she/he/it can teach?	*Czy myślisz, że ten robot może uczyć innych?*
	Do you think she/he/it can think?	*Czy myślisz, że ten robot potrafi myśleć?*
Imaginative	*Do you think she/he/it can tell a lie?*	*Czy myślisz, że ten robot potrafi kłamać?*
	Do you think she/he/it can pretend?	*Czy myślisz, że ten robot potrafi udawać?*
	Do you think she/he/it can imagine?	*Czy myślisz, że ten robot może coś wyobrazić?*
	Do you think she/he/it can make a joke?	*Czy myślisz, że ten robot potrafi żartować?*
	Do you think she/he/it can dream?	*Czy myślisz, że ten robot może śnić?*

Fig. 6 AMS (Attribution of Mental States) Questionnaire

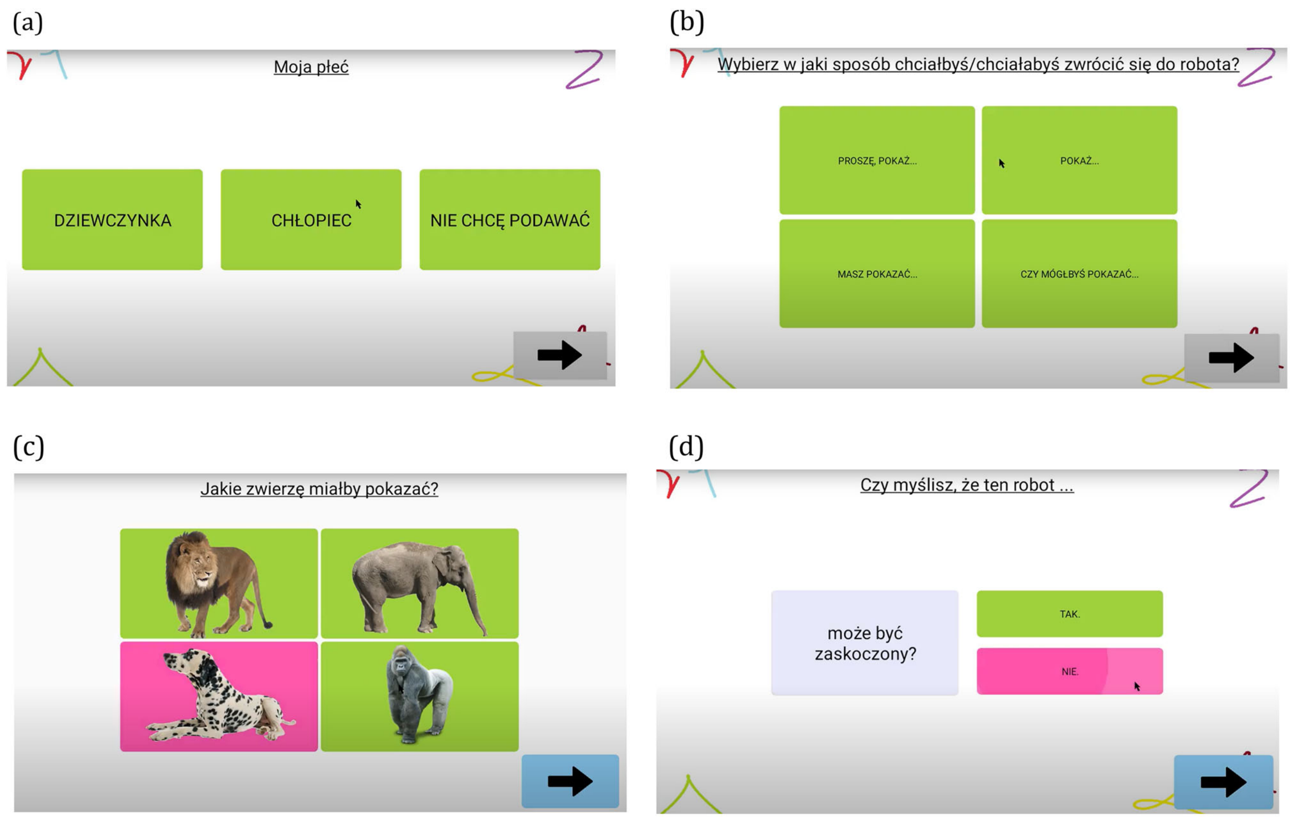

Fig. 7 Screenshot of data-gathering application (**a**) Gender selections screen stating "My gender"/ "*Moja płeć*" (**b**) Request selection screen stating "Select how you would like to address the robot" / "*Wybierz w jaki sposób chciałbyś/chciałabyś zwrócić się do robota*" (**c**) Animal selection screen stating "What animal should the robot show? " / "*Jakie zwierzę miałby pokazać?*" (**d**) One of 25 AMS questionnaire screens

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