Drawings for Insight on Preschoolers' Perception of Robots*

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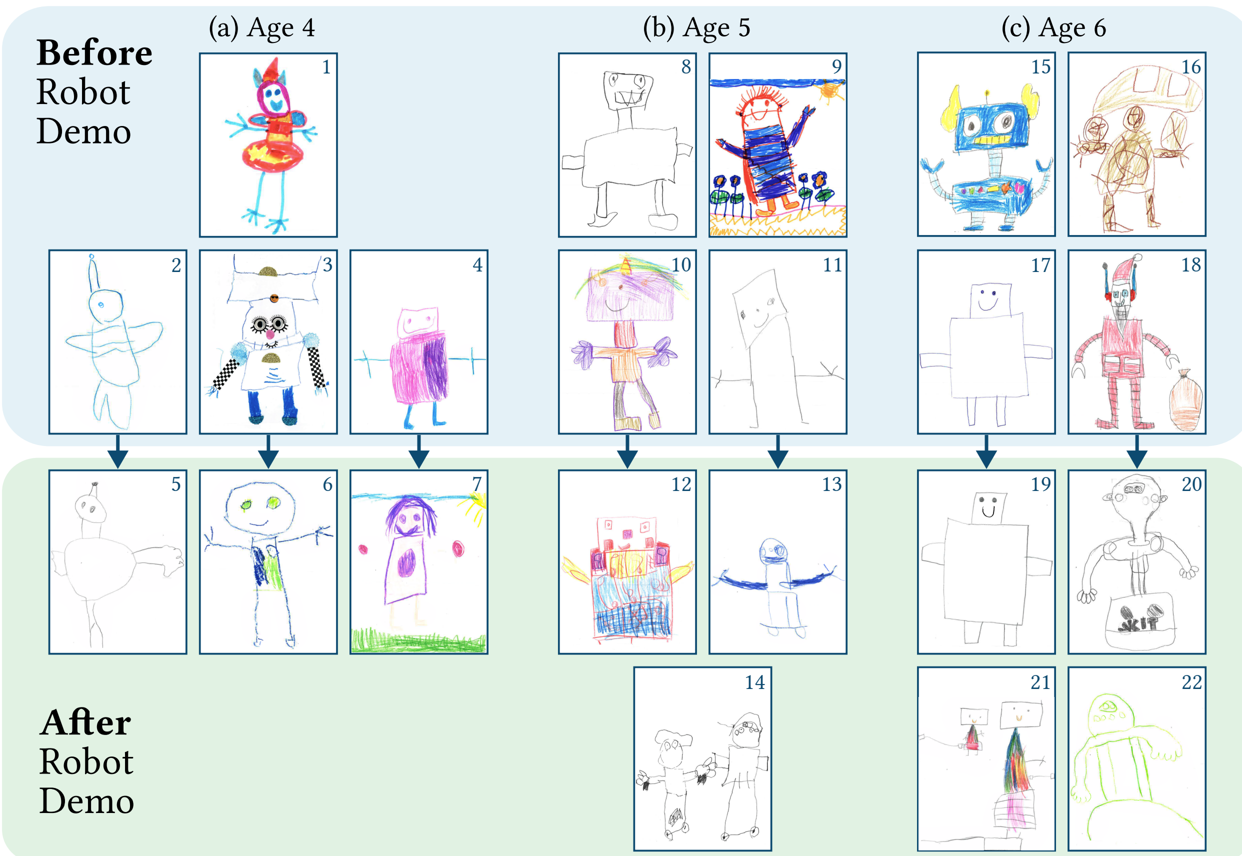

Figure 1: A subset of the children's drawings of robots (N=50) made before and after participating in a robot demo, clustered according to the age group. Arrows link the drawings that are likely to be drawn by the same child (since no identifiable information was collected in the study, the correctness of the association cannot be guaranteed).

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ABSTRACT

The design of robots and robot-mediated activities for children needs to be informed by their expectations on robots, to ensure acceptability and effectiveness. Children drawings are a powerful tool to understand and describe these expectations, containing actionable insights for robot designers. We report a preliminary study of 50 drawings made by preschool children and investigate (i) their perception of robots and (ii) the change in perception induced by a short experience with real robots. Our analyses reveal that the children's age not only influences their perception of robots, but also how their perception changes after encountering robots.

CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in interaction design**; **User studies**; *User centered design.*

KEYWORDS

child-robot interaction; preschoolers; drawings; perception of robots

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1 INTRODUCTION

As robotic technologies continue to permeate preschool children's daily life as toys, game companions or tutors, understanding children's perception of robots has become critical for Child-Robot Interaction (CRI) research [3, 5, 7, 18, 20]. At the same time relatively little research exists on how preschool children interpret and understand robots [18], not in the last place due to the fact that traditional methods based on questionnaires and self-reports are difficult to implement at this age [4, 19].

Children drawings have long been identified in child psychology as a "mirror to their mind" and a powerful tool to access the child's representation of the world [9, 21]. Indeed, various studies employ drawings to reveal and compare how preschoolers perceive robots before and after encountering them [5, 8, 10, 20]. However, few works use drawings outside of participatory design settings, no guidelines exist for analysing the drawings, and no conclusive findings have been drawn concerning children's conceptualisation of robots. Several studies [8, 10] incorporated drawing procedures primarily to engage children in interviews, rather than to analyse the drawings themselves. Others [5] viewed preschoolers as a small part of a much broader spectrum of participants (up to 13 years old) and gave limited importance to the role that drawing analysis could play towards understanding the conceptualisation of robots across different age groups. Finally, one study concentrated solely on preschoolers' drawings [20], aiming to identify differences in robot depictions before and after two months of weekly interaction with educational robots designed to teach coding skills. As the study did not reveal any meaningful differences, the question of insights into children's perception of robots derived from drawings remains under-explored and unanswered.

This paper is an effort towards the development of user-centered design for robots and CRI activities tailored for preschool children. Achieving this goal requires identifying information about children that can influence acceptability and effectiveness of CRI, e.g., their perception of robots, developing tools to reveal it, and finally using it to offer guidelines that engineers can rely on. To this end, the research team spans a range of competencies, including child psychology, technology assessment, robotics and HRI[1].

Concretely, we report a preliminary study involving 50 robot drawings made by preschool children before and after encountering real robots, that aims to investigate (i) their perception of robots and (ii) the change brought to this perception by a short experience with versatile collaborative robots. To analyse the drawings, we propose a scheme to characterise the elements in each drawing using a set of formal categories. Using this scheme, we describe significant differences in how the 4- to 6-year-olds conceptualise the robot, and discuss several insights to the design of robots and robot-mediated activities in kindergartens.

2 METHODOLOGY

2.1 Study design

In this study[2], we collected two sets of robot drawings made by preschool children enrolled in a local kindergarten: the first one within the week before they visited a robotics laboratory at the local university, and the second one within two weeks afterwards. For the drawing, the children were given a paper template, prompting them to imagine, draw and name their own robot.

The visit to the laboratory introduced the children to versatile collaborative humanoid robots, via a two-part demonstration of approximately one hour. The first part involved the ARMAR-III robot [2] in a kitchen setting (Figure 2a) while the second part involved the ARMAR-6 robot [1] in an industrial setting (Figure 2b). In both parts, the robots performed various recognition and manipulation tasks in collaboration with a researcher. In the kitchen setting, the robot handed items from the table and the fridge, and took care of putting the dishes in the dishwasher. In the industrial setting, the robot collaboratively inserted a cover, as shown in Figure 2b. In both parts, the researcher offered children simple explanations about the robots' abilities and components, engaged them via questions, and invited them to interact with the robots via object handovers.

We collected a total of 50 drawings. The first set contains 31 drawings, made by 16 females and 13 males, aged 5.03 (0.89) years old.[3] The second set contains 19 drawings, by 11 females and 8 males, aged 5.21 (0.83) years old. Most, but not all, children participated in both drawing activities. With no identifiable information collected, we are not able to provide the exact number of overlaps.

2.2 Coding scheme to analyse the drawings

To analyse the drawings, we developed a coding scheme with 12 categories (**C1–C12**) to describe each image using a uniform set of formal characteristics. To create the coding scheme, we initially

[1]KIT real-world laboratory "Robotics AI" project: https://www.robotics-ai.kit.edu/
[2]Ethical approval was granted by the university's institutional review board.
[3]Two drawings were excluded due to unreported age and gender.

(a) ARMAR-III demonstration.

(b) ARMAR-6 demonstration.

Figure 2: Robot demonstrations shown to the children.

documented all the elements children used to depict a robot and identified the frequently occurring elements that varied across individual images. The coding scheme was initially created by the child psychologist, and refined over interactions with two HRI researchers. The resulting scheme was then used by the child psychologist and two other researchers (not involved in its development) to independently rate the set of 50 drawings[4], yielding three raters per drawing. The three raters then discussed the discrepancies and reached a consensus, resolving disagreements by majority voting.

The first three categories in the coding scheme relate to the *head*, *mouth* and *eye(s)* shape (**C1**–**C3**). We observed that almost all robot drawings had a common basic structure, similar to how children of this age draw a human [11, 16], including head, torso, arms, and legs (see Figure 1). In the depiction of the head, constant elements such as eyes and mouth were also present, schematically drawn as a human face. While this depiction reveals many similarities with a human figure drawing, important differences are present. For instance, eyes, traditionally round in human face drawings, in robot depictions could be both round (e.g., drawing D6 in Figure 1) and square (e.g., D12). Similar differences are observed in the depiction of the head and mouth. Conversely, robots' torso and limbs are almost always similar to those elements in a human figure: parallel straight lines and elongated rectangles. Being of little distinctive value, torso and limbs were not included in the coding scheme. On the other hand, we kept the more descriptive features (head, eyes and mouth depiction) for image analysis in order to determine to what extent the concept of a robot is linked to that of a human.

Additional elements, such as hair, dress, fingers, feet, buttons, antennas, ears, wings, etc., are present in the majority of the drawings. We classified these elements based on their *human*, *animal* and *mechanical* nature (**C4**–**C6**), as they help determine to what extent the concept of a robot is linked to the image of a living or non-living being. From this list we excluded some elements which were not of comparative (differential) value, namely feet, neck (as they were invariable in drawings) and fingers (as children at the age of 4–6 often draw fingers like set of "sticks", which makes it impossible to characterise them as human, animal or mechanical).

Variations in the level of image elaboration were also noted, from rather schematic and monochrome (e.g., D11), to having more details and different colours (e.g., D9). We thus introduced the categories *image elaboration* (high vs. low based on the number of details in the drawing) and *colouring* (whether the robot's contour is empty or coloured) (**C7**–**C8**). These categories aim to describe the child's engagement in the activity and interest in the subject (reflecting the time and effort spent on the image creation).

Furthermore, we consider the amount of *distinctive* features (of animal, human and mechanical nature) included in the drawing (**C9**–**C11**). This metric, called *features variety*, is intended to disclose how the concept of a robot is refined with new experiences, by counting the various features attributed to robots. In contrast to the previous categories of colouring and elaboration, this measures how accurately the children understand what a robot is and is not.

Lastly, the names children gave to the robots varied from those similar to human names (e.g., Leo, Rosi) to those not typical for humans (e.g., A7, Herus). We capture this in the *name type* category **C12**. The choice of the name should reveal how distinctive in child's representation the robot is, compared to the familiar circle of human-like names owners (children, adults, pets, favourite toys, etc.). Not giving a name can indicate uncertainty in what name is applicable for the robot.

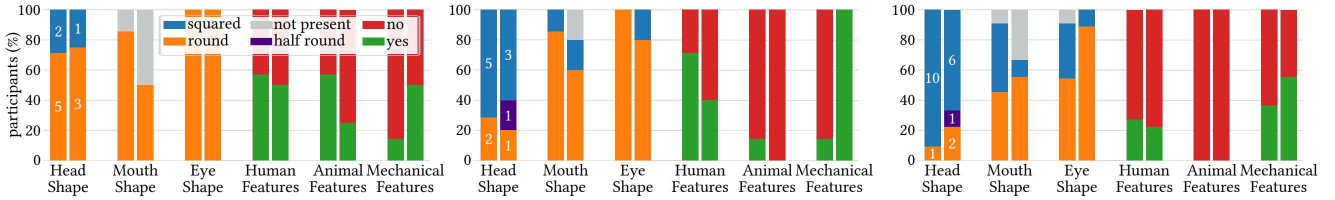
3 RESULTS AND DISCUSSION

A total of 43 drawings were considered for the analysis from the initial set of 50. We excluded 2 drawings due to unreported age, 2 for not following the task and 3 for lacking necessary features for analysis (e.g., recognisable head and torso). Figures 3 and 4 report the results for **C1**–**C12** conditioned by age.

Robot images in the initial drawings of the 4-year-olds (see Figures 1a and 3a-left bars) closely mirror the familiar images of humans, living beings, fictional characters encountered in their daily surroundings, books or cartoons (as denoted by the prevalence of round heads, mouths and eyes, as well as the equal likelihood of human and animal features). These robots may take the form of an ordinary girl (drawing D7 in Figure 1), fairy (D1) or prince (D3), or an unknown creature (D2), amalgamating real features in the unique way children perceive them. Encounters with real robots do not seem to significantly alter the initial representation (see the paired drawings in Figure 1a), rather, they may contribute some distinctive and appealing features to the general image of a living being. For example, in D6, a child incorporates magic cameras capable of resizing the robot, as commented by the child. As a whole, we observe attempts to recreate previous images, often unfinished (D5 and D7) due to the lack of motivation (Figure 4a).

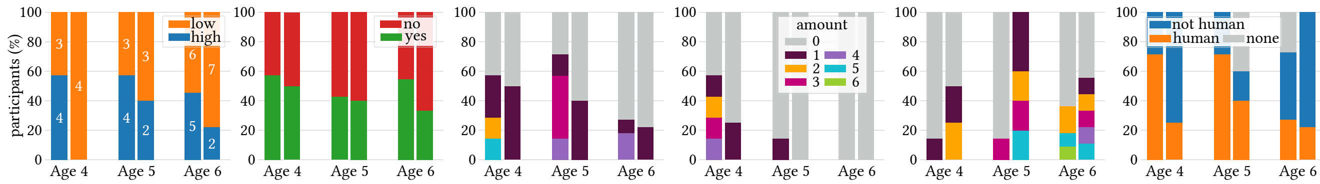
At the age of 5 (see Figure 3b), the initial drawings are mainly based on the typical human image (including round eyes, mouth, eyelashes, hair, dress, etc., in D9–D11), partially complemented by animal (horn in D10) or non-human-like features (squared head or mouth in D8, D10, D11). Children at this age may still lean towards the imaginative world of the 4-year-olds, but they also probe the more reality-oriented approach of the 6-year-olds. Exposure to real robots at this age induces substantial changes in the robots representation: human features become less prominent and mechanical features increase notably. Squared non-human-like elements replace rounded forms on the "face" (pair D10-D12). 5-year-olds experiment with replicating observed robot appearances (D14), substituting point-like human eyes with large round camera-like

[4]We merged the drawings in pre- and post-demo and shuffled the order for the rating.



(a) Age 4 (b) Age 5 (c) Age 6

Figure 3: Drawing characteristics in the pre-demo (left bar) and post-demo (right bar) robot drawings (categories C1–C6). Numbers on the bars denote the total number of children that make up the fraction at that age group in the pre- or post-demo.



(a) Image elaboration (b) Colouring (c) Distinctive human (d) Distinctive animal (e) Dist. mechanical (f) Name type

Figure 4: Distribution of image elaboration, colouring, the amount of distinctive features, and name type (C7–C12).

features, or changing head shape to half-round and incorporating wheels instead of limbs (pair D11-D13).

The initial drawings of 6-year-old children show more stereotypical characteristics of a robot (see Figure 3c), aligning with how older children depict robots [6, 13, 17]. These drawings, beside squared parts of the robot figure, often feature common attributes such as antennas, grippers, buttons, spring-like arms (D15 and D18) or signs of superhero abilities (D16). At this age, children shift their focus towards reality, becoming more attuned to the social world around them, its rules, norms, shared knowledge, etc. [12, 15]. Exposure to real robots imparts new information, compelling children to integrate this knowledge into their drawings. Post-demo robot images show a reduction in stereotypical features, such as square forms for heads, eyes, mouths (robots may lack the mouth entirely D22) and features like antennas and gripper-like hands (D20-D22). Children, drawing inspiration from their new experiences, try to depict more accurately how real robots are designed (D20), emphasise their functionality (e.g., placing it in the kitchen) and operation (e.g., cables leading to sockets in D21).

We found that the initial interest in drawing robots, estimated through image elaboration and colouring, was rather high (Figures 4a and 4b), even considering that the novelty of the task might have contributed to it. Revisiting the same task after encountering a real robot appeared less interesting, especially for the 4-year-olds. Some children simply re-made their first drawing (D2-D5 and D17-D19). Figure 4c shows that image elaboration in post-demo drawings decreased mainly by removing additional human-like features from robot images, reducing their diversity to one element in each age group (prior to exposure, their number ranged up to 6 elements). At the same time, the variety of additional mechanical features increased in all age groups, most notably at the age of 5 (Figure 4e). These changes not only indicate that real experience contributed to clarifying the robot concept (making it more distant from human-like images) but also show that some children sought to enrich the image of the robot with more specific and diverse features, potentially showing higher interest in gaining knowledge about robots. The same tendency is revealed in robot names: the children tended to give specific (non-human-like) robot names in post-demo drawings, compared to pre-demo (Figure 4f).

4 CONCLUSION

Albeit preliminary, the results suggest a correlation between the age of the children and the features of robots in their drawings, allowing us to characterise the initial robot perception in different age groups, as well as how a brief but real experience with robots can influence the initial concept. Based on our comparative description, we can tentatively outline some guidelines for design elements that seem to be important for different preschool ages. For the 4- to 5-year-olds, the robot's appearance should not be tied to a definite image, leaving room for invention and playing out their scenarios (as suggested by the variety of feature types and inspirations that characterize the drawings of this group). At the same time, the robot's expressiveness seems to be crucial: for example, [14] observed that children aged 3–4 displayed their most active reactions when the robot's eyes changed into a heart shape and cheeks turned red. Conversely, the marked changes in the type of features used in the post-demo drawings suggest that for 5- to 6-year-olds, understanding the robot's functionality could become more important, as they might like to discover how to control and manage the robot's actions. This assumption relates to the study in [18], where children of 4- to 7-year-olds answered a question about robots' purpose ("what are robots for?").

These conclusions are indeed preliminary. We hope to find further evidence from the ongoing field study in the kindergarten with two social robots interacting with children in different activities. At the end of this study, along with the data about children's engagement, we will analyse the third set of robot drawings, which will hopefully give us additional insight into the robot concept and whether it changes after a prolonged social interaction with a robot.

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