Draw a Robot Task: The Influence of Children's Age and Drawings on Robot Interactions

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Abstract— **Prior work has used the Draw a Robot Task (DART) as a way to understand children's implicit preconceptions of robots. However, no work to date has attempted to correlate DART scores with external measures. In this study, we explore how age and childhood exposure to technology influence DART responses. We also examine how DART results influence subsequent interactions with and attention to a real robot. We find a surprising lack of significant correlations between the DART and other measures, except in the oldest age group of children (7-year-olds). As such, we recommend using this task with older children or supplementing it with other implicit tasks to fully understand early robot perceptions.**

I. INTRODUCTION

For decades, scientists and educators have utilized the Draw a Scientist Task ("DAST") to explore the perceptions and stereotypes individuals have concerning scientists. This task that is particularly useful for child populations, as it requires no verbal or written responses [1]. Children's drawings of scientists are coded for a number of predefined features, with their pictures often demonstrating a heavy representation of scientists that are male, white, and don laboratory coats. These representations do not reflect the breadth of actual scientists, and as such the DAST has been used to explore implicit biases about science, potentially indicating a drawer's future interests or career trajectories (see [2] for a review).

Recent research has suggested that these drawings do not reliably predict other measures or outcomes and may not be tapping personal perceptions at all. Studies have shown that DAST scores lack correlations with children's career aspirations or scientific interest [3] and are only sometimes correlated with surveys of stereotypical thinking [4]. Thus, children may be interpreting "draw a scientist" to simply mean draw a publicly stereotypical scientist and not their own personal idea of what a scientist could be (e.g., [5]). This begs the question, what are tasks like the DAST actually tapping, and are they a useful tool to utilize when exploring children's perceptions?

Despite its shortcomings, the DAST has now been adapted to explore stereotypes in a number of other areas [6] [7], including children's perceptions of robots, using the Draw a Robot Task (DART). This body of work has shown that the DART is able to be administered to children as young as 5 years of age [8], and that the results of the DART change with training or experience with robots [9]. However, to date, no study has examined how DART pictures correlate with any other measures or perceptions of robots. As in the DAST, this opens up the possibility that the DART is not necessarily informative as a tool for exploring robot perceptions.

In the current study, we utilized a DART with children aged 5-7-years-old and examined how variation in children's robot drawings informed their subsequent behavior towards and attention to an in-person interactive robot. In particular, we examine the children's eye gaze as an indicator of the perceived social abilities of the robot [10]. Using these preliminary findings, we propose a series of modifications and/or additions to the traditional DART task that could increase its validity in future studies. In particular, we recommend that the DART be employed with early elementary, as opposed to kindergarten, subject pools.

II. PARTICIPANTS

Participating families were recruited from a small city in the eastern United States via an existing laboratory database and social media postings. Thirty-two children aged 5-7 years (*M*=6.81 years, *SD*=0.94; 17 girls and 15 boys) completed the study in a developmental psychology research lab. An additional 7 children began the study but were excluded due to refusal to complete the task (n=6) or issues with the recording equipment (n=1). According to parent report, 97 percent of participants were white, and 3 percent were "other race, ethnicity, or origin".

III. PROCEDURES

A. Draw a Robot Task

Children were seated at a table where an experimenter provided them with a sheet of white A4 paper and crayons. The experimenter asked the participants "Can you draw a robot?". Children were given as much time as they needed to complete their drawing. Once they indicated they were finished, the experimenter asked a short series of follow up questions. First, they asked the child to explain their drawing ("Can you tell me what you drew?"). Then, participants were asked what the robot did, where it was located, what its gender was, if there were other agents in the drawing, and clarifications on any aspects of the picture that the child had not already mentioned (adapted from [8] [11]. After all questions were answered, children proceeded on to the tangram task phase in an adjacent room.

B. Tangram Task

Participants entered a testing room and were seated at a table across from either a human instructor or the robot instructor. All children saw both instructors, with the order of first instructor randomly counterbalanced across participants. Various tangram pieces and a piece of paper with a tangram illustration were on the table in front of the participant. The experimenter sat in a chair behind the child and appeared busy so as not to influence the participant-instructor interactions. For each instructor (robot and human), participants first completed an introduction phase where the instructor asked the child a series of warm up questions and taught them how to complete a simple puzzle. They then proceeded to the tangram task, modeled off of previous human-robot interaction work with adult participants [12]. Participants were asked to assemble colored tangram blocks into a shape using an illustration as a guide. The instructor provided feedback and encouragement to assist the child as they completed the puzzle (see [13] for a description of instructor prompts). Children were given as much time as necessary to complete the puzzle. For the purpose of this manuscript, only the tangram task phase with the robot instructor was analyzed.

C. Robot Set-Up

The Misty II (Misty Robotics) was used as the robot instructor for the tangram task due to its child-friendly appearance and interactive features. The robot appeared to be autonomous to the child, although in reality it was being controlled by a human operator in a separate room. The operator used a touchscreen interface to select from 70 pre-defined robot behaviors to assist the child. All behaviors were composed of a combination of six fundamental robot actions: to speak, change facial expression, look in a direction, point in a direction, tilt its head, and pause for a short amount of time.

IV. CODING & ANALYSIS

A. Draw a Robot Coding

Children's drawings were coded based both on their verbal descriptions (transcribed from video) and on the content of the drawings themselves. Consistent with prior literature [14], a checklist was created that included a number of animate/agentive features (e.g., eyes, mouth, fingers, legs), mechanical features (e.g., buttons, antenna, wheels, claws), and the robot's basic shape or form (organic/animate, box-like, or a combination). A subset of animate features was grouped into a 'facial feature' category to explore how those features, specifically, interacted with other measures. Answers to the follow-up questions were also transcribed and categorized.

B. Tangram Task Time Coding

Session videos were coded for the duration of the tangram task phase, from the moment the illustration of the puzzle was presented until the participant completed the puzzle.

C. Eye Gaze Duration

Eye gaze data was extracted from the video feed of the camera positioned directly below the robot. This camera provided a clear view of the participant's face during the interaction. For each frame of the video feed, we identified whether the participant was looking at the agent (robot or human instructor), the puzzle and puzzle pieces, the paper with the picture of the puzzle, or other areas in the room. The process required associating the coordinates of the participants eye gaze with one of these areas of interest. For each video, we labeled a center point for each of the three main areas of interest (agent, puzzle, paper). Coordinates corresponding to the participant's eye gaze were produced by processing the video with OpenFace [15]. Once coordinates were generated, they were associated with the center point of area of interest to which they most closely aligned. Any coordinates that were not sufficiently close to any of the targets were categorized as other.

V. RESULTS

A. Robot Drawing Characteristics

To describe the types of robots the children drew, we report the gender, shape, and aliveness of the robots. Almost half of the robots were male (49%), 13% were female, and 38% were described as a machine, both genders, or an ungendered animal. These percentages align with previous work showing that a majority of children draw robots that are male (e.g., [8]). There were some differences based on the gender of the participant. Male children more often drew a male robot (63%). Female children also drew a male robot more often than female robot (33%), but they drew a female robot more frequently than male children (22%). There were no other effects of participant gender on robot drawings. In terms of shape, 69% of the robots had a class box-like shape, 19% had an organic shape, and 11% had features of both. When talking about their robots, 55% of the children said their robot was alive, 37% said it was not alive, and 8% did not answer.

Though most robots were drawn as box-like, children were significantly more likely to draw and mention agentive features (M=5.58, SD=1.70) rather than mechanical ones (M=1.29, SD=1.20, $t(37)$=11.67, $p>$.001). Thus, the overall shape may have resembled a machine, but the specific features within this shape involved human-like faces, hands, and legs as opposed to buttons, claws, and wheels.

B. Influence of Age and Home Technology Exposure

To examine individual child characteristics and how they relate to preconceived notions of a robot, we analyzed possible effects of age and home technology use on the types of features that were included in the robot drawings. There was no significant relationship between age and the number of agentive (r=0.17,p=.30) or mechanical (r=.16, p=.34) features, but age did correlate with facial features (r=-.32, p=.05). With nearly half of our population being over the age of seven, we grouped participants according to older (7 years and above) and younger (under 7 years) bins and utilized an independent samples t-test to examine any differences across age group. There was no significant difference across age groups for the number of agentive (p=.55) or and mechanical (p=0.28) features, but the older group significantly fewer facial features than the younger group (p=0.0499) There was no significant relationship between the number of types of devices at home (out of 9 possible types) and the number of agentive, mechanical, or facial features drawn by children, either across or within age group (all ps>.050. Similarly, there was no significant relationship between the total number of devices at home (the summation of all tvs, iPads, computers, robots) or the frequency of technology use at home (never to frequently) and the number of agentive, mechanical, or facial features drawn (all ps>.05). Therefore, it does not seem that technology use and exposure in the home had any bearing on children's drawings of a robot.

C. Influence of Robot Drawings on Robot Interactions

To examine whether a child's preconceived notions of a robot influenced how they subsequently interacted with one, we analyzed possible relationships between the features of their drawings and behavioral measures (proportion of time gazing at robot, total time gazing at robot, task completion time). As shown in Table I, no correlations were found between robot features and proportion of gaze time, total gaze time, and task completion time.

Due to the fact that children's ability to draw changes significantly across the early elementary years, particularly in relation to related tasks such as the DAST [4], [16], we examined whether there were group age effects on the relationship between drawings and attention (eye gaze). There were no significant correlations between the features of the younger chlidren's drawings and their attention during the tangram task (all ps>.05). However, there was a significant relationship in the older children between that the number of facial features drawn and the proportion of the task time spent looking at the robot (r=.600, p=.018).

VI. DISCUSSION

In the current study, we examined relationships between the characteristics of young children (their age, their technology exposure) and their subsequent drawings of a robot. We also explored how participant drawings correlated with later behavioral measures when interacting with an actual robot. Generally speaking, we found that the DART task had few significant relationships with any other measures when looking across all ages.

When binning children by age (older or younger than 7 years), we did uncover some interesting findings. For example, older children draw significantly fewer facial features than younger children, which could suggest they view the robot to be more machine-like and less capable of being social. Additionally, when older children (and not younger children) drew more facial features, they spent a greater proportion of time looking at the robot. This could indicate that, for older children who expect the robot to be more animate, they engage with the robot in a more social manner by looking at it more. Future analyses can further substantiate this claim by examining other social cues (e.g., speech, gestures) that the children exhibit while interacting with the robot and their relationships with the DART.

		Proportion Gaze	**Total Gaze**	**Total Time**
All ages (N=32)	Agentive	.113	-.051	-.016
		.538	.783	.933
	Mechanical	-.062	-.021	.059
		.735	.911	.749
	Facial	.106	.048	-.013
		.565	.793	.942
5-6 yo (N=17)	Agentive	-.029	-.169	-.137
		.913	.517	.601
	Mechanical	.121	.171	.268
		.643	.511	.299
	Facial	-.224	-.154	-.187
		.387	.555	.472
7 yo (N=15)	Agentive	.309	.341	.147
		.263	.213	.601
	Mechanical	-.209	-.209	.107
		.455	.455	.705
	Facial	**.600***	.030	-.349
		.018	.915	.203

TABLE I

CORRELATIONS BETWEEN DRAWN ROBOT FEATURES AND TIMES. THE TOP VALUE IS THE PEARSON CORRELATION AND THE BOTTOM IS THE p-VALUE.

Age effects have been noted when exploring related drawings in the Draw a Scientist Task. Here, younger children are more likely to draw scientists who are ambiguous in gender [16], and older children are more likely to draw scientists as male [17]. Some have suggested that this effect may be due to exposure, with older children more likely to see stereotypical scientists as male in the media or even in their own classrooms [17]. Therefore, it's possible that children in our study were exposed to more machine-like robots as they got older, causing them to draw fewer facial features. Future work should explore this idea by asking about technology exposure in the home and also via media or classrooms.

It's also possible that the DART is only useful as a tool in older child populations. Unlike other drawing tasks, there is not much work exploring how children's drawings of robots might change with age. However, work exploring early perceptions of robots more generally suggest that there are large age effects in terms of perceptions of what a robot actually is or can do. Across the lifespan, individuals change in relation to attributes of agency, sensory ability, emotional intelligence, and biological needs ascribed to robots [18], [19]. Given these explicit perception changes, it stands to reason that more implicit measures such as drawings should reflect similar developments. More studies are needed to examine how features present in the DART change across age.

Regardless of age, the lack of effects we found between the DART and other measures does draw into question the relevance and utility of this task for assessing robotic stereotypes. Much like that DAST, it's possible that the DART is tapping a publicly stereotypical idea of a robot [5], but not personally held beliefs about robots. Alternatively, it's possible that the specific measures we used were not associated with variable DART outcomes. In our study, we explored how a general idea of a robot (measured via DART) might influence interactions with a very specific machine - Misty. Given that all drawings were collected before these interactions, it stands to reason that participant conceptions of a stereotypical robot do not necessarily align with their tangible experience with a socially-contingent robot. It would be interesting to look at how the drawings of children change both before and after this live interaction.

Finally, it is worth noting that our particular DART method did vary somewhat from prior research. Much like the DAST asks children to "Draw a scientist", we asked children to simply "Draw a robot". However, the few other studies utilizing the DART have added more to this question, asking children to "draw a robot working" [11] or "draw a picture of a robot doing something robots often do" [9]. This omission on our part was intentional. We assumed asking about work or "doing" would trigger a very specific type of robot perception, and we were interested in children's ideas of robots more generally. However, it is possible that this subtle change in our methodology influenced our results, as has been found when altering the wording in the DAST [16]. Future work is necessary to examine the influence of wording changes on children's robot drawings.

Taken together, the results of this study show that children are capable of drawing robots from an early age, and are equally capable of interacting with and learning from a socially-contingent robot. However, the connections between these measures are tenuous at best. If anything, the current findings suggest a plethora of open questions that still need to be answered in order to fully understand the connections between robot drawings and interactions. We suggest either alternative or supplemental tasks to the DART when examining children's preconceived notions of robots. For example, one could ask children to rank a series of photos from least to most robotic (a typicality ranking task, see [20], ask children to list the names of different robots they know and then categorize those features (a typicality recall task, similar to [21], or respond to questions about preferences for different types of robots (e.g., [22]). These tasks might be particularly helpful for younger children with less sophisticated drawing skills. We also suggest utilizing the DART particularly with older child populations, where the connection between drawings and other external measures appear to be more substantial.

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