Influence of a Social Robot's Co-presence on Children's Figural Creativity

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ABSTRACT

Children's creativity contributes to their cognitive and affective growth. Creativity is influenced by children's social interactions with their peers during collaborative tasks. We studied the role of a social robot's presence in enhancing children's figural creativity in a collaborative drawing task. We designed an autonomous child-robot interaction, where the child and the robot collaboratively completed a drawing on a tablet screen. We compared the collaboratively generated children's drawings in the robot interaction group with a control group that completed the task on a tablet in the absence of a robot. The goal was to study if the presence of a social robot influences children's creativity in a collaborative drawing task. A total of 67 participants in the 6-10 year-old age group were evenly distributed across a robot condition (R) and a tablet-only control condition (T). We observed no significant gains in creativity of the drawings as measured by the Test for Creative Thinking - Drawing Production (TCT-DP). Participants that interacted with the robot claimed to have more fun in the game as compared to the control group, and perceived the robot to be less good of an artist than the participants in the control condition did. We discuss the role of the robot's embodiment on children's creativity and implications on designing child-robot interaction for fostering creativity.

CCS CONCEPTS

• Human-centered computing → Collaborative interaction • Applied computing → Psychology; • Computer systems organization → Robotic autonomy.

KEYWORDS

Social robots, co-creativity, child-robot interaction

INTRODUCTION

Creativity is defined by the ability to fluently produce novel ideas that add value [1]. Creativity in children has been shown to facilitate problem solving, adaptability, self-expression and health. Integrating creative skills into educational institutions' curricula provides increased learning benefits [3]. Standardized creativity measures have previously demonstrated that as children progress from kindergarten to elementary school (ages 8-10), their creativity drops [2]. Creativity can be learned and is influenced by a person's environment and social interactions [3]. Creativity can be influenced by the classroom environment, and is fostered when activities are presented in a permissive and game-like fashion [4]. Collaboration, that is multiple people working together towards a common goal significantly influences creativity [5]. Artificial embodied agents, such as social robots, have been used as effective pedagogical tools for young children, leading to both cognitive and affective gains [6]. Given how interactions with others influence children's creativity, especially in collaborative tasks, in this work, we explore whether collaborative interaction with social robots can promote creative behaviors in children. Previous research has demonstrated that a social robot can help adults be engaged in a creative activity for longer times and come up with more creative ideas [7], and children can learn verbal creativity from a social robot [8].

In this work, we explore if the presence of the social robot Jibo that demonstrates artificial creative behaviors can help children think more creatively in a collaborative drawing game. Creativity manifests in different forms namely, *verbal* and *figural*. We focus on children's *figural* creativity, which involves creative thinking in visual arts (e.g., drawing, painting, sculpting), since generating drawings is central to the interaction. Alves-Oliveria et al. [9] studied the role of a robot controlled remotely in a Wizard of Oz manner, in comparison with a tablet, in stimulating creativity in adults in a collaborative drawing task. They found no significant effect of the robot's presence on children's creativity. No such study has been carried out for children and for a fully autonomous interaction.

We designed a collaborative drawing interaction between a social robot and a child participant to understand the effects of the robot's presence on children's creativity outcomes. The game mechanics involved one player (child or robot) starting a drawing on a touchscreen tablet with one stroke and the other player completing it to form an object, before switching turns. We made

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use of the Sketch-RNN drawing model, trained on the QuickDraw dataset of drawings, to generates drawing strokes that convert a starting stroke into a meaningful object [10]. The robot acted as a collaborative peer that took turns with the child to either begin a new drawing prompt or complete a drawing prompt started by the child.

In order to understand the role of the robot's embodiment in children's creativity gains, we conducted a randomized controlled trial to compare the figural creativity exhibited by participants that played the game with the robot, with the control group that played the game with the tablet in the absence of the robot. 67 participants in the 6-10 year-old age group were recruited with parental consent. Participants were divided in two groups: robot-condition (R condition) and tablet-condition (T condition). Creativity of the generated drawings was measured using the TCT-DP test for *figural* creativity. We observed no significant creativity gains in the robot condition. Hence, the mere presence of an embodied collaborative robot did not lead to creativity gains. This is the first study of its kind involving young children and using a fully autonomous collaborative drawing interaction. While we observed no significant creativity gains, this study opens up the space to explore robotic interactions as a Creativity Support Tool (CST) for young children, and introduces the use of generative modeling techniques such as Generative Adversarial Networks [11], Variational Inference [12], and Autoregressive [13] models to enable robots to express creativity in fully autonomous interactions.

STUDY DESIGN

System Design

The system comprised of three components: The robot, the tablet and the model (Fig 1). We made use of the Jibo robot since it is capable of social interactions such as conversation and animation and is children-friendly. Further, Jibo can be fully automated to communicate with the Android drawing app and synchronize its interactions with the tablet's drawing user interface. Jibo robot communicates with the Android tablet using Jibo SDK. The collaborative game is played on the tablet. The gameplay involves two players (child and robot/tablet) where they alternate turns to draw a starting prompt (such as a few strokes), and select a target drawing object (such as an 'ant') and the other player follows by converting the starting prompt into the target object. The final drawing challenge given by any player must be a subset of the 32 objects provided in the game menu. The selected prompt is expressed in speech and a written word (and not a pre-existing drawing). The drawings generated on the tablet make use of the Sketch-RNN generative drawing model, trained on 32 common objects, that is running on a server on the tablet and completing images [10] (Fig 2 & 3). The model makes use of Recurrent Neural Networks to generate complete drawings from a starting prompt. Jibo communicates with the tablet to know the category that has been selected, speaks a dialogue to indicate that Jibo is the other player that is drawing for the category selected (eg. "Oh, a Flamingo. Look at me go.") and looks down at the tablet as the drawing begins. This gives the impression of the robot pretending to draw on the tablet. The robot/tablet begin with instructions to explain the game. The child draws a starting prompt on the screen, and selects a target drawing category for the robot and Jibo converts the prompt into the selected category. Then they switch turns, and Jibo draws a prompt and selects a target drawing for the child to complete. They play the game for 3 rounds of 60 seconds each before which the robot terminates the game.

Study Conditions

Participants were randomly divided in two study groups: Robot interaction group (R condition) and Tablet-only group (T condition). Both groups played the game on a touchscreen tablet. In the R group, the robot acted as the other player, and in the T group, the tablet itself was the other player. Both the interactions used the same drawing model and we controlled for time of engagement and quantity of dialogue across the two conditions. The robot (R condition) and tablet (T condition) used speech based interactions to communicate: (a) the drawing challenge, (b) the object they are currently drawing, and (c) indicating when time is up and transfer of turn. In order to control for the sociability in the two conditions, the robot does not engage in any other social interactions or animations in this study. In both the study conditions, the drawing model remains the same, but in the control group, the participants are told that they are playing with the tablet, and the tablet speaker speaks the dialogues.

Data Collection

Participants' drawings were recorded in each round and were scored for creativity using the TCT-DP scale by coders blind to the study condition and hypothesis. Further, participants were administered a post-test questionnaire with the following two questions: (i) On a scale of 1 to 5, how fun was the game? (where 1 is the least fun, and 5 is the most fun) and (ii) On a scale of 1 to 5, how creative do you think the robot (or tablet) is (where 1 is the least creative and 5 is the most creative)? The term '*artistic'* was used in place of creativity for younger children who did not understand '*creative'*.

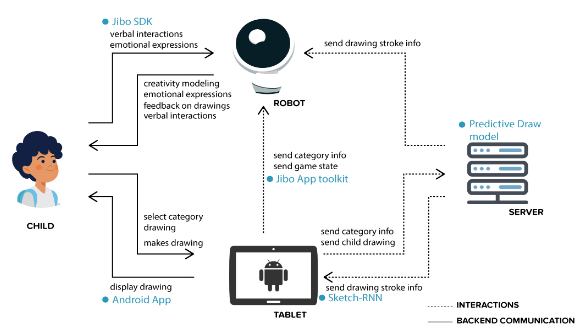

Figure 1: System Design of the Interaction involves the child (L),

the Jibo robot (top) and the touchscreen tablet (bottom) which runs the Sketch-RNN model (R)

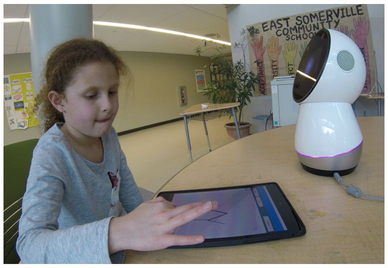

Figure 2: Child playing the collaborative drawing game with Jibo

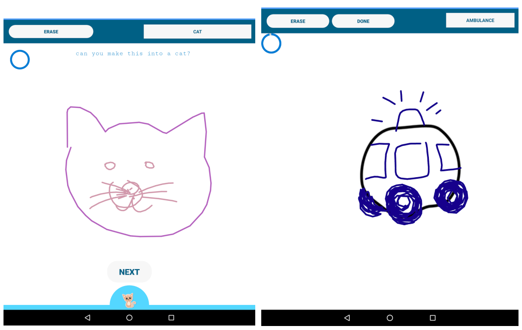

Figure 3: Tablet interfaces. (left) Robot completing the child's drawing into a cat. (right) Child completing the robot's drawing into an ambulance.

Hypothesis

While previous studies using a Wizard of Oz human-robot interactions for co-drawing demonstrated that the embodiment of the robot did not lead to significant changes in children's creativity [9], we were curious if automating the interaction or conducting this study for young children, who do learn creativity from peers and mentors, would produce any different results.

We hypothesized that participants that interact with the robot will generate more creative drawings that the participants in the tablet-only condition.

Results

While participants in the robot condition overall scored higher than the participants in the tablet-only condition, no significant difference between the two study conditions was observed (p>0.05).

Study Groups	**n**	**TCT-DP scores**	**Did you have fun? (1-5 scale)**	**How creative? (1-5 scale)**
Robot	34	32.88 ± 9.64	3.45 ± 1.35	2.24 ± 1.42
Tablet-only	33	27.75 ± 11.11	2.44 ± 1.61	3.57 ± 1.54
p		*P=0.054*	*p=0.002**	*p=0.03**

Table 1: TCT-DP scores of drawings in the study groups

In the post-test questionnaire, participants who interacted with the robot indicated that they found the interaction to be more fun as compared to participants in the tablet-only condition. Participants in the tablet-only condition thought that the tablet was more creative as compared to participants in the robot condition.

DISCUSSION & FUTURE WORK

In this work, we have compared children's creativity in the presence and absence of a robotic peer in a collaborative drawing game. We observed that the robot's presence lead to no significant creativity gains, hence disproving our hypothesis that the presence of a robot can have a positive influence on children's creativity. This indicates that the embodiment of the robot did not have a positive influence on children's figural creativity. Participants had more fun playing the game with the robot. The participants perceived the robot's creativity to be significantly lower than the tablet's creativity, even when they used the same drawing model. We speculate that this could be a result of having greater expectations from an embodied agent as compared to a tablet.

Creativity is a socially learned behavior that is enhance by co-present peers who demonstrate creativity or scaffold for creativity, such as by asking reflective questions or providing challenges. It is not only the co-presence of peers, but also their social interactions and their expressed creativity that leads to an increase in creativity in children. In this interaction, we controlled for the two study conditions to be identical (the tablet and the robot), where the embodied agent acted as the other player but did not exhibit any social interactions. We suggest that it is not only the presence of a social robot (like in this study) but also the social interactions with the child (such as demonstrating creative behaviors or scaffolding for creativity using questions and reflective prompts) that facilitate creative thinking in children. The fun nature of collaborating with a playful robotic peer, and the robot's ability to engage with the participants socially and emotionally, situates social robots as an effective creativity support tool for children. In future work, we will leverage not just the embodiment but also the social interactions, such as creativity demonstration and creativity scaffolding of the robot, to enhance creative learning in children. This is the first Child-robot Interaction study using a fully autonomous collaborative drawing interaction. In this task, the players had to convert starting prompts to fixed target drawings that the other player selected. In order to afford for greater creativity, a more open-ended drawing task where the players could convert the drawing prompt into anything they would like would be valuable. While we observed no significant creativity gains, this study introduces possibilities to design collaborative creative interactions that leverage the advances of generative modelling techniques to enable embodied agents to produce different forms of art such as drawing, prose, music, stories and painting, and leverage these interactions to foster creativity in children.

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