Sparking Creativity with Robots:
A Design Perspective

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Abstract—We present the design and evaluation process of a robot aimed at stimulating creativity in humans in a drawing-oriented collaborative drawing task. Collaboration towards a common goal is known to be one of the most influential factors for creativity nourishing. The social robot acted as a collaborative peer in a drawing activity, taking turns with the human, to complete their drawing. In each turn, both "artists" (the robot and the human) draw something new until they achieved their final drawing. The goal was to study if a robot, in comparison with a tablet, can stimulate creativity. A total of 28 participants were distributed across robot and tablet conditions. Creativity scores for each drawing were calculated. Contrary to what was expected, creativity score did not present statistically significant main effect across conditions. We discuss our results under a design perspective, addressing the role of the robot's embodiment and presence, as well as the purpose of use for robots in society and what implications there is for design.

Index Terms—Social robots, co-creativity, critical design, speculative design, embodiment

I. INTRODUCTION

Creativity is one of the most sought-after skills with major implications for well-being and personal life, and it is related to career professional success in career [1]–[3]. The role of creativity in society has been highlighted and valued [4]. As a consequence, developed societies have put emphasis on the value of innovation, collaboration, and creative problem solving, over standardized knowledge [5]. Therefore, the economy of developed societies is shifting from an *industrial* economy, that valued manufacturing work and standard memorization of procedures, towards a *creative* economy, valuing creativity at work [6]–[8]. Knowing this, it becomes imperative to study and develop ways to spark creativity, specially using new technologies, such as social robots.

Scholars have been debating about how to harnesses the creative potential. On the one hand, changes in the traditional school system have been suggested, namely concerning curriculum content, teaching approaches, and education for empowerment [9]. Other developments have been made targeting adults and the workplace, specifically by studying which work environment characteristics stimulate creativity [10], how communication and the quality of the relationship affects creativity [11], and other additional conditions related with creativity nourishing, such as independence and the nature of the task itself [12]. From these variables that influence creativity development, collaboration (or teamwork), defined by a group of people working together towards a common goal by interacting with each other, is known to be one of the most influential factors [13].

In this work, we designed and developed a collaborative activity between a social robot and a human participant to understand the effects of human-robot interaction (HRI) on creativity outcomes. The team was constituted by one humanoid robot and one adult participant that engaged in an open-ended collaborative drawing task. This meant that the "artists" (study participants and the robot) could draw anything. The resulting product, i.e., their final drawing, was evaluated in terms of creativity scores. We compared the results with a control condition constituted by a tablet to investigate the effects of the robot's embodiment and presence on creativity.

II. RELATED WORK

A. Defining Creativity

Creativity is considered one of the highest human cognitive abilities [22]. It is a multi-faced concept with over 60 different definitions in the field of psychology alone [23], [24]. While earliest definitions of creativity described this ability as a function of an individual [14], creativity definition has evolved and is now defined as an interaction between aptitude, environment, and process by which an individual or a group produces a tangible product that is both novel and useful, within the social context [25]. More definitions are present in

TABLE I
Summary of selected definitions of creativity in timeline order.

Author(s)	Creativity definition
Guilford, 1967 [14]	Creativity is defined as the embodiment of thought in the form of external behavior, consisting of three characteristics: fluency, flexibility, and originality.
Torrance, 1998 [15]	Creativity is viewed as a series of flows, including problem identification, speculation, construction of hypothetical assumptions and creation, and the sharing of ideas with others.
Amabile, 1996 [16]	Creativity is regarded as the interaction between the individual and its external environment, including three components: domain-relevant skills, creativity-relevant skills creative-thinking skills, and task motivation.
Sternberg and Lubart, 1996 [17]	Creativity is perceived as an ability that everyone has, though with varying levels that are affected by the combination of six types of different and interrelated elements: intellectual abilities, knowledge, thinking styles, personality, motivation, and environmental elements.
Boden, 2004 [18]	Creativity is composed of Psychological and Historical creativity: P-creativity involves coming up with a surprising, valuable idea thats new to the person who invented it; an idea is H-creative if no one else has had it before and it has arisen for the first time in human history.
Baer and Kaufman, 2005 [19]	Creativity is explained through the lenses of the Amusement Park Theory that states intelligence, motivation, and a suitable environment, are necessary pre-requisites of creativity.
Sawyer, 2017 [20]	Creativity is understood in the context of a group emergence where flow, collaboration, and improvisation processes take place. When group synchrony is reached, it becomes difficult to discriminate the individual contribution of each person, as "the whole is greater than the individual parts".
Cronin and Loewenstein, 2018 [21]	Creativity is a process of following cues to generate insights that change our perspectives, which with the craft we can use to form inventions and enlightenment.

the literature, and an overview of selected creativity definitions can be found in Table I.

Creativity is also composed of different domains, namely figural and verbal. While figural creativity involves creative thinking in visual arts (e.g., drawing, painting, sculpting), verbal creativity relates with communication of ideas and thoughts (e.g., poetry, discourse, and communication) [26]. Creativity is also characterized in terms of the "four P's of creativity", that represent essential cornerstones for creativity research. These four P's are the Person (covers information about personality, intellect, temperament, physique, traits, habits, attitudes, self-concept, value systems, defense mechanisms, and behaviour), Process (relates to motivation, perception, learning, thinking, and communication), Product (when an idea becomes embodied into tangible form), and Press (or environment, and refers to the relationship between human beings and their environment) [27]. In light of these dimensions, different tests and interventions for creative thinking were developed (see a literature review on [28]). For additional material on creativity assessment, see [29]–[32].

Given that the nature of our task consists in a drawing activity, our work focuses on *figural creativity*. The final drawing is evaluated in terms of creativity, which means we have focused on the study of the *creative product*, since a creativity score is computed for the final drawing.

B. Collaborative Technology for Creativity

Technology appears as promising in the field of creativity [33]. Lubart (2005), envisions computers promoting creativity in different ways and has defined fours possible future roles for computers in the field of creativity [34]:

- **Computer as nanny** – computers encourage creativity by monitoring the working process and supporting the potentially creative person according to the progress made.
- **Computer as pen-pal** – computers facilitate the exchange of creative ideas between diverse people by integrating and represent them on a physical space.
- **Computer as coach** – computers can support the creative process by providing information in different ways that people can come up with creative ideas, serving as analogs to jump-start the creative process.
- **Computer as colleague** – computers work in a real partnership in the creative process with humans, and this is the most ambitious vision of humancomputer interaction.

Computers have already been used to serve as a tool to help game designers to co-design new levels for their games, acting as a colleague, showing a positive influence for the creative level design process [35]. Additionally, when children create a story with autonomous virtual agents in a tablet app, their creative idea generation process is richer with more fluency of ideas, demonstrating that the autonomous behavior of technology can spark creativity in a storytelling task [36]. Other interesting projects with virtual environments have been developed to demonstrate technological creativity, e.g., [37].

Robots have also joined technologies for creativity promotion. A social robot was used to encourage participants to generate creative ideas for their Zen Rock Garden. The results showed that participants engaged in the creativity task for longer periods of time and provided almost twice the number of creative expressions in the robot condition compared to the PowerPoint condition [38]. A different study used a social robot to stimulate curiosity, an essential creative trait, in children. Children's curiosity levels were higher after interacting with the curious and social robot, denoting the impact
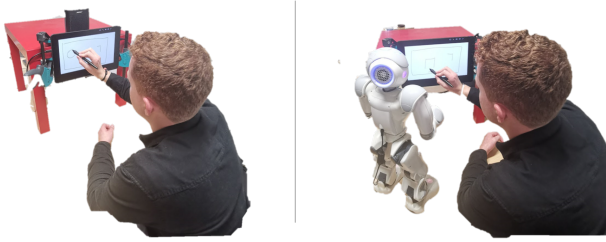
Fig. 1. Experimental study conditions: *on the right:* participant drawing with a robot; *on the left:* participant drawing with a tablet.

Fig. 2. Examples of final drawings: *on the right:* drawing made my a participant and a robot. The green aspects of the drawing were the elements drawn by the robot; *on the left:* drawing made by a participant and the tablet. The red strokes are the elements drawn by the tablet.

o robots in humans' creative behavior [39]. Additionally, a robot is being used to stimulate creativity in children during a storytelling task. This robot aims to act as a character in children's stories providing additional ideas for their story plot. Preliminary results were promising in relation with creativity stimulation [40]–[42].

III. EXPERIMENTAL STUDY: ROBOTS FOR CREATIVITY SPARK

This work is a design proposal that envisions social robots as drivers for human creativity. To test the hypothesis that robots can play a role in stimulating human creativity, we created a scenario in which a human participant and a robot collaboratively draw something together. This was compared to another study condition in which a participant draw collaboratively with a tablet. For a visual representation of the study conditions, see Figure 1. The drawing task has a collaborative nature because the robot and the human take turns during the drawing process. Additionally, the drawing was open-ended, which means that no specific instruction for a drawing was provided and the task only finishes when the human participant is satisfied with their drawing. The goal was to test if the embodiment and the presence of a robot can stimulate human creativity. It is established in the HRI literature that the mere physical presence of a social robot influences the interaction with the human counterpart [43]–[45], making our research question the following: *can the embodiment and the presence of social robot lead to human creativity during a collaborative drawing task?* Furthermore, our study hypothesis is that *during a collaborative drawing between a human participant and a social robot, figural creativity levels on the human will increase, compared to drawing with a tablet.*

A. Participants

A total of 28 participants were involved in this study, being randomly distributed across two study conditions (robot or tablet conditions). Participants in the tablet condition were 22-30 years old ($M = 24.25$, $SD = 2.33$), 57.1% male, and 57.1% had interacted with a robots before; participants in the robot condition were 19-33 years old ($M = 24.35$, $SD = 4.49$), 71.4% male, and 64.3% had interacted a robots before. Participants were recruited from the Technical University of Lisbon in Portugal, constituting a student academic population. Their participation was voluntary, and each participant signed
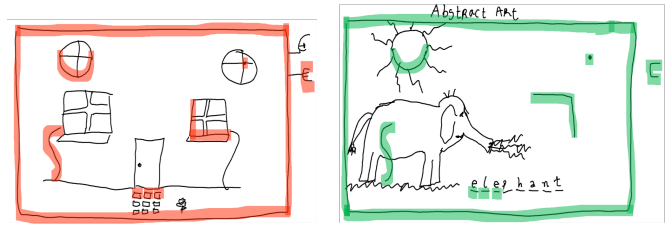
a consent form prior to the starting of the study and assented to participate.

B. Creativity Measure

We used the Test for Creative Thinking-Drawing Production (TCT-DP) test to measure the figural creativity of the human participants. TCT-DP is a well established test in the field of creativity, applicable to persons of a broad age range, is culture-fair, and helps identifying high creative potentials as well as low creative, neglected, and poorly developed ones [46]–[48]. A version of the test adapted to the Portuguese population was used [49].

TCT-DP consists of a sheet of paper with six graphic elements of a circle, a dot, a dashed line, a 90-degree angle, a curved line, and a small open square, placed at fixed and pre-established locations on the page. All of the elements, except for the small open square, are enclosed in a large rectangular frame, and this forms a short of an incomplete drawing. In its traditional form, participants are instructed to "complete the drawing initiated by an artist" and must produce a drawing using these elements. In the case of our study, we changed the instruction and participants were told to "draw something together with the robot", since the this was a collaborative drawing task. In our case, the robot (or the tablet) would draw the already six graphic elements predefined by the creative test and participants would complete the drawing. This ensured that the drawings made by the robot or the tablet across all study sessions were the same, thus, controlling for the creativity stimuli. For an example of how the drawings looked like, see Figure 2. In our study, instead of a sheet of paper used in the traditional application of the TCT-DP, we used a tablet for the drawing task. We opted for this method because the NAO robot (https://www.softbankrobotics.com/emea/en/nao) used for our study lacks dexterity to write. Therefore, a tablet was used to simulate the robot's drawing ability.

The final drawing made by the participants and the robot was scored according to the 14-point scoring system using in general an ordinal measurement scale, proposed by Urban (2005) [47]. A trained psychologist that underwent TCT-DP training scored each drawing. The criteria used to code the drawings are the following:

1) **Continuations (Cn)** – number of graphic elements used among the initial elements proposed.
2) **Completions (Cm)** – number of graphic elements used in a meaningful way.
3) **New Elements (Ne)** – number of new items added to the composition.
4) **Connections with lines (Cl)** – number of contacts established between the initial graphic elements.
5) **Connections made that contribute to a theme (Cth)** – degree to which the elements were connected thematically.
6) **Boundary-breaking being fragment-dependent (Bdf)** – use of the element outside the frame.
7) **Boundary-breaking being fragment-independent (Bfi)** – use of added elements outside the frame.
8) **Perspective (Pe)** – use of three-dimensional drawing techniques.
9) **Humor, affectivity/emotionality/expressive power of the drawing (Hu)** – creation of a humorist or emotional atmosphere.
10) **Unconventionality B (Uca)** – Unconventional manipulation of the paper. Because we used a tablet for participants to draw that had a fixed location on the table to enable the robot to simulate its drawing, we have excluded this score from our study.
11) **Unconventionality B (Ucb)** – use of abstract, surrealistic, fictional and/or symbolic themes.
12) **Unconventionality C (Ucc)** – use of words, numbers, and/or cartoon-like elements.
13) **Unconventionality C (Ucd)** – non-stereotypical utilization of fragments of figures.
14) **Speed (Sp)** – Time for completion of the drawing. Since we did not limited the time that participants could draw with the robot to avoid imposing many restrictions on this task, we have excluded this score from our study.

C. Procedure

Before starting the experiment, participants were asked to read and sign a consent form. After that, the drawing task began and the participant sat in front of the tablet while listening the instructions that the researchers provided, being free to ask any clarification question. The instruction provided to the participants was that they would be "drawing with the robot (or the tablet) something they wished." When everything was clear, the wizard-of-oz (WoZ) started. Both the robot/tablet and the participant had two turns to contribute to the drawing. When the 4 turns were finished, the participant would signal the researchers that the drawing was complete and the experiment finished.

D. Results

We analyzed the impact of the robot on the human creativity, by using the non-parametric Mann-Whitney U Test given that our sample followed a non-normal distribution. The between-subject factor was the embodiment (robot or tablet) and the within-subject factor was the score computer

for figural creativity. There was no significant main effect of creativity nor a significant interaction between the embodiment and creativity, $U = 91.000$, $p = 0.400$. Additionally, we explored two additional dimensions of the TCT-DP introduced by Nogueira (2017), namely conventional and the non-conventional thinking [50]. The reliability of the items for the non-conventional thinking was poor, $p = 0.475$, and questionable for the conventional thinking $p = 0.688$. The Mann-Whitney U Test did not reveal statistically significant results in conventional and non conventional thinking, $p > .5$.

IV. DISCUSSION

Creativity is of paramount importance in our current society. With this work, we provided a speculative design study that aims to explore co-creativity tasks between humans and robots. Having robots performing or supporting the creative human process is a way to explore the design of robots for social good. Indeed, creativity is an ability that is desired in developed societies, and that has the potential to be stimulated if trained [28], [51]–[54]. Despite our experiment being one of the first to explore creativity in the field of HRI, we were not able to support our study hypothesis, as no significant improvement in creativity was found when drawing with the robot. Despite of the desire to include interactive technologies in roles that stimulate and foster human abilities, such as of being creative, doing so is not a trivial task. In the case of our work, designing an experiment with a collaborative drawing scenario proposed challenges that need to be addressed in the design perspective. Particularly, the choice of the task can lead to user frustration (e.g., some said the robot "ruined their drawing"), or have higher expectations over robots' abilities (e.g., some participants had higher expectation of the drawing ability of the robot).

The discussion about creativity allow us to reflect on education and on what is taught and how. In this perspective, this project is critical to reflect on traditional learning strategies, the roles in education, and the content being delivered. As we have highlighted in the related work, creativity is not the mere result of learning information, but the use of such information to produce something that can combine previous knowledge to accomplishment something else – from solving problems of different nature, to come up with innovative ideas. Due to this, it is interesting to explore the potential opportunities offered in the exchange and collaboration with robotic partners, which can be an incentive and a guide for the creative process, making it more stimulating and effective. Consequentially, areas of application for exploring scenarios of co-creation with robots can be framed within the notion of robots for social good. In this regard, more investigation should be made using different methodologies for analyzing the process of co-creation with robots, namely behavioral analysis of the creative process that can yield exclusive results that are not implicated in the final creative product. Also, variables related with the person, such as the their levels of curiosity and acceptance of robots, should be controlled.

The appearance that a robot should have is another interesting reflection for the design of systems that aims of stimulating creativity, by exploring the role of humanoid robots in contrast to minimalist appearance of robots [1]. Additionally, we should consider diversified contexts, such as school, workplaces and other collaborative settings, as well as long-term multi-party interactions, to explore this topic and learn more about the effective application and use of robots for social good.

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