# Human Creativity Can be Facilitated Through Interacting With a Social Robot


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***Abstract*—Is it possible to design robots of the future so that they can enhance people's creative endeavors? Forty-eight young adults were asked to produce their most creative ideas in a small Zen rock garden in a laboratory setting. Participants were randomly assigned to one of two conditions. In one condition, the robot Robovie (through a Wizard of Oz interface) encouraged participants to generate creative ideas (e.g., "Can you think of another way to do that?"), and pulled relevant images and video clip from the web for each participant to look at which could help spur the participant into more creative expressions. In a second condition, participants engaged in the same Zen rock garden task with the same core information, but through the modality of a self-paced PowerPoint presentation. Results showed that participants engaged in the creativity task longer and provided almost twice the number of creative expressions in the robot condition compared to the PowerPoint condition. Discussion focuses on a vision of social robotics coupled with advances in natural language processing to enhance the human creative mind and spirit.**



***Keywords—human-robot interaction; creativity; cooperative interaction design; interaction pattern; natural language processing; social robot***


## I. Introduction

As humans, we create art, music, and machines. We create digital life. We create new ideas that have never been thought of before, and new ways of doing things. Science depends on the creative mind. So does the economic viability of nations today. Is it possible to design robots of the future so that they can enhance human creative endeavors? This paper presents an experimental study that addresses this question.

On a general level, creativity has been defined as (a) the ability to produce novel, original, or unexpected work that is high in quality and appropriate in that it is useful and meets the constraints of the task [1], and (b) any act, idea, or product that changes or transforms an existing domain [2]. Of course, there's a difference between creative expressions that transform a society and the everyday small creative acts that all of us engage in, to varying degrees. Accordingly, researchers have proposed that there is a continuum between two types of creativity [3]. Big-C creativity [4] includes, for example, Watson's and Crick's determination of the structure of DNA, Mozart's compositions, Newton's and Leibniz's (independent) invention of calculus, and Shakespeare's plays. In turn, little-c creativity happens daily in all of our lives, and includes our novel and personally meaningful creative actions [5-9].

As early as the 1990s, researchers have studied ways in which computer technologies can enhance human creativity. For example, Shneiderman and colleagues [10] sought "to develop improved software and user interfaces that empower users to be not only more productive but also more innovative" [10, p. 61]. Others have shown that software that was designed to guide its users through various steps of the creative process (what the researchers referred to as problem presentation, response generation, and response validation, for example) can lead to greater creativity in users' solutions to open-ended problems [11-12]. Also, a simulated software agent (though Wizard of Oz method) was found to have an effect on group collaboration in problem solving by creating new awareness and a focus shift [13].

Given these sort of promising findings in HCI to promote human creativity, it seems surprising that the ideas have hardly been brought forward into HRI. Granted, the HRI literature does show evidence that the mere presence of social robots can improve human performance on certain cognitive and motor tasks, and in particular easy and well-learned tasks [14-15]. But we are not aware of any research that has sought to leverage the affordances of an embodied robot to promote human creativity, except for a recent proof of concept study coming from our own lab [16].

Thus this current study seeks to take a significant step forward in investigating whether human creativity can be enhanced through interacting with a social robot. We focused on "little-c" creative expressions, since they are much more common, and in this way more amenable to experimental investigation. We then needed to settle on one specific aspect of creativity. To do so, we first conceptually distinguished between the production, or restatement of information, which we viewed as a form of learning, from the transformation of information, which we viewed as a creative act. For example, imagine if you were an artist working with oils, and you saw


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Van Gogh's *The Starry Night* and then sought to duplicate it. Even if you rendered a skilled production, people would presumably not think of you as a creative artist. In contrast, if you studied Van Gogh's paintings and then used some of his techniques and images in your own unique way, that seems to us a creative expression, not a production. It might only be "little c" creative if your talents are meagre. But with more talent and good fortune you could transform the art world.

Thus in this study we focused on whether participants could generate artistic techniques and effects, and when presented with specific techniques and effects, whether they only reproduced them or could transform them. The artistic expressions occurred in a small Zen rock garden in our laboratory. We had two conditions. In one condition, the participants were creating while in the presence of a humanoid social robot, which (through a WoZ interface) presented the participant with two modes of interaction that we envision as part of the future interaction modalities of social robots. One was that the robot listened to the participant's ideas and then pulled relevant images and video clip from the web for the participant to look at which could help spur the participant into more creative expressions. The second was that the robot asked the participant general questions—such as, "Can you think of another way to do that?"—to spur the participant's creative expressions. In the second condition, participants were not asked these questions, but engaged in the same Zen rock garden task with the same core information through the modality of a self-paced PowerPoint presentation. We designed this comparison condition with an eye toward ecological validity insofar as people commonly search online for examples of domain-specific content to generate from creatively, without external verbal probes.

While there have been some findings to the contrary [17], generally speaking the HRI literature shows that when interacting with an embodied robot that people increase their participation in the task at hand, compared to interacting with a video display of the same robot [18-19], or a screen-projected computer agent [19]. Thus we hypothesized that participants would be more creative by receiving the information through interaction with the embodied social robot compared to the self-paced PowerPoint.

## II. METHOD

### A. Participants

Forty eight undergraduate students in the age range of 18 to 25 ($M$ = 20.38, $SD$ = 2.06) participated in this study, with 24 participants (14 females, 10 males) randomly assigned to each of the two conditions. Participants received either course credit or $20 for participation.

### B. The Humanoid Robot, Robovie

This study used the humanoid robot, Robovie, developed by researchers at the Advanced Telecommunications Research Institute International (ATR) in Japan (see Figure 1). In the WoZ method, one controller controlled Robovie's locomotion; another controlled when Robovie would say preset units of speech. Many of Robovie's preset units of speech were designed to allow for the insertion of keywords based on specific answers provided by the participant. For example, Robovie would ask the participant to share some past creative experiences that they have had that are somewhat like rock gardening. If the participant provided an answer (e.g., if the participant said that she once made sandcastles in the sand), the speech controller would enter the keyword <*sandcastle*> into a specified field on the control interface, and Robovie would continue on with the tailored response: "That sounds great. Tell me the sort of techniques you used to create your <*sandcastle*>." In this way, we structured a human-robot interaction that was tailored to each participant, and reasonably seamless. In addition, this particular WoZ methodology provided a future framework for making this system autonomous by simplifying the demands of automated natural language processing (NLP) which would need to recognize, extract, and then insert only the keywords. By typing responses, this second controller also could respond through Robovie with real-time brief answers to questions that the participant posed to the robot. Robovie spoke with a natural sounding feminine voice.

### C. The Artistic Creativity Sessions: Human-Robot and Self-Paced PowerPoint

We sequenced the Human-Robot condition drawing on and then extending *Interaction Pattern Design* in HRI [20-23]. Interaction patterns refer to characterizations of essential features of social interaction between humans and robots, specified abstractly enough such that many different instantiations of the interaction can be uniquely realized given different types of robots, purposes, and contexts of use. As an analogy, an *Introduction* between people is an interaction pattern in that it can happen many different ways individually and cross-culturally (with different initial verbal greetings, a handshake, a bow, a Namaste greeting, etc.), but these interactions are similarly structured, serve similar purposes, and when you see them enacted you know you are seeing people being introduced to one another. The *Introduction* interaction pattern has been successfully embedded in studies to facilitate human-robot interaction [24-25]. For the purpose of this study, we employed some existing interaction patterns, and developed and implemented 10 additional interaction patterns for human-robot interaction that aimed to help foster the human creative process (see details below, with each interaction pattern named in italic).

Each participant would come into the laboratory individually and was introduced to Robovie. Robovie would greet her and, after shaking hands and exchanging a few pleasantries (*Introduction*), explained that it was there to help the participant with the task of developing creative ideas for designing a Zen rock garden, adding that: "The objective of the task is not to have a complete design, but rather to try out creative ideas. We want to see your most creative ideas." The experimenter then would leave Robovie and the participant alone to complete the task. Before starting on the task, Robovie first would discuss the reflective and meditative nature of Zen rock gardening and invite the participant to ring a nearby gong and take a moment of silence together (*Sharing Cultural Customs and Beliefs; Invitation to Participate in Cultural*

Fig. 1. Demonstrator engages in rock garden designing with Robovie.

*Practice*). Robovie would then lead the participant (*In Motion Together*) to a rock garden that we built in our lab, comprised of sand, rocks, and a rake. Robovie would inform the participant: "I am here to help foster your creative potential. I am networked to the web and can search for interesting images and videos. There is a wealth of information out there and I can help filter and tailor to fit your specific needs and curiosities. Let's see what we can uncover and create."

We then moved forward with enacting the 10 human-robot interaction patterns that aimed to help foster the human creative process (see the accompanying video for examples of how some of them unfolded in the Participant-Robovie interaction). Robovie started in gently and first asked, "Tell me what you know about Zen rock gardens" (*Define the Creative Space*). Robovie then followed up by drawing on the participant's past experience, "Tell me about your past creative experiences. What sorts of creations have you made in the past that are somewhat like Zen rock gardens?" After the participant responded (e.g., sandcastle, finger painting, etc.), Robovie would then explore with the participant the techniques one would use for whichever creation was supplied by the participant, and how such techniques might be incorporated into Zen rock gardening (*Evaluate Similar Examples*). While conversing with the participant using such probes and encouragements, Robovie also pulled up on a large display some photos of Zen rock gardens in Japan (see Fig. 2), and showed a short video clip (see Fig. 3) of a monk engaged in Zen rock gardening (*Inventory Ideas*). With each photo/video stimulus, Robovie would ask the participant to focus on the features that the participant was drawn to (*Reflect on Intuition*), and then extend the ideas in a more creative way and to try them out on the rock garden design space (*Pushing the Limits*). During this process, Robovie encouraged the participant to adopt new perspectives with probes such as: "I've noticed that you have been drawn to using the rake. Are there other ways you could manipulate the sand" (*Consider the Alternative*)? At the same time, Robovie also kept the participant grounded to the roots of the artistic form with reminders such as: "The rocks are a traditional part of the garden" (*Build on Foundational Work*). In addition, Robovie not only supported novel ideas from the participant with encouragement, such as: "I like *<your use of rocks>*" (*Validate Decision*), but also offered constructive criticism: "That looks very similar to me. Can you do something else" (*Engage in Creative Conflict*)?

Finally, after they had worked through all the visual stimuli, Robovie would ask the participant to engage in one final creative expression: "I'd like you to have one last go. Break loose. One last chance here today to try out your most creative ideas. Let me see what you got" (*Break Loose*). Robovie then remained silent during this break loose period until the participant indicated that she was finished. The experimenter then was alerted by a bell that participant rang, and returned to end the human-robot interaction.

In the Self-Paced condition, the participants worked alone with the aid of a PowerPoint, comparable to how people would work during self-paced online courses and lessons. The experimenter introduced the participant to the rock garden task and instructed her to look through a PowerPoint consisting of

Fig. 2. First picture stimulus shown in both condition.

pictures and a video of Zen rock gardens in Japan (the same photos and video presented in the same order as those in the Human-Robot Collaboration condition). The experimenter would then ask the participant to try out her ideas on the rock garden design space, and—using exactly the same language as Robovie in the Human-Robot condition—emphasize to the participant: “The objective of the task is not to have a complete design, but rather to try out creative ideas. We want to see your most creative ideas.” The experimenter then would leave the participant to work alone, self-paced, until the participant rang a small bell on the table to indicate that she was finished with the task. Both conditions contained the same visual stimuli in the form of the pictures and video. In both conditions, in our instructions to participants we emphasized that the objective of the task was to create different creative ideas rather than a complete design.

In both conditions, from the moment the experimenter left the room, the participants were given up to an hour to work on the rock garden. If a participant finished before the hour was up, she would ring a bell on a nearby table as instructed, and the experimenter would re-enter the room and end the creativity session. If a participant reached the one hour time limit, then either Robovie in the Human-Robot condition or the experimenter in the Self-Paced condition would interrupt and end the creativity session. Immediately following the above interaction, the experimenter conducted an approximately 20-minute individual semi-structured interview with each participant [26-27]. The interviews sought to assess participants’ perceptions of the creative process they had just experienced. See Table 1 for the interview questions that were asked of each participant.

### *D. Creative Expressions Coding & Reliability*

The study sessions were video recorded with multiple cameras to capture every action that the participants performed on the rock garden design space and the stimuli that showed up on the large display. The video recordings were then reviewed for coding. Coders coded participants’ creative expressions from a top-down view of the design space with the video recordings on mute. In this way, the coders were able to maintain objectivity by focusing on the movements being made on the design space without being influenced by the accompanying social dialogue. In order to keep track of when a visual stimulus was seen by the participant, in a separate window the coders also viewed a recording of the design session from an angle that showed the screen displaying the images and video.

Coding began with the participant’s first movement on the design space. In both conditions that first movement sometimes occurred before the participant had seen any visual stimulus, in which case the expressions were coded as creative expressions. After each visual stimulus was seen by the participant, the coders would check off that stimulus on the coding sheet, and from that point forward, if the participant made an expression that replicated a design feature that was tied to that specific stimulus, that expression would not be considered a creative expression, and thus not coded. For example, in Fig. 2, some of the predetermined design features associated with the stimulus are raked single straight line, raked multiple straight line, touching and overlapping of lines, single rock placement, and two rocks touching placement. The list of stimulus features would add up cumulatively, such that with each new stimulus seen by the participant, additional design features associated with the new stimulus would be added to the list of expressions that would no longer be coded as creative expressions. This process continued until the experimenter re-entered, at which point coding ended. Based on our coding records, all participants viewed all five visual stimuli, thus across conditions, all participants received the same amount of stimulus information.

To further illustrate our coding, consider the video that each participant saw of a monk raking a circle pattern in the sand (see Fig. 3). If a participant simply replicated this idea on the design space, as the participant did as shown in Fig. 4, then we viewed that as learning and did not code the act as a creative expression. However, if a participant transformed the idea and created a spiral instead of a circle, or flipped the rake over and created a circle with a different effect, or used a rock as the tool to create the circle, then we coded these expressions as creative. As shown in Fig. 5, for example, the participant transformed the original idea presented in the video stimulus by using a rock instead of a rake to create a unique effect of a rolling circle pattern on the sand.

The coding of creative expressions occurred at three overarching levels: (1) tool usage (e.g., using the back, handle, or a single prong of the rake, using hands or other body parts, using rocks, and other innovative methods such as blowing the sand to shape a pattern), (2) rock placement (e.g., stacking of rocks, leaning of rocks, burying rocks under sand, etc.), and (3) sand pattern (e.g., zigzag lines, dots, spirals, stars, etc.). Participants received one creativity point for each new (qualitatively different) design effect under these three categories. A design effect was not considered a creative expression if the participant (a) reproduced one of their own design effects (already counted as creative), or (b) reproduced one of the design effects shown in the visual stimuli. To be clear, we are not labeling each of the participant’s expressions as high or low, but only as creative or not creative. The participant’s creativity score was computed by totaling his or her number of creativity points received.

Fig. 3. Still capture from the video stimulus of a monk making a raked circle.

Fig. 4. A participant recreating the raked circle stimulus after viewing the video from Fig. 3. This activity was not coded as a creative expression.

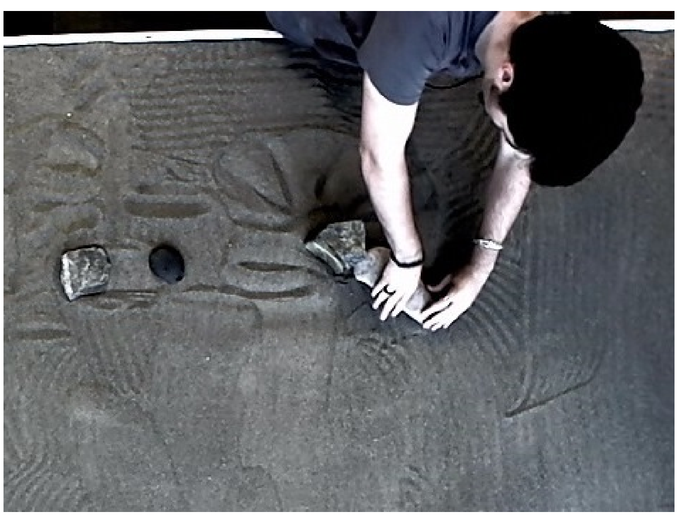

Fig. 5. A participant transforming the rake circle stimulus. After seeing the video depicted in Fig. 3, this participant picked up the rock in his hand and used it (instead of the rake) to make a circle pattern around the center rock. This action was coded as a creative expression.

A second coder trained in the use of the coding system recoded the data for 12 randomly selected participants (6 in each condition). A high degree of reliability was found between creative expression scores: single measure intraclass correlation coefficient (ICC) was .983, with a 95% confidence interval from .941 - .995.

## III. RESULTS

### A. Creative Expressions

The mean number of creative expressions in the Human-Robot condition ($M = 23.58$, $SD = 9.76$) was almost double the mean number of creative expressions in the PowerPoint condition ($M = 12.33$, $SD = 6.08$). A t-test showed a significant difference in the means, $t(38.53) = 4.79$, $p < .001$, $d = 1.38$.

Building on this core result, we then conducted a further analysis that took into account time on task, as we had recorded that information as part of our Method. We found that participants spent longer on the task in the Human-Robot condition ($M = 28.1$ minutes, $SD = 8.64$, range: 15 to 51 minutes) than they did in the PowerPoint condition ($M = 14.3$ minutes, $SD = 8.28$, range: 6 to 43 minutes). This difference was statistically significant, $t(45.92) = 5.66$, $p < .001$. Thus while the participants in the Human-Robot condition did have more creative expressions on average, they also spent substantially more time working on the creativity task.

There is fairly strong positive correlation between the amount of time spent and the number of creative expressions, $r = 0.647$. This relationship is shown in Fig. 6. Note that participants in the Human-Robot condition (solid red dots) tended both to produce more creative expressions and to spend more time on the task than participants in the PowerPoint condition (open circles).

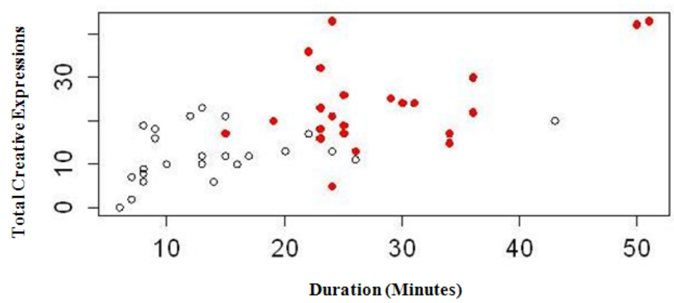


Fig. 6. Total number of creative expressions in relation to duration spent.

Using linear regression to model the total number of creative expressions as a function of duration and the condition (Human-Robot Condition = 1, PowerPoint Condition = 0), we found that the duration of time spent had a significant relationship with number of creative expressions, $t = 3.31$, $p = .002$. We next controlled for duration, and the effect of condition alone was found to be close to statistical significance, $t = 1.93$, $p = .059$, $d = 1.64$.

Finally, we constructed a linear model which included the two variables above along with an interaction term. This model addressed the question of whether or not there was a difference between the two conditions in the *rate* at which participants produced creative expressions. The model including an interaction term did not produce a statistically significant improvement over the model above. This suggests that participants in the two conditions produced creative expressions at similar rates.

### B. Participants' Percetions of Their Creative Process

Table 1 presents results of interview questions on participants' perceptions of the creative process they had engaged in across the two conditions.

TABLE I. PERCEPTIONS OF THE CREATIVE PROCESS

| **Interview Question** | **% Yes/Affirm** | |
|---|---|---|
| | ***Human-Robot*** | ***PowerPoint*** |
| Do you think your rock garden ideas were creative? | 75 | 75 |
| Did you feel engaged in the task? | 100 | 100 |
| Did you feel creative inspirtion while you were trying out your ideas on the rock garden? | 83 | 75 |
| Was having Robovie there helpful or not helpful to your creative process, or neither? | 92 | n/a |
| Some people find that Robovie is supportive of their ideas. Did you find Robovie supportive, or not supportive? | 92 | n/a |
| Some people find that Robovie is critical of their ideas. Did you find Robovie to be critical, or not critical? | 17 | n/a |
| One person I talked to said they really liked working with a robot instead of a person because they didn't feel judged by Robovie in a way they might have been by a person. Do you agree or disagree with that person? | 67 | n/a |

No significant differences were found across conditions in the above responses, indicating that participants largely perceived their experiences similarly across conditions, despite the differences found in their actual performances. In addition, no statistically significant gender differences were found on any of the measures reported in these results.

## IV. DISCUSSION

The core result of this study supported our hypothesis. Recall that we assessed creativity in two ways. One was to count each time a participant generated a new use of a tool or created a new effect in the Zen rock garden. The other was to count each time a participant transformed a technique or effect she or he was presented with (e.g., through a video clip of a Japanese monk creating in a Zen rock garden). Results showed that on average, participants provided almost twice the number of creative expressions in the Human-Robot condition compared to the PowerPoint condition. In addition, the interaction with Robovie seemed compelling to the participants insofar as in the post-task interviews, all of them (100%) said that they felt engaged in the task, and the large majority of them said that Robovie was helpful in their creative process (92%), and that Robovie was supportive of their ideas (92%).

One reason that participants were more creative in the rock garden with Robovie compared to the self-paced PowerPoint is that participants spent more time creating with Robovie. An implication is that a social robot can increase people's time on task and lead to further creative expressions. But time on task was not the only reason. For when this factor was controlled in our linear regression model, there was a close to statistically significant effect by condition ($p$ = .059) on the number of creative expressions. Given our relatively small sample size, this effect is suggestive that the interaction with Robovie itself was influential in increasing participant's creative expressions.

What exactly about Robovie led to more time on task and more creative expressions? One possibility is the simple social presence of an embodied humanoid robot [14-15]. A second possibility is the additional language cues from the robot. A third possibility is what the robot actually did in terms of its interactions being structured by previously established interaction patterns (such as the *Introduction*) and the ten new interaction patterns generated and implemented in this study (such as *Defining the Creative Space*, and *Engaging in Creative Conflict*). By generating and successfully implementing ten new interaction patterns this study extends an emerging body of work on *Interaction Pattern Design* [20-23]. A future direction would be to test the role of the embodied technological form by comparing creativity effects between interaction with a social robot (as in this study) and the same natural language processing and AI embedded in a smartphone.

One limitation of this study was that it did not have a third condition that controlled for a human presenting the same information. Our reasoning was that a single study cannot do everything, and so we focused resources on the control condition that we believed was the most important: the PowerPoint. For that condition allowed us to uncover further unique affordances of the technology when the same information is embedded in a social compared to a non-social form of technology. It also more directly leads to future applications, as we envision robotic systems replacing more conventional and static technological forms of interactions. Still, a future direction of this work would be to investigate if and how creative expressions differ when people interact with a robot compared to another person. For such an investigation, our guess is that different creativity measures would be needed that would be sensitive to different forms of creativity that could emerge between these different modalities of interaction.

A possible critique of our coding system is that we coded all expressions prior to participants seeing the first stimulus as a creative expression, and that it is possible that the participants had already learned these actions elsewhere, in which case (based on our conceptualization) the actions were reproductions not creative expressions. We saw no easy way to assess what domain-specific knowledge participants had beforehand. But in any case, the critique does not seem too serious for two reasons. First, creating in a Zen rock garden is an unusual task for a population living in the United States, so it is unlikely many people had direct experience with the task. Second, even if creativity scores were slightly inflated, they would be slightly inflated across both conditions, and thus make it even more difficult to establish the statistically significant difference that we found.

For a moment now, we would like to step back from the specifics of this study and discuss the larger endeavor that we sought to situate this study within.

Some 5-10 thousand years ago, the rise of agriculture in the Neolithic period allowed for surpluses of food, and the concentration of people in cities, which in turn resulted in the intermixing and transformation of different ideas. That is when creativity has been said to burgeon within us as a species [28-29]. Now, today, we're perhaps at a new junction in human evolution where the "mixing" of ideas can occur with humans interacting not only with other humans and our tools, but with embodied intelligent personified technological systems.

The "look and feel" of our vision at this junction can be conveyed by analogy to research meetings that many readers will have engaged in. Imagine, for example, that you are sitting around a meeting table with a collaborator, and he has a computer keyboard in his hands, which controls a flat screen display on the wall. You're generating new ideas through lively discussion and the intermixing of ideas. As discussion unfolds, your collaborator picks out key ideas, and—in the midst of discussion—searches the web to bring forward relevant timely information. If the discussion was about HRI and creativity, for example, you might have mentioned that you remember Ben Shneiderman having done early work on computer tools to enhance creativity, and your collaborator might quickly search that person's name and the keyword of creativity, and perhaps pull up an abstract of one of Shneiderman's papers for the two of you to look at quickly, to help fuel your discussion. Or your collaborator might search on typical methods used in creativity research, and filter the results, and put those search results up on the screen, if the conversation was going there; or if he thought the conversation would be more generative by going there. He might pull up different definitions of creativity, and juxtapose them, and show how some of the definitions extend what the two of you are talking about. Imagine, too, that your collaborator was skilled in facilitating the creative energies and expressions of individuals, and asked important and generative questions at key times.

Now imagine that this collaborator was not a person but a social robot sitting around the table with you, and leveraging not human intelligence but artificial intelligence (AI) in conjunction with its natural language processing and speech expression. One important idea to see in this possible human-robot modality of the future is that it does not duplicate what a human does in this context, but—because AI works differently than human intelligence—creates new forms of interaction that can spur human creativity in ways that have not been possible ever in the past.

This is a vision of computing and HRI that we are seeking to advance. For this reason, we WoZ'd the social robot Robovie so that the robot could engage the participants in some of the "look and feel" of these interactions.

We are aware that some researchers within the HRI community have spoken against WoZ empirical studies [30] and say that HRI studies should focus on the here-and-now of what robots can actually do. The here-and-now of robots is important, for sure. But WoZ studies are also important for providing insight into what humans would potentially do if we created the robots to perform in the way they were being controlled [e.g., 25, 31-32]. The method can be thought of as a more formal extension of prototyping in HCI: trying to get data on humans interacting with systems not yet built so as to provide guidance on what to build, and how.

For this study in particular, if we could not find creativity effects with a WoZ'd social robot, there would be little reason to put in the necessary large technical efforts to move toward corresponding autonomous systems. But we did find the effects.

What, then, would be needed to move toward an autonomous robot system to enhance human creativity? Perhaps the most difficult challenge is to develop the natural language processing (NLP). Existing conversational NLP systems are being used in an ever-growing variety of contexts with increasingly large user bases, including Siri and Google Now. These systems are developed through large, expert engineering efforts, and their actual substance have narrow conversational expertise (e.g., providing driving directions). This could be one approach to take, while scoping the specific creativity domain narrowly but of relevance. Alternatively, drawing on work by Zettlemoyer and colleagues [33], one could seek to develop new nearest-neighbor techniques to automatically build dialog managers from examples of desired conversational interactions, while using a learned, linguistically informed distance metric to enable generalization from few examples. This approach would alleviate engineering costs, and also support human creativity by mimicking and generalizing the example interactions. It would also allow non-technical users to test and populate the system.

One way or another—and likely through many ways—NLP is advancing quickly. Academic institutions and industry are putting huge resources into this area. It will break open in many consumer venues. A recent advance, for example, involves a new AI version of Mattel's Barbie doll, which can be thought of as a robot doll. While most human conversations with smartphones rarely extend beyond one-question, one answer, the conversations with the new Barbie are said to go 10-200 interchanges deep [34]. Barbie can also remember key information from past exchanges, such as the child's favourite pop star; and Barbie can bring that information forward in later conversation. Our point here is that what we WoZ'd with Robovie is not "pie in the sky" but within technical reach in the near future.

As NLP forms part of the increasingly sophisticated functions of embodied social technologies, including robots, how will these technologies be employed? Will the underlying architectures be oriented mostly to a consumer culture that entertains, driven by corporate marketing? Or is it possible to put forward, as we are beginning to do here, a different vision for this technological revolution—a vision that is in the service of enhancing one of the beautiful aspects of who we are as a species: the creativity of the human mind and spirit.


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