LLM-enhanced Interactions in Human-Robot Collaborative Drawing with Older Adults

Marianne Bossema[1,2], Somaya Ben Allouch[3,4], Aske Plaat[2] and Rob Saunders[2]

***Abstract*—The goal of this study is to identify factors that support and enhance older adults' creative experiences in human-robot co-creativity. Because the research into the use of robots for creativity support with older adults remains underexplored, we carried out an exploratory case study. We took a participatory approach and collaborated with professional art educators to design a course "Drawing with Robots" for adults aged 65 and over. The course featured human-human and human-robot drawing activities with various types of robots. We observed collaborative drawing interactions, interviewed participants on their experiences and analyzed collected data. Findings show that participants preferred acting as curators, evaluating creative suggestions from the robot in a teacher or coach role. They favored request-based interactions, consulting the robot on demand. When we enhanced a robot with a multimodal Large Language Model (LLM), participants appreciated its spoken dialogue capabilities. However, they reported that the robot's feedback sometimes showed a lack of understanding of their individual artistic goals and preferences. Our findings highlight the potential of LLM-enhanced robots for creativity support and inform design considerations for human-robot co-creativity with the target group of older adults.**

***Index Terms*—Human-Robot Interaction, Human-Robot Collaboration, Human-Robot Co-Creativity, Gerontechnology**

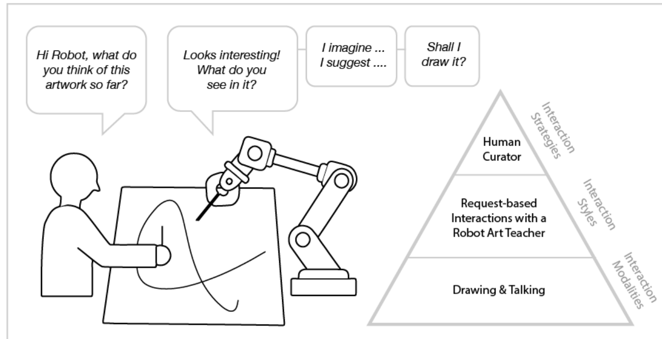


Fig. 1: Impression of an interaction during a course 'Drawing with Robots' for older adults, where we observed and analysed creative collaborations using the Interaction Framework for Human–Computer Co-Creativity [11].

I. Introduction

Engaging in creative activities can improve cognitive health, emotional well-being, and social connection [1, 2, 3, 4]. For older adults, this provides opportunities for lifelong learning and self-discovery, which can be particularly meaningful in later life, contributing to a sense of vitality and active engagement with the world [2, 5, 6, 7]. Although studies have investigated the possibilities of robots for creativity support and art therapy (e.g. [8, 9, 10]), the potential of robotics and artificial intelligence (AI) to support older people in creative activities remains underexplored [10]. As robots and AI become increasingly integrated into daily life, investigating how older adults might collaborate with intelligent systems in open-ended tasks is timely and important. We are investigating this in the context of collaborative drawing, which provides a rich environment to study how humans and robots negotiate ideas, share control, and co-create. Studying collaborative drawing tasks provides opportunities for significant insights into human-robot co-creativity as an open-ended form of human-robot collaboration.

We conducted an exploratory case study using a participatory approach to observe older adults in co-creative interactions. Actively involving the target group in Human-Robot Interaction (HRI) design fosters acceptance [12, 13, 14]. We organized an eight-week course "Drawing with Robots" together with professional artists, leveraging their artistic and educational expertise. Two groups of seniors (n=18) engaged in human-human and human-robot drawing activities. Participants' feedback shaped the course, and we tried out interactions with robots of varied designs and behaviors III. Data analysis was guided by Kantosalo et al.'s Interaction Framework for Human–Computer Co-Creativity [11], examining Interaction Modalities, Styles, and Strategies to map participants' needs and preferences (Figure 1).

This paper addresses the research question of how we can design interaction strategies, styles and modalities to support human-robot co-creativity for older adults. We contribute by expanding the understanding of co-creative HRI and identify design considerations based on these findings: a) Participants preferred the role of human curator, evaluating creative suggestions from the robot in a teacher or coach role; b) They favored request-based interactions, maintaining control over the creative process; c) Spoken dialogue with the robot was well received; however, d) while the robot provided inspiration through conversation, its feedback often lacked awareness of participants' individual artistic goals and preferences.

In Section II we present foundational concepts and related works. Section III details the participatory methodology, the robots used, and the methods for data collection and analysis. Section IV presents the results, highlighting the main themes. In Section V we discuss findings, explanations, and limitations. Section VI concludes with a summary of findings and proposed key design considerations.

II. BACKGROUND

This section highlights foundational concepts and related works, informing our approach and research questions.

A. Designing with and for Older Adults

As discussed in the introduction, creative activities provide benefits for older adults, while the role of AI and robotics in supporting creativity for the target group remains under-explored [10]. Lee and Riek [14] argue for a shift away from viewing aging primarily as a process of decline, toward a more supportive, developmental model. One solution is to involve older adults as co-designers in the robot design process. They propose that this approach values the existing strengths of older adults and may create more sustainable solutions for them. Ostrowski et al. [13] examined older adults' views on social robot interactions during a year-long co-design process. Participants provided detailed insights, identifying key areas for development. The research argues for continued collaboration with older adults to ensure responsible and human-centered robot design. These studies informed our participatory approach, in which we closely collaborate with older adults in a long-term, eight-week course, where participants meet once a week, and help select the most promising directions for further research.

Next to taking a participatory approach, it is essential to build upon literature on older adults' needs, motivations, and interaction preferences. Research has shown that older adults, compared to younger individuals, are less likely to use trial-and-error strategies and rely more on existing knowledge [15, 16]. However, this varies between individuals and depends on factors such as the effort required to set goals, take action, and evaluate outcomes [17]. In addition, there are affective factors, and it has been shown that instructional frames that portray a positive account of aging can improve learning [18]. In their work on Self-Determination Theory, Deci and Ryan emphasize that satisfaction of the basic psychological needs for autonomy, competence, and relatedness enhances motivation and learning [19]. Heckhausen's Motivational Theory of Lifespan Development [20] suggests that people aim to maximize control over their environment to meet personal needs and desires. Individuals actively adapt their motivational strategies to maintain a sense of control and well-being, which has an impact on exploration and learning [17].

This suggest that older adults' sense of autonomy and control should be taken into account when designing co-creative HRI for the target group.

B. Interaction Strategies: Collaboration Roles and Modes

Interaction strategies determine what a co-creative system focuses on and how it adapts over time, based on evaluation metrics, goals, and reasoning [11].

Lubart [21] outlines four key robot roles (nanny, penpal, coach, colleague) based on conventions, reflecting familiar patterns. Maher [22] describes three main functions for computers in human-computer co-creativity: support, enhance and generate. Kantosalo and Toivonen [23] argue that there is an overlap between these classifications, and propose two modes: task-divided and alternating co-creativity. In alternating co-creativity, partners take turns in creating a new concept evaluated by both parties, and in task-divided co-creativity, partners take specific roles within the co-creative process, producing new concepts evaluated by one party.

Deterding et al. [24] introduced Mixed-Initiative Creative Interfaces (MICIs) as a new paradigm of computational creativity, enabled by developments in AI. A MICI can be considered a form of alternating co-creativity, allowing both human and computational agents to shape the process dynamically. This requires balanced agency, with human and computer equally contributing and influencing the creative process. The computer acts as a partner that complements and challenges human creativity, with the process evolving in a closed feedback loop through continuous, reciprocal input.

There are unanswered questions on how interaction strategies affect (perceived) control and creative autonomy in human-robot co-creativity with older adults.

C. Interaction Styles: Behaviors Supporting Co-creativity

Interaction styles are the structured ways humans and computers interact during co-creative tasks [11]. While Kantosalo et al. conceptualize turn-taking, request-based, and operation-based interaction styles, Rezwana and Maher analyzed existing co-creative systems, and propose that collaboration styles are structured through participation styles (turn-taking or parallel), task distribution (shared or distributed tasks), and the timing of initiative (planned or spontaneous) [25].

In addition to these interaction styles, psychology and education studies have highlighted specific behaviors for creativity support and collaboration. Han et al. examined the impact of perspective-taking feedback on creative performance and evaluations, finding a significant positive effect on self-reported creativity. They suggest that considering another person's perspective involves continuously assessing their knowledge, goals, and intentions [26]. Similarly, Eyal et al. advocate for 'perspective getting,' a bottom-up approach in which individuals actively seek information from others, for instance by asking questions and processing responses [27].

Research in human-robot co-creativity has demonstrated that educational techniques such as demonstration and scaffolding provide valuable opportunities for creative support. In a study by Hubbard et al. [28], a robot demonstrating verbal creativity in storytelling promoted creative responses in children. Likewise, Ali et al. [9] found that a robot employing scaffolding techniques—such as asking questions, prompting, and making suggestions—enhanced children's creativity. Scaffolding helps structure interactions and provides adaptive guidance, enabling individuals to learn and engage more effectively when they encounter challenges [29, 30, 31].

The opportunities of these behaviors have not yet been explored in human-robot co-creativity with older adults.

D. Interaction Modalities: Drawing and Talking

Kantosalo et al. [11] define Interaction Modalities as the mediums of communication implemented through one or more sensory channels. In human-robot collaborative drawing, communication primarily takes place through the visual channel; the drawing product. In addition, other information channels may be used. Rezwana and Maher [25] reveal a significant gap in communication channels, with most systems only able to communicate through the shared product, without providing direct feedback. They argue that introducing diverse communication modalities can enhance coordination and improve the quality of collaboration.

Recent advancements in LLMs open up new opportunities for communication, supporting interaction dynamics and the negotiation of control. Zhang et al. [32] argue that the integration of LLMs with robotics has introduced a transformative paradigm in HRI. They reviewed recent advances and explored how LLMs can be used in robotic systems for complex tasks. The researchers conclude that despite the advancements, challenges for simulating contextual understanding remain. Allgeuer et al. [33] explore the use of LLMs to equip robotic agents with human-like social and cognitive abilities for open-ended conversation and collaboration. They integrated an LLM with a robot's sensory perceptions and capabilities, combining speech recognition, object detection, and gesture detection. The LLM acts as the central coordinator, enabling natural, interactive control of the robot. Dogan et al. [34] advocate for integrating human explanations with the common sense knowledge of LLMs to help robots navigate complex tasks while adhering to social norms and accommodating individual preferences. Meanwhile, Spitale et al. [35] examine the appropriateness of an LLM-equipped robotic well-being coach. They emphasize the importance of follow-up questioning to prevent bias and stereotyping, arguing that the robot should avoid making assumptions without human clarification.

LLMs can enhance robots with advanced conversational abilities, however, challenges remain in contextual understanding, ethical alignment, and mitigating bias.

E. Underexplored areas

Human-robot co-creativity with older adults has been underexplored, including the design of robot behaviors to support creativity with the population. While autonomy and (percieved) control are known to be important, it is unclear how interaction strategies, styles and modalities shape creative experiences with older adults. Although LLMs can enhance HRI with advanced conversational skills, challenges in contextual understanding remain to be further explored. Our research question addresses these areas, looking at how we can design interaction strategies, styles and modalities to support human-robot co-creativity for older adults.

III. Methodology

Between May and October 2024, we organized a course 'Drawing with Robots' for older adults. The course consisted of eight sessions and was offered to two groups of older adults, aged 65 years and over (n=18). For each group, an artist and a volunteer were involved, experienced in working with the target group. During the sessions, the first author of this paper

(a) human-human drawing week 1 (b) human-human drawing week 4

(c) presenting artwork to the group (d) group discussion

Fig. 2: Human-human drawing and group discussions.

attended as an observer, while a student assistant was operating the robots. The project received funding from a Dutch Cultural Funding agency that aims to promote the enjoyment of life of seniors in The Netherlands through active art practice.

We took participants' creative input as a starting point to encourage active engagement. We valued their perspectives and welcomed feedback they considered meaningful in relation to any aspect of the course. In the course, we offered human-human and human-robot drawing activities in dyadic and group settings (Figure 4). The robot prototypes had varied physical designs and behaviors, further described below. This allowed for observing people's reactions, and to map out the needs and desires of participants when collaborating with robots that have different forms of intelligent behavior. Data analysis was guided by the Interaction Framework for Human–Computer Co-Creativity by Kantosalo et al [23]. This framework defines key aspects of creative human-computer collaboration at three domain-agnostic levels: interaction modalities, interaction styles, and interaction strategies. Modalities encompass the channels for exchanging information, styles describe the behaviors, and strategies are the goals and plans steering these behaviors (Figure 1).

A. Participants

Participants were recruited through the art teachers' networks and an Amsterdam welfare organization. All participants were independently living seniors aged 65 years and over, sixteen women and two men. In the first group (n=10), there were four people with a mild cognitive disability (n=4). The course for the first group ran from May to mid-July 2024, and was organized in a community center for participatory arts, a familiar place for these four participants. The course for the second group with eight elderly (n=8), ran from early July to late August 2024. None of the participants had any impairment. The courses were held in two loca-

TABLE I: Outline of the weekly course program. For image impressions see Figures 1 and 2.

	Activity	Interaction Strategies, Styles, Modalities	Robot type / capabilities
1	Human-human collaborativ drawing, dyadic	Peer collaboration, Dynamic, Drawing and talking	No robots
2	Designing / drawing with bristle bots, group	Robot as artist, Dynamic, Drawing	Bristle bots, reactive agents
3	Drawing with mobile drawbots, group	Robot as artist, Dynamic, Drawing	Mobile robot, sensor-driven, pre-programmed
4	Imitation game, human-robot, dyadic	Peer collaboration, Turn-taking, Drawing	Robot arm, sensor-driven, pre-programmed
5	Imitation game, human-robot, dyadic	Peer collaboration, Turn-taking, Drawing	Robot arm, sensor-driven, pre-programmed
6	Circle drawing game, humans-robot, group	Peer collaboration, Turn-taking, Drawing and text	LLM-enhanced robot arm
7	Structured dialogue, human-robot, dyadic	Robot as coach, Request-based, Drawing and talking	LLM-enhanced robot arm, TTS
8	Open dialogue, human-robot, dyadic	Robot as coach, Request-based, Drawing and talking	LLM-enhanced robot arm, TTS, STT

tions in Amsterdam, a Dutch university campus and a center for contemporary art. The courses were concluded together with a closing party, where participants presented their work, exchanged experiences, and reported on insights gained. All participants gave informed consent on data management before starting the course. The information letter and consent form were approved by the University's Ethics Review Committee.

B. Collaborations

The two artists involved had experience as art teachers for older adults. Each artist formed a team with a volunteer they had worked with before. One artist-volunteer pair was assigned to the first group and the other to the second, remaining with their respective groups for the entire course. Before the start of the course, in January 2024, the first author organized a brainstorming session with the artists and volunteers to discuss the course program and activities. With the same group, there was a pilot test in April 2024 to try out the robot prototypes and to collect feedback for improvements. The robot prototypes were developed by the first author, with support from computer science students. A graduate student, working at the RobotLab of the university, was present before and during the course to assist the first author. After each session, the first author and the artists evaluated the session and discussed the program for the next. Although robot prototypes had been prepared in consultation for specific activities, changes could be made in the use of the prototypes in the art lessons, based on the provided feedback.

C. Course Design and Principles

During the eight sessions of each course, participants engaged in various collaborative drawing activities (Table I) using traditional drawing media. This choice was made because of the familiarity of the target group with these media. Moreover, it offers opportunities for multimodal, multi-sensory experiences that can enhance creative engagement [36], and can be supported by embodied, co-present human-robot interactions. Each session started with an introduction by the art teacher, explaining the session program. When relevant, the operation of the robot prototype was demonstrated. After the introduction, participants went through the same rounds: 1) an exercise to get acquainted with the materials, the robot, and the form of interaction (Figure 2b); 2) in-between group reflection (Figure 2c); 3) working towards a collaborative end product; and, 4) final group discussion (Figure 2d). During sessions with a single robot, we set up a circuit with the following steps: 1) exploring techniques in human-human collaborative drawing interactions; 2) collaborating with the robot; 3) talking to the first author about experiences; and, 4) elaborating on the artwork, and if desired returning to step 2. During the sessions, the artist and the volunteer gave feedback and answered questions. The first author observed participants' interactions with the robots and each other, focusing on interaction modalities, styles and strategies [11], to identify factors that encourage playful exploration, learning, and enjoyment in creative activities. Observations were recorded in the form of notes, photographs, video, and audio.

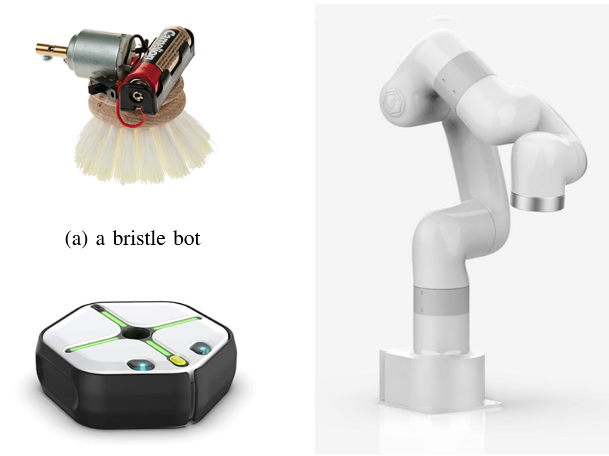
D. Course Activities

Weekly activities and the robot prototypes are described in the following subsections, see Table I for an overview.

1) Human-Human Collaborative Drawing: In the first session, participants worked in pairs to create a shared collaborative drawing (Figure 2a). They were free to choose a form of collaboration, a drawing style or a subject. It was emphasized that the goal was to make a collaborative artwork, and to use the entire canvas as a shared space. Participants were given watercolor pencils in vivid colors and water pens, brushes with a refillable water reservoir, allowing for blending and watercolor effects. We observed interactions strategies, styles and modalities.

2) Human-Robot Collaborative Drawing: The robot prototypes used in the following sessions had different designs and capabilities for collaborative behavior, see Figure 3. We observed how participants reacted to the robots and noted differences in ways of interacting with them.

For the activity of **making small drawing machines**, we used bristle bots (Figure 3a) equipped with a small DC motor, causing the bots to move by vibrating their bristles against a surface. These bots lack any perception of their surroundings. Movement is determined by motor vibrations, physical structure, and collisions with other objects. Their small size allowed for easy picking up and repositioning. We provided a collection of materials that the bots could drag around, leaving trails when dipped in paint. Participants were encouraged to experiment with the materials and the drawing patterns that emerged. After an individual trial run, all the bots were brought together on a shared canvas. Participants named their robots and introduced them to the group, after which we created a collaborative artwork (Figure 4a).



(a) a bristle bot

(b) uFactory Lite 6

(c) iRobot Root

Fig. 3: Robots used in the course.

In order to explore how participants would collaborate with a simple reflex agent, we introduced the activity of **drawing with a mobile robot** (Figure 4b). We used two iRobot Root robots, hexagonal robots approximately 170 mm in diameter and 45 mm in height [37] (Figure 3c). These robots can move while holding a pen and are equipped with color- and touch sensors, enabling them to respond to colors on the canvas and to touch input. We programmed them using the iRobot® Education Python® SDK [38] to draw either curved or straight lines and respond to colors by changing direction or drawing patterns. One robot was set to draw curved lines and circles, while the other made straight lines and triangles. Participants could control the robots by repositioning them on the canvas, touching them to start/stop or drive fast forward, and by using colors to influence their drawing behavior. In the first round, two groups of 4-5 participants experimented with both robots to create patterns and compositions. In the second round, the same groups could either continue drawing with the robot or remove it to further work on the composition.

Next, there were two weeks with activities of dyadic **drawing games with a robot arm**. We used an Ufactory Lite 6 robot arm [39], see Figure 3b, programmed with the xArm Python SDK [40], together with an infrared touch frame to detect the users' drawing movements. Both activities were 'imitation games', where human and robot took turns, and the robot responded by drawing a transformed version of the previous human stroke(s), see Figure 4c. In the first game, the robot mirrored the participants' strokes, which could be used to draw primitive masks, ornaments, or insects. In the second game, the robot repeated each stroke multiple times, starting from the endpoint of the previous stroke, allowing participants to create plants or other recursive patterns.

In the last three sessions, we equipped the **robot arm with a multimodal LLM** and attached a webcam to capture the drawings. We implemented the OpenAI Developer API [41] in a Python program to facilitate the integration. In session 6, the robot participated in a group drawing activity, where each member added to a drawing before passing it on (Figure 4d). When the robot received a drawing, it was captured and sent to GPT-4o [41], along with a list of words corresponding to folder names containing SVG files of human-made sketches [42]. The prompt instructed GPT-4o to select a word that had not been chosen before. The temperature variable was set to the default value of 1. Based on the chosen folder name, an SVG file was selected and converted into a set of points for the robot to draw. Location and scale of the robot drawing were determined based on the largest open space identified by the OpenCV Distance Transform algorithm [43].

In the following session, we programmed the LLM-enhanced robot arm to function as a conversation partner and enabled voice output using OpenAI's Text-to-Speech model, Whisper-1 [41]. Participants created collages and presented these to the robot during the process (Figure 4e). Artwork was sent to GPT-4o, together with a predefined prompt, asking the LLM for a description and two suggestions. At the end of the robot's spoken response, it suggested to generate an image for inspiration. If the participant agreed, an image was generated using DALL-E 3 [41]. When the image was displayed on a laptop screen, the robot proposed adding a drawing to the collage. If the participant consented, the assistant activated the robot's drawing process as described earlier.

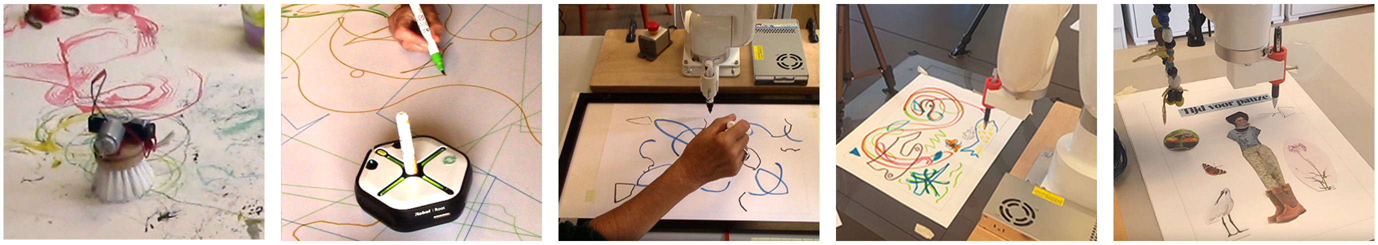
Finally we prepared the LLM-enhanced robot arm for open dialogues by incorporating Speech-to-Text capabilities [41]. Participants could present drawings to the robot and ask open questions, for example, to tell a story about the drawing, or provide specific advice on elements of interest.

E. Data Collection and Analysis

During all sessions, human-human and human-robot drawing interactions were video recorded, capturing the drawing process and conversations of each pair or group from an overhead camera. We took photographs of the interactions and drawings, and audio recorded discussions.

We analyzed audio recordings of the retrospective discussions during sessions 7 and 8. The retrospectives supported comparing the weekly activities, and getting an insight in participants' experiences during the course. We also carried out an analysis of the human-human collaborative drawing videos, recorded during the first session with both groups, to gain insights into the creative dialogues that occur naturally between humans. For both analyses, we applied thematic coding using ATLAS.ti software [44]. After an initial inspection of all transcribed recordings to become familiar with the content, we conducted a following round of systematic coding to identify key themes. Codes were assigned to segments of video based on recurring conversational topics, behaviors and interactions, and were iteratively refined into final themes.

For this exploratory study, we chose member checking as the preferred approach to validate our findings and to ensure that the outcomes accurately and authentically reflect the perspectives and experiences of participants. We organized a session with 7 participants and 1 of the volunteers. We



(a) Week 2: Group drawing activity with bristle bots. (b) Week 3: Group drawing activity with mobile drawbot. (c) Weeks 4 & 5: Dyadic imitation games with a robot arm. (d) Week 6: Group drawing activity with a robot arm. (e) Week 7 & 8: Dialogue with an LLM-enhanced robot arm.

Fig. 4: Weekly human-robot drawing activities.

presented key findings in a presentation with photographs of the course activities and used participants' quotes to illustrate the major themes we defined. We collected feedback by asking whether the findings reflected peoples' experiences and if anything was missing or needed revision. We incorporated peoples' feedback and refined our conclusions, ensuring the findings authentically represent their perspectives.

IV. Results

To gain insight into participants' self-reported experiences, we analyzed the retrospective discussions from sessions 7 and 8. This allowed for a retrospective comparison of robot types and interactions. In addition, we analyzed the human-human collaborative drawing interactions from the first sessions. We used the Co-Creative Framework for Interaction Design [11] for the analysis, looking at Interaction Modalities, Styles and Strategies.

A. Interaction Modalities: Drawing and Talking

1) Analysis of Retrospective Discussions: When we equipped the robot with an LLM and spoken dialogue functionalities, the robot became a conversation partner. During the retrospective discussions, participants highlighted several ways in which human-robot conversation could support their creative process (Figure 5). For example, participants mentioned that the robot's detailed descriptions helped with attentive observation (n=5), and its suggestions or stories provided inspiration (n=5). One participant appreciated the motivation it offered: *"I really like that I don't have to make something beautiful. That I can just make something crazy. And that the robot is also happy about it and says: oh, how nice!"* Another participant valued the structured feedback: *"The robot adds creativity because it clearly structures what the subject is, what you can do with it, and how to work it out."* Conversations were seen as useful at various moments during the process (n=2), especially when participants needed direction: *"It's inspiring when you have no idea how to proceed, but I also like to try things myself first. It could be helpful throughout the process, depending on the needs of the person drawing."* Participants mentioned that conversation also provides opportunities for step-by-step instructions (n=2) or personalized tasks to challenge creativity (n=3): *"Yes, giving assignments, like we got from the teacher now. That would be nice."*

2) Analysis of Human-Human Collaborative Drawing: Analysis of human-human collaborative drawing interactions revealed that all pairs naturally engaged in spoken dialogue while drawing. Throughout the interaction, participants continuously exchanged information about the drawing process and product. Conversation varied based on individual needs at different stages during collaboration. Figure 6 shows a timeline plot of drawing and conversational actions, observed during a typical session. Initially, conversation was used to negotiate goals and approach. After that, it flowed seamlessly alongside the drawing activity, allowing participants to keep an eye on the canvas while communicating, without needing to pause or switch contexts. While participants generally started by taking turns, they were sometimes drawing simultaneously once they could anticipate each other's actions. The timeline plot (Figure 6) highlights conversational strategies for coordination and sense making during the drawing process, occurring across all teams, though with varying frequencies and timing.

In human-human collaborative drawing, participants naturally used spoken dialogue to build common ground. They also appreciated this communication strategy when collaborating with a robot. Conversation allowed for an extra communication channel, next to the drawing product itself.

B. Interaction Styles: Dialogues supporting co-creativity

Through conversation, the LLM-enhanced robot was able to make suggestions, tell stories and generate images in response to participants' artistic expressions. Recognizable analogies and semantic relationships helped people connect visual elements from their drawings to the robot's responses. Participants mentioned that human-robot conversation contributed to this alignment (n=7): *"The robot gives a suggestion that fits your drawing. That's good."* Participants explained however, that the robot also missed aspects that they themselves imagined (n=5) : *"The robot mentioned it all, but didn't really go into the symbolism."* Another participant had an abstract idea of what her drawing was about: *"So for me it was speed versus frozen time, so to speak."*, while the robot only responded to the literal things detected in the drawing. Using an LLM allowed the robot to generate answers and simulate understanding, based on the information embedded in the LLM training data. Participants' reactions suggest that the preferences, needs and skills of the human interaction partner were not yet sufficiently taken into account.

The robot's own drawing capabilities were not equally important to everyone. Some participants indicated that they preferred to draw themselves, and were more interested in the conversational capabilities of the robot for creativity support (n=5), others explained that they wanted the robot to teach them how to draw (n=2). A robot demonstrating and teaching drawing techniques seemed useful to them: *"For example, I can't draw depth at all. So I can ask him to teach me that step by step."* For a robot contributing to a drawing, it was felt that this should be personalized and aligned with the goal of the drawing, also fitting the (desired) style and perspective (n=7).

C. Interaction Strategies: Roles, Dynamics and Control

In comparison to the LLM-enhanced robot, people found the other robots difficult to collaborate with. There were mixed feelings about the level of control people had over the creative process, illustrated by statements such as: *"That little robot was really quirky"*. Respondents explained that, when interacting with those robots, they felt frustrated by the lack of control they had in the creative process (n=4).

Some participants indicated that they would have wanted more time and step-by-step instructions to learn how to explore and exploit the possibilities (n=4). One participant explained that the LLM-enhanced robot with spoken dialogue support was the best fit for learning: *"That robot gave me good examples and I could learn from that"*. Once the robot was equipped with conversational skills, it took on an advisory role and people consulted the robot when they wanted. These request-based interactions were different from interactions in previous sessions, with drawing on a shared canvas, simultaneously or taking turns. It shifted the role of participants to that of a curator, being more in control. Figure 4 gives an impression of the weekly human-robot drawing activities carried out during the course. The activities involved different interaction strategies, styles and modalities. When asked about the role of the robot as a peer collaborator taking turns with them on a shared artwork, a participant answered: *"Yes, that was fun, but then it's just a fun experiment. It's not like I'm making something for myself"*. This participant found that peer collaboration left less room for own creative goals and development in the long run. We also discussed the robot in the role of an assistant, carrying out creative tasks in the place of humans. One participant argued that this could be of added value for people who are unable to carry out these tasks themselves, which was considered a different target group than the participants in the course.

V. Discussion

In this section we analyze and interpret results, and relate our findings to existing literature. We identify limitations and opportunities for future research.

A. Methodological Insights

We investigated human-robot collaborative creativity through an exploratory, participatory approach aligned with recommendations for responsible, human-centered robot design through sustained collaboration [14, 13]. This allowed participants to become more familiar with the technology over time, and to explore and compare possibilities based on their experiences. Our method aligns with calls for long-term, participatory engagement in the research and design process by involving older adults throughout the course. Member checking with a subset of the participants and an instructor allowed for adding validity. Using the Interaction Framework for Human–Computer Co-Creativity [11] allowed us to compare interaction strategies, styles, and modalities across different robot types and behaviors, and to analyze participants' responses.

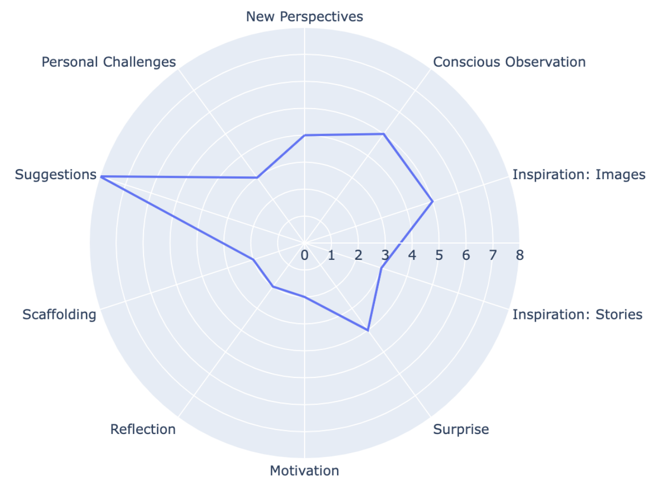


Fig. 5: The robot's conversational strategies that participants reported as useful for creativity support.

B. Interaction Strategies, Styles and Modalities

Participants preferred taking the role of a human curator, evaluating creative content as suggested by a robot in the role of art teacher or coach. Through request-based interactions, consulting the robot on demand, they kept control over the creative process and product. This interaction strategy and style aligns with the concept of task-divided co-creativity [23]. Participants in our study were less inclined toward alternating modes, or mixed-initiative co-creativity as proposed by Deterding [24]. This may be related to Self-Determination Theory, emphasizing the importance of autonomy, competence, and relatedness in learning [19]. Heckhausen's theory on adapting strategies to maintain a sense of control and well-being [20] could also explain a preference for more familiar and predictable forms of collaboration. This suggests that older adults' sense of autonomy and control should be taken into account when designing human-robot co-creativity for the target group.

Regarding the interaction modalities, our results confirm Rezwana and Maher's finding that introducing diverse communication channels can improve collaboration [25]. The LLM-enhanced robot's ability to provide inspiration and feedback

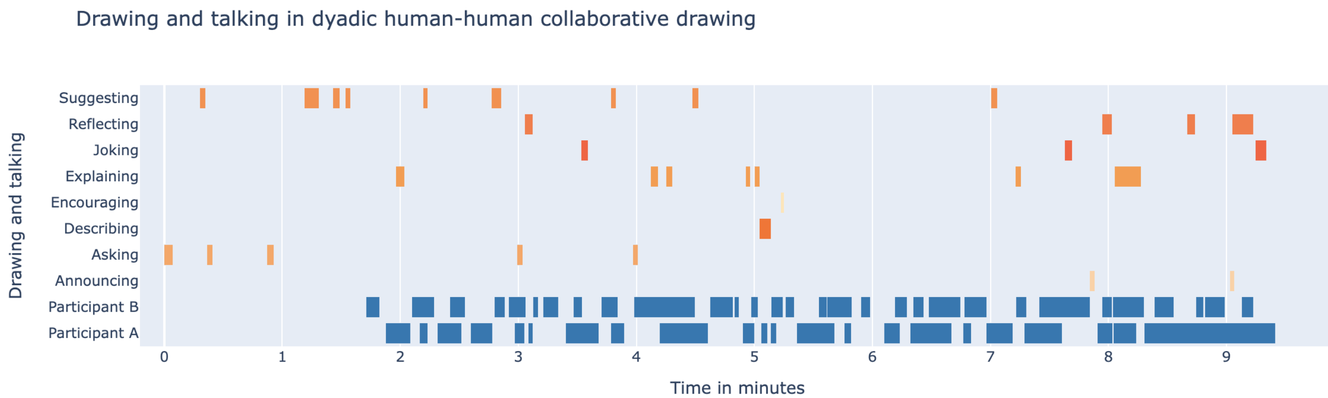


Fig. 6: A timeline of drawing and conversation actions during a typical session of dyadic human-human collaborative drawing.

through conversation resonated with participants. Similar to the studies with children [28, 9], we found that scaffolding techniques can be effective, such as step-by-step instructions and guided learning. Although participants appreciated talking to the robot about their artwork, they also noted that the robot's feedback sometimes lacked an understanding of their individual perspective, their preferences, and artistic goals. This suggests a need for further research into the use of human-robot conversations to improve user modeling. Perspective-taking techniques, such as those proposed by Han et al. [26], could be used to collect data, allowing robots to better tailor their responses to individual artistic goals and preferences.

C. Limitations and Opportunities

This study has several limitations that should be considered when interpreting the results. The exploratory nature of the study means that the findings are based on a small sample size and limited to specific settings, which affects the generalizability of the results to broader populations of older adults. However, this approach allows for the identification of novel insights and directions for future research.

Although novelty in HRI is typically seen as a source of noise that needs to be reduced, first encounters are also informative [45]. In this exploratory study, we investigated first encounters with the technology, which makes a novelty effect inevitable. This might have affected participants' preference for familiar collaborative roles and interaction patterns, allowing for more (perceived) control. Since familiarity develops over time, it is important to further investigate long-term engagement and adaptation, and let older adults become more familiar with novel forms of creative collaboration. Familiarity may also influence older adults' preferences on the distribution of user and robot initiative.

We mapped out forms of verbal communication occurring during collaborative drawing sessions. However, we did not yet look at the role of nonverbal communication, and the dynamics of drawing and talking. There are opportunities to further investigate the interplay of different forms of communication, and how this can effectively support the co-creative process.

VI. Conclusion

We investigated how we can design interaction strategies, styles and modalities to support human-robot co-creativity for older adults. We conducted an exploratory, participatory study with 18 participants and contribute with the following findings: a) Participants preferred the role of human curator, evaluating creative suggestions from the robot in a teacher or coach role; b) They favored request-based interactions, maintaining control over the creative process; c) Spoken dialogue with the robot was well received; however, d) While the robot provided inspiration through conversation, its feedback often lacked awareness of participants' individual artistic goals and preferences. Bringing together these findings and the opportunities identified in the Discussion, we propose the following design considerations and future directions.

- **Interaction Strategies: Dynamic Co-Creative Roles**
  Consider the sense of autonomy and control of older adults when designing for the target group. As this may vary and change over time, explore more flexible role negotiation mechanisms based on user preferences and engagement levels;
- **Interaction Styles: Perspective-taking**
  Further explore how human-robot conversation can contribute to context awareness and user modeling. Perspective-taking techniques can allow for better tailoring robot responses to individual artistic goals and preferences;
- **Interaction Modalities: Multimodal Communication**
  Spoken dialogue can improve creative collaboration. Investigate how different forms of communication- i.e. verbal, nonverbal, through the creative product- can complement and enhance each other in human-robot co-creative processes.

Acknowledgment

This publication is part of the project 'Social robotics and generative AI to support and enhance creative experiences for older adults', with project number 023.019.021 of the research program Doctoral Grant for Teachers financed by the Dutch Research Council (NWO). The course 'Drawing with Robots' was funded by Lang Leve Kunst Fonds in The Netherlands.

References

[1] D. Fancourt, *Arts in Health: Designing and Researching Interventions*. Oxford University Press, 2017.

[2] D. Fancourt and S. Finn, *What is the evidence on the role of the arts in improving health and well-being? A scoping review*. World Health Organization. Regional Office for Europe, 2019.

[3] E. Gorny-Wegrzyn and B. Perry, "Creative art: connection to health and well-being," *Open journal of social sciences*, vol. 10, no. 12, pp. 290–303, 2022.

[4] C.-Y. Tan, C.-Q. Chuah, S.-T. Lee, and C.-S. Tan, "Being creative makes you happier: The positive effect of creativity on subjective well-being," *International Journal of Environmental Research and Public Health*, vol. 18, no. 14, p. 7244, 2021.

[5] A. H. Y. Ho, S. H. X. Ma, M.-H. R. Ho, J. S. M. Pang, E. Ortega, and R. Bajpai, "Arts for ageing well: a propensity score matching analysis of the effects of arts engagements on holistic well-being among older asian adults above 50 years of age," *BMJ open*, vol. 9, no. 11, p. e029555, 2019.

[6] M. Fioranelli, M. G. Roccia, and M. L. Garo, "The role of arts engagement in reducing cognitive decline and improving quality of life in healthy older people: a systematic review," *Frontiers in Psychology*, vol. 14, p. 1232357, 2023.

[7] B. Groot, L. de Kock, Y. Liu, C. Dedding, J. Schrijver, T. Teunissen, M. van Hartingsveldt, J. Menderink, Y. Lengams, J. Lindenberg, *et al.*, "The value of active arts engagement on health and well-being of older adults: A nation-wide participatory study," *Int. J. Environ. Res. Public Health*, vol. 18, no. 15, p. 8222, 2021.

[8] M. D. Cooney and M. L. R. Menezes, "Design for an art therapy robot: An explorative review of the theoretical foundations for engaging in emotional and creative painting with a robot," *Multimodal Technologies and Interaction*, vol. 2, no. 3, p. 52, 2018.

[9] S. Ali, N. Devasia, H. W. Park, and C. Breazeal, "Social robots as creativity eliciting agents," *Front. Robot. AI*, vol. 8, p. 673730, 2021.

[10] M. Bossema, S. B. Allouch, A. Plaat, and R. Saunders, "Human-robot co-creativity: A scoping review: Informing a research agenda for human-robot co-creativity with older adults," in *2023 32nd IEEE International Conference on Robot and Human Interactive Communication (RO-MAN)*, pp. 988–995, IEEE, 2023.

[11] A. Kantosalo, P. T. Ravikumar, K. Grace, and T. Takala, "Modalities, styles and strategies: An interaction framework for human-computer co-creativity.," in *ICCC*, pp. 57–64, 2020.

[12] W. A. Rogers, T. Kadylak, and M. A. Bayles, "Maximizing the benefits of participatory design for human–robot interaction research with older adults," *Human Factors*, vol. 64, no. 3, pp. 441–450, 2022.

[13] A. K. Ostrowski, J. Zhang, C. Breazeal, and H. W. Park, "Promising directions for human-robot interactions defined by older adults," *Front. Robot. AI*, vol. 11, p. 1289414, 2024.

[14] H. R. Lee and L. Riek, "Designing robots for aging: Wisdom as a critical lens," *ACM Trans. Human-Robot Interact.*, vol. 12, no. 1, pp. 1–21, 2023.

[15] M. Romero, P. Hyvonen, and E. Barberà, "Creativity in collaborative learning across the life span," *Creative Education*, vol. 3, no. 4, pp. 422–429, 2012.

[16] M. Sakaki, A. Yagi, and K. Murayama, "Curiosity in old age: A possible key to achieving adaptive aging," *Neuroscience & Biobehavioral Reviews*, vol. 88, pp. 106–116, 2018.

[17] P.-Y. Oudeyer, J. Gottlieb, and M. Lopes, "Intrinsic motivation, curiosity, and learning: Theory and applications in educational technologies," *Progress in brain research*, vol. 229, pp. 257–284, 2016.

[18] L. L. Carstensen, J. A. Mikels, and M. Mather, "Aging and the intersection of cognition, motivation, and emotion," in *Handbook of the psychology of aging*, pp. 343–362, Elsevier, 2006.

[19] E. L. Deci and R. M. Ryan, "The" what" and" why" of goal pursuits: Human needs and the self-determination of behavior," *Psychological inquiry*, vol. 11, no. 4, pp. 227–268, 2000.

[20] J. Heckhausen, C. Wrosch, and R. Schulz, "A motivational theory of life-span development.," *Psychological review*, vol. 117, no. 1, p. 32, 2010.

[21] T. Lubart, "How can computers be partners in the creative process: Classification and commentary on the special issue," *Int. J. Human-Comput. Stud.*, vol. 63, no. 4-5, pp. 365–369, 2005.

[22] M. L. Maher, "Computational and collective creativity: Who's being creative?," in *ICCC*, pp. 67–71, 2012.

[23] A. Kantosalo and H. Toivonen, "Modes for creative human-computer collaboration: Alternating and task-divided co-creativity," in *Proceedings of the seventh international conference on computational creativity*, pp. 77–84, 2016.

[24] S. Deterding, J. Hook, R. Fiebrink, M. Gillies, J. Gow, M. Akten, G. Smith, A. Liapis, and K. Compton, "Mixed-Initiative Creative Interfaces," in *2017 CHI Conf. Ext. Abstr. Human Factors Comput. Syst.*, pp. 628–635, 2017.

[25] J. Rezwana and M. L. Maher, "Designing creative ai partners with COFI: A framework for modeling interaction in human-AI co-creative systems," *ACM Trans. Comput.-Human Interact.*, vol. 30, no. 5, pp. 1–28, 2023.

[26] J. Han, H. Long, M. Ge, and W. Pang, "Perspective-taking feedback: A new feedback affecting creativity," *Creativity Research Journal*, vol. 34, no. 2, pp. 228–243, 2022.

[27] T. Eyal, M. Steffel, and N. Epley, "Perspective mistaking: Accurately understanding the mind of another requires getting perspective, not taking perspective.," *Journal of personality and social psychology*, vol. 114, no. 4, p. 547, 2018.

[28] L. J. Hubbard, Y. Chen, E. Colunga, P. Kim, and T. Yeh, "Child-robot interaction to integrate reflective storytelling into creative play," in *Proc. 13th Conf. Creativity Cognition*, pp. 1–8, 2021.

[29] L. S. Vygotsky, *Mind in Society: The Development of Higher Psychological Processes*, vol. 86. Harvard University Press, 1978.

[30] R. K. Sawyer and D. Henriksen, *Explaining Creativity: The Science of Human Innovation*. Oxford University Press, 2024.

[31] M. E. Ligthart, S. M. De Droog, M. Bossema, L. Elloumi, K. Hoogland, M. H. Smakman, K. V. Hindriks, and S. Ben Allouch, "Design specifications for a social robot math tutor," in *Proceedings of the 2023 ACM/IEEE International Conference on Human-Robot Interaction*, pp. 321–330, 2023.

[32] C. Zhang, J. Chen, J. Li, Y. Peng, and Z. Mao, "Large language models for human-robot interaction: A review," *Biomim. Intell. Robot.*, p. 100131, 2023.

[33] P. Allgeuer, H. Ali, and S. Wermter, "When robots get chatty: Grounding multimodal human-robot conversation and collaboration," *Preprint arXiv:2407.00518*, 2024.

[34] F. I. Dogan, U. Ozyurt, G. Cinar, and H. Gunes, "Grace: Generating socially appropriate robot actions leveraging llms and human explanations," *arXiv preprint arXiv:2409.16879*, 2024.

[35] M. Spitale, M. Axelsson, and H. Gunes, "Appropriateness of llm-equipped robotic well-being coach language in the workplace: A qualitative evaluation," *arXiv preprint arXiv:2401.14935*, 2024.

[36] L. D. Hinz, *Expressive Therapies Continuum: A Framework for using Art in Therapy*. Routledge, 2019.

[37] iRobot Corp., "iRobot Root Pro." https://edu.irobot.com/shop/coding-robots/root?variant=269695, 2023. Accessed: September 10, 2024.

[38] iRobot Corp., "iRobot Education Python SDK." https://github.com/iRobotEducation/irobot-edu-python-sdk, 2024. Accessed: September 10, 2024.

[39] uFactory Ltd., "uFactory Lite 6 Developer Manual." https://www.ufactory.cc/wp-content/uploads/2023/04/Lite-6-Developer-Manual-V1.11.0.pdf, n.d. Accessed: September 11, 2024.

[40] uFactory Ltd., "xArm Python SDK." https://github.com/xArm-Developer/xArm-Python-SDK, 2024. Accessed: September 11, 2024.

[41] OpenAI, *OpenAI Developer API*, 2024. https://platform.openai.com/docs.

[42] M. Eitz, J. Hays, and M. Alexa, "How do humans sketch objects?," *ACM Trans. Graph. (Proc. SIGGRAPH)*, vol. 31, no. 4, pp. 44:1–44:10, 2012.

[43] OpenCV Development Team, *OpenCV: Open Source Computer Vision Library*. OpenCV, 2024. Distance Transform Algorithm.

[44] ATLAS.ti Scientific Software Development GmbH, *ATLAS.ti: Qualitative Data Analysis Software*, 2024. v23.0.

[45] C. V. Smedegaard, "Reframing the role of novelty within social HRI: From noise to information," in *Proc. 14th ACM/IEEE Int. Conf. Human-Robot Interact.*, pp. 411–420, IEEE, 2019.