Reframing Computational Co-Creativity: An Embodied Socio-Cognitive Lens

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Abstract

In this paper, we propose a redefinition of computational co-creativity to better incorporate the roles of embodiment and intersubjectivity, recognizing the intricate dynamics necessary for human-AI collaboration. Utilizing theories from human-computer interaction, social cognition, and creativity research, we critique the narrow scope of existing co-creativity definitions for their failure to encompass the embodied and intersubjective aspects fundamental to human co-creative processes. We posit that an AI agent must possess creative agency, sensemaking ability, and support open-ended improvisational interactions to participate effectively in co-creative processes. Furthermore, we examine how existing frameworks in computational co-creativity literature support our broader definition, aiming to bridge theoretical concepts with practical applications in co-creative systems. Through this redefinition, we aim to broaden the scope of computational co-creativity research, intertwining human experiences, technological advancements, and creative processes, thereby enriching our approach to designing human-AI co-creative systems.

Introduction

Collaborative creativity (co-creativity) is an integral part of human existence, deeply ingrained in our daily interactions, and essential for making sense of the complex world around us (Sawyer 2000; Lemons 2005). Through this collective creativity, we navigate the challenges and intricacies of our environment, leveraging the combined strength of our ideas and innovations. This shared process of creation not only enhances our ability to understand and adapt but also fosters a richer, more diverse tapestry of cultural and technological advancements. Building on this foundation, the emergence of generative AI technologies like ChatGPT (Achiam et al. 2023), DALL-E (Betker et al. 2023), and Stable Diffusion (Podell et al. 2023) introduces new dimensions to co-creativity, but with AI systems (Wingström, Hautala, and Lundman 2023).

With generative AI technologies transforming industries and everyday life, the potential for creative collaboration with these intelligent systems has captured global attention. As these technologies facilitate novel human-AI collaborations, it is crucial to examine and define what is co-creativity critically. Given our inherent proficiency in co-creativity, understanding the principles that underpin human co-creative interactions can significantly inform and improve our engagements with AI agents. By applying these insights, we can develop co-creative AI systems that can effectively augment human creativity and foster collaborations.

The idea of envisioning machines as intelligent, creative partners is a key focus of computational co-creativity, a subset of human-centered AI. This concept involves reshaping the interaction between humans and AI systems to engage in creative tasks such as writing poetry, composing music, dancing, drawing, etc. In the literature, multiple terms describe the phenomena of co-creativity. Candy and Edmonds (2002) first used the phrase "co-creativity" to express collaborative creativity between humans, computers, or both. Other terms include "mixed-initiative co-creativity" (Yannakakis, Liapis, and Alexopoulos 2014), "mixed-initiative creative interfaces" (Deterding et al. 2017), and "centaur systems" (Goldstein, Lawrence, and Miner 2017).

Like the various terms referring to co-creativity, there are many definitions of what co-creativity means in the field of computational co-creativity. However, the current forms of framing co-creativity do not address the notions of embodiment and social cognition, which are crucial for how humans creatively collaborate. In this paper, we propose a new definition of computational co-creativity, synthesizing theories from human-computer interaction, embodiment, and social cognition to refocus the primary concerns and challenges to address while designing co-creative systems.

Review Of Existing Definitions

Yannakakis et al. (2014) define co-creativity as "the task of creating artifacts via the interaction of a human initiative and a computational initiative." In this context, 'initiative' implies the independent contribution to the artifact's creation by both the human and the computational partner at the start of their interaction. However, this definition leaves open the question of whether sustained interaction between the human and the computational partner is required or if an initial contribution from the computational side is sufficient for the process to be considered co-creative.

Davis et al. (2015) describe co-creativity as "when computers and humans collaborate to build a shared creative artifact." Similarly, Kantosalo et al. (2014) claim: "Collaborative creativity is characterized by a shared responsibility between the human and the computational participant over the created artifact." These definitions imply that in co-creative systems, both humans and computational agents are actively involved in working on a mutually created artifact or sharing the responsibility for its creation. This suggests that the computational partner's role goes beyond just initiating the process; sustained interaction is necessary. However, these definitions leave some questions unanswered, such as what exactly "sharing" of responsibility entails in the creative process and whether the computational partner needs the capability to comprehend ongoing interactions or the development of the artifact itself.

Expanding on this topic, Karimi et al. (2018) define a co-creative system as an "Interaction between at least one AI agent and at least one human where they take action based on the response of their partner and their own conceptualization of creativity during the co-creative task." This description suggests a dynamic action-response cycle, where the computational agent not only reacts but also possesses some understanding of creativity. Yet, it remains ambiguous whether the computational partner's responses are informed by a comprehensive grasp of the ongoing interaction as a whole or are simply reactions to the most recent action. This distinction is crucial in understanding the depth of the computational agent's involvement and capability in the co-creative process.

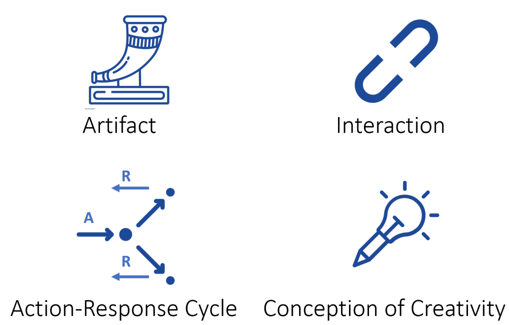

Figure 1: Existing Elements of Computational Co-Creativity

Based on these various definitions, it appears that four key elements are fundamental to computational co-creativity literature (as shown in Figure 1): the creation of shared artifacts, a well-defined interaction, the presence of an action-response cycle, and the individual conceptualization of creativity by each participant. Although these definitions lay a cursory understanding of co-creativity between humans and AI, they leave space for a more detailed and nuanced interpretation. We propose that the concept of computational co-creativity should be redefined to align more closely with the complex embodied dynamics found in human-to-human creative interactions. This redefinition would mean delving into the richer aspects of human experiences and interactions, moving past the basic functional elements.

Theoretical Lenses For Reframing Co-creativity

To gain insight into the ever-evolving landscape of human-AI co-creativity, we must tap into a diverse array of theories, frameworks, and fields of study. Together, they provide a holistic view of how humans, technology, and creativity intersect. In this section, we offer an overview of the theories and domains that are foundational theoretical lenses we use for the redefinition.

Embodiment in HCI

The concept of embodiment in the third wave of Human-Computer Interaction (HCI) (Rogers 2012) serves as the fundamental perspective through which we examine the interplay between technology and the human body, particularly its impact on our perceptual experiences. Embodied theories are pivotal in understanding the crucial role of human agency and technological mediation in co-creative activities. Embodiment, in this context, pertains to our existence as living, feeling, bodily beings situated in a physical world. Within the theory of embodiment, there are several key works that have significantly influenced our approach to human-AI co-creation. Below, we discuss a few of these influential works.

In her book "Human-Machine Reconfiguration," Lucy Suchman delves deeply into the intricate relationships between humans and nonhuman entities (Suchman and Suchman 2007). She particularly emphasizes the distribution of agencies, which denotes the capacities for actions shared between humans and machines. Suchman introduces the concept of reconfiguration to capture this dynamic distribution of agency. Her argument centers on the idea that material practices shape our cultural imaginaries, and the range of thinking possibilities available to us informs these practices. By engaging in human-machine reconfiguration, we can unlock new agencies and modes of thinking, thus expanding our cultural imaginaries.

Suchman's exploration of reconfiguration extends to the core notion of figuration, highlighting that in our world, nothing is purely literal; our thinking is inherently metaphorical. She further introduces the concept of materialized figuration to suggest that technologies are manifestations of our cultural imaginaries. This perspective prompts us to investigate how humans and machines are configured or figured in relation to each other. It encourages us to understand the similarities, differences, and relational dynamics between people and machines, ultimately exploring various reconfigurations in which humans and machines can interact and collaborate in novel ways.

Suchman's concept of material figuration draws inspiration from Donna Haraway's idea of material-semiotic figuration. Haraway views figurations as both material (physical) and semiotic (meaning-bearing) entities, highlighting the embodied nature of knowledge production. These figurations are more than just metaphors; they are tangible and have real-world implications. Figurations often blur the boundaries between traditionally separated categories, like human and animal, organism and machine, and physical and non-physical (Haraway 2010). This approach challenges the conventional dichotomies prevalent in scientific discourse. A prime example of Haraway's figuration is the "cyborg," a hybrid of machine and organism. The cyborg symbolizes the breakdown of clear distinctions between humans and machines. This perspective is crucial for co-creative AI, as it advocates the development of AI systems that are integrated extensions or collaborators to human users rather than as separate entities.

Suchman's idea of reconfiguration and distribution of agency is similar to the theory of distributed cognition developed by Edward Hutchins(2000). According to this theory, cognitive processes are not confined to an individual's mind but are distributed across individuals, objects in the environment, and interactions between them. While both Suchman's work and distributed cognition deal with the interaction between humans and technology, Suchman places more emphasis on the mutual shaping and reconfiguration of both humans and technology in these interactions. In contrast, distributed cognition focuses on the distribution of cognitive processes across humans and environmental elements, including technology, not attributing agency to the technology.

Building on the work of Suchman, Paul Dourish described the concept of embodied interaction. Dourish states, "Embodied interaction is the creation, manipulation, and sharing of meaning through engaged interaction with artifacts" (Dourish 2004). Dourish uses phenomenological principles to highlight the significance of physicality, context, and the environment in shaping interactions with technology. His approach positions interaction as an inherently situated, embodied, and social practice deeply integrated into our everyday lives. Dourish further discusses that meaning construction can happen in three ways – ontologically, intersubjectively, and intentionally (Marshall and Hornecker 2013). Ontologically, meaning arises from intentional interactions with the world rather than being something that is objectively predetermined. As a result, the meaning can vary greatly among different individuals. Intersubjectively, meaning is created when two or more individuals reach a common understanding in a social setting despite not having direct access to each other's mental states. Intentionally, the meaning is directed to or towards the world that we live in, further emphasizing that meaning construction is embodied.

In "Technology and the Lifeworld," Don Ihde delves into the complex interplay between humans and technology through the lens of postphenomenology (Ihde 1990). This approach, which extends traditional phenomenology, emphasizes how technologies are not mere tools but are integral to shaping our experiences and perceptions. Ihde categorizes human-technology relations into four types – embodiment, hermeneutic, alterity, and background relations – each elucidating different aspects of how technology mediates our engagement with the world. His concept of multistability, the idea that technology can have multiple meanings and uses depending on the user and context, aligns closely with the embodied interaction in HCI. Ihde's insights are instrumental in understanding that technology (AI), in co-creative activities, is a dynamic participant that transforms and is transformed by human interaction.

Social Cognition

In this section, the focus is on the role of collaboration in the design of co-creative systems, with a particular emphasis on social cognition theories. These theories offer valuable insights into human interaction and communication, which are fundamental to developing AI systems aiming to facilitate an embodied co-creative experience.

Theory of Mind & Enactivism

Social cognition, also known as intersubjectivity, refers to our capacity to comprehend and interact with other thinking beings (Shapiro and Spaulding 2021). This encompasses the psychological mechanisms that facilitate our integration into social groups (Frith 2008). Traditional theories in this field include the Theory of Mind (ToM), which suggests individuals infer others' mental states to inform their actions (Premack and Woodruff 1978), and Simulation Theory (ST), positing that people use their own minds as a template to simulate and understand others' thoughts without needing a formal theory (Gordon 1996).

Over time, scholars like Fuchs (2009), De Jaegher (2009), and Gallagher (2001) have identified critical concerns with ToM and ST, particularly regarding their conceptualization of the mind. They argue that ToM and ST erroneously isolate the mind, suggesting it operates independently to understand others through mere observation, termed the 'inner-world hypothesis' (Fuchs and De Jaegher 2009). Moreover, these theories are criticized for overly individualizing social cognition, implying a detached observer's perspective rather than an interactive one. A significant critique is their lack of emphasis on embodiment, adhering to a Cartesian dualism that separates mind and body, thus simplifying social cognition to a mere exchange of information, ignoring the integral role of embodied interaction.

Contrary to dualism, the concept of embodied cognition, particularly enactivism, posits that cognition is not merely a mental activity but emerges from physical interactions and movements within the environment, suggesting an active rather than passive acquisition of knowledge (Shapiro and Spaulding 2021). Enactivism is categorized into three types: autopoietic, sensorimotor, and radical (Ward, Silverman, and Villalobos 2017). Autopoietic enactivism views cognition as an organism's active engagement with its environment to maintain life (Thompson 2010). Sensorimotor enactivism focuses on cognition as arising from the exploration of the environment and the dependencies between actions, senses, and surroundings, essentially equating cognition with action (Shapiro and Spaulding 2021). Radical enactivism challenges the necessity of internal mental states for cognition, advocating for an understanding of cognition as dynamic interactions with the environment, devoid of internal representations (Ward, Silverman, and Villalobos 2017).

Participatory Sensemaking (PSM)

Participatory Sensemaking (PSM) is a cognitive framework developed by Di Paolo and De Jaegher to deepen our understanding of social cognition, using enactive cognition as its foundation. PSM is positioned closer to autopoietic enactivism but also incorporates elements from sensorimotor enactivism. The essence of PSM is to conceptualize social interaction through the lens of embodied engagement, focusing on how individuals collaboratively make sense of their environment. This involves a dynamic integration of motor activities and cognitive processes, fostering shared understanding and influencing collective decision-making (De Jaegher and Di Paolo 2007).

From the enactive viewpoint, scholars see social cognition as emerging from interaction, where participants in social contexts inherently align their actions and expressions, similar to interconnected systems observed in nature, like synchronized pendulums or fireflies (De Jaegher and Di Paolo 2007; Fuchs and De Jaegher 2009; Thompson 2010). This coordination can manifest in various patterns such as synchronization or rhythmic alignment. Di Paolo and De Jaegher describe participatory sensemaking as a dynamic interplay where joint meaning is created through interaction, suggesting that collaboration leads to unique understanding that transcends individual cognition. PSM is formally defined as "The coordination of intentional activity in interaction, whereby individual sensemaking processes are affected, and new domains of social sensemaking can be generated that were not available to each individual on their own (De Jaegher and Di Paolo 2007)."

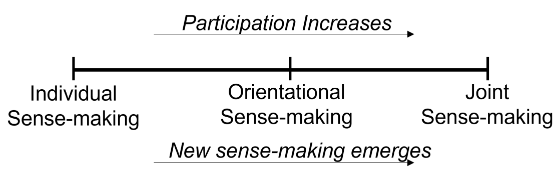

Figure 2: Degrees of participation and sense-making

We can analyze how coordination and interaction influence sense-making by examining the levels of participation in social interactions, as outlined by Di Paolo and De Jaegher (2007). This approach divides participation into individual, orientational, and joint sense-making, as shown in Figure 2. Individual sense-making occurs when participants engage independently without a collective goal. Orientational sense-making arises when individuals influence or are influenced by each other's actions or ideas. Joint sense-making, the highest participation level, involves collaborative efforts leading to a shared outcome

Creativity and Improvisation

In this section, we focus on dissecting the subtleties of creativity and improvisation that either facilitate or augment creative processes. This examination is essential for designing co-creative AI agents. By delving into various theories of creativity and improvisation, we aim to highlight the fluid and spontaneous nature of creative acts. This understanding is crucial for developing AI systems that are not only participants in creative endeavors but also capable of enhancing and dynamically responding to elements of improvisation.

Theories of creativity

Creativity is explored across various fields, including psychology, philosophy, cognitive science, sociology, and computer science. The interpretation of creativity varies depending on the specific field or perspective. A notable framework for understanding creativity from a psychological perspective is the "four P's of creativity," which was proposed by Rhodes. These four P's are person, process, product, and press (Rhodes 1961). Each 'P' offers a unique lens for examining creativity: 'Person' looks at the characteristics of the creative individual, 'Process' examines the steps or actions taken to achieve creativity, 'Product' focuses on the attributes of the creative output or the result of the creative process, and 'Press' delves into the environmental, historical, cultural, or societal contexts that influence the creative individual, process, or product.

While the four P's framework offers a comprehensive approach to understanding creativity, it doesn't provide a definitive definition of creativity. Margaret Boden, viewing from a cognitive science perspective, describes creativity as the ability to generate ideas that are both novel and valuable (Boden 2009). She distinguishes novelty as having two dimensions: psychological and historical. Boden introduces two types of creativity: P-creativity (psychological creativity) and H-creativity (historical creativity). P-creativity refers to ideas that are new to the individual who comes up with them, whereas H-creativity encompasses ideas that are not only P-creative but also unprecedented in history. Building on this, Gero, from a design studies perspective, proposes a third type known as S-creativity (situated creativity) to describe a different aspect of novelty (Gero 2000). According to Gero, S-creativity occurs when a design features ideas that may not be historically novel or new to the designer but are novel within the specific context of that design situation.

Boden identified three types of creativity that can be modeled computationally to yield novel outcomes: combinational, exploratory, and transformational creativity (Boden 2009). These forms of creativity involve manipulating or navigating through a conceptual or design space. Combinational creativity arises when familiar ideas are combined in unfamiliar ways. Exploratory creativity is achieved by finding creative solutions within a culturally accepted conceptual space governed by specific generative rules and exploring previously untouched areas of this space to understand its potential and limitations. Transformational creativity occurs when the very structure of the conceptual space is altered, changing its foundational dimensions or assumptions, thereby enabling creative solutions that were previously impossible.

Historically, creativity has often been examined from an individual standpoint, as seen in Boden's concepts of P-creativity and H-creativity. However, to enhance the design of co-creative AI, it's essential to view creativity through a collaborative lens. Csikszentmihalyi–in an intersubjective framework–proposed the "systems model of creativity," explaining creativity as an interaction among three components: the domain, the field, and the individual (Czikszentmihalyi 1988). Building upon Csikszentmihalyi's model, Glaveanu reinterprets Rhodes' 4P's framework (person, process, product, and press) (Rhodes 1961) into a "5A's framework" for creativity (Glaveanu 2013). In this model, creativity emerges from the interplay between the actor (the individual with unique attributes within a societal context), action (the coordination and behavioral manifestation of the individual), artifact (contextualized within its cultural setting), audience (reflecting the social world), and affordance (emphasizing the material world's influence). This framework acknowledges the complex relationship between individual creativity and its social and material environments.

Creativity, according to Glaveanu, is "a complex socio-cultural-psychological process that, through working with 'culturally-impregnated' materials within an intersubjective space, leads to the generation of artifacts that are evaluated as new and significant by one or more persons or communities at a given time (Glaveanu 2010)." This definition comprehensively encapsulates the various aspects of creativity, emphasizing its inherently social, embodied, and intersubjective nature. Among the various perspectives on creativity, the approach of this paper resonates most closely with Glaveanu's definition.

Theories of Improvisation

Sawyer and DeZutter introduced the concept of distributed creativity (Sawyer and DeZutter 2009), which focuses on the collective creative output generated by collaborating groups. They suggest that the most creative outcomes emerge when collaborators contribute complementary and unexpected ideas, resulting in a shared product that surpasses what any individual could have produced alone. While this concept shows the significance of collaboration in creativity, it's the process of improvisation that is key to these emergent, collaborative creative outcomes.

Building on the concept of distributed creativity, which highlights the importance of group collaboration in generating creative outcomes, Keith Sawyer provides a detailed analysis of improvisation in his book "Group Genius: The Creative Power of Collaboration" (Sawyer 2017). Sawyer's approach to improvisation is characterized by its emergent nature, arising from the collective dynamics of a group. He emphasizes the need for fluidity and the ability to adapt within improvisational contexts, where creativity is a collective phenomenon rather than an individual pursuit. According to Sawyer, the structure of improvisation strikes a balance between established rules and spontaneous creative expression. It necessitates attentive listening and an iterative process of idea development, often guided by narrative elements. He further highlights improvisation has three essential characteristics: unpredictability, ambiguity, and retrospective interpretation (Sawyer 2018).

Pressing delved into the complexity of improvisation, especially in music, blending insights from various disciplines to decode the improvisational process (Pressing 2007). He described it as a synergy of a performer's skill, instinct, and real-time responsiveness, supported by intricate neural and cognitive frameworks. This process, according to Pressing, harnesses well-established knowledge and abilities, demonstrating that improvisation is a structured cognitive act, not just spontaneous or unstructured. Following this framework, scholars like Mendonca and Crossan have examined and extended the concept to show how improvisational skills like adaptability and quick decision-making enhance problem-solving and innovation in various fields like organizational and emergency management (Mendonca and Wallace 2007; Crossan 1998), suggesting that we can foster creative solutions and dynamic problem-solving capabilities by strategically incorporating these improvisation techniques.

Following the ideas of distributed creativity and improvisational structure outlined by various scholars, Magerko et al. put forward the concept of developing a computational model for improvisation, drawing inspiration from the practices of improv theatre artists (Magerko et al. 2009). Building on this idea, Fuller and Magerko introduced the concept of a shared mental model (Fuller and Magerko 2010) aimed at creating improvisational, creative agents. This model is based on the notion of shared knowledge or cognitive frameworks among group members engaged in creative improvisational activities.

Magerko and Long developed an Improvisational HCI framework aimed at designing co-creative systems (Magerko and Long 2020). This framework outlines four essential types of knowledge required for creating improvisational co-creative agents. The first type, interactively-learned knowledge, pertains to information that the agent acquires through direct, improvisational interactions with unfamiliar objects or through learning new interaction patterns. The second type, tacit knowledge, encompasses the established conventions and formal terminologies specific to a particular domain. The third type, interactional knowledge, involves understanding the social and decision-making processes integral to improvisation. Lastly, transformational knowledge involves generating innovative ideas by applying the established language and concepts of tacit knowledge. Together, these knowledge types form the foundation for developing agents capable of effective and creative improvisation within co-creative systems.

Redefining Computational Co-creativity

Definitions play a pivotal role in driving research forward. As Buchanan highlights, definitions are not static end-points but strategic tools in inquiry. They help researchers and collaborators establish a clear direction for their work, fostering progress and innovation (Buchanan 2001). Redefining co-creativity is, therefore, essential to steer the exploration of human-AI collaboration in new directions. By integrating insights from third-wave HCI, social cognition, and creativity theories, we can offer fresh perspectives and a deeper understanding of this complex domain. This approach doesn't just define co-creativity; it broadens its scope, intertwining human experiences, technological advancements, and creative processes, thereby enriching our approach to human-AI co-creativity.

In redefining computational co-creativity, it is essential to move beyond traditional perspectives. This redefinition requires a deeper understanding of creative agency, not just as a concept but as a practice actively shared between humans and AI. Moreover, the interaction in co-creativity transcends

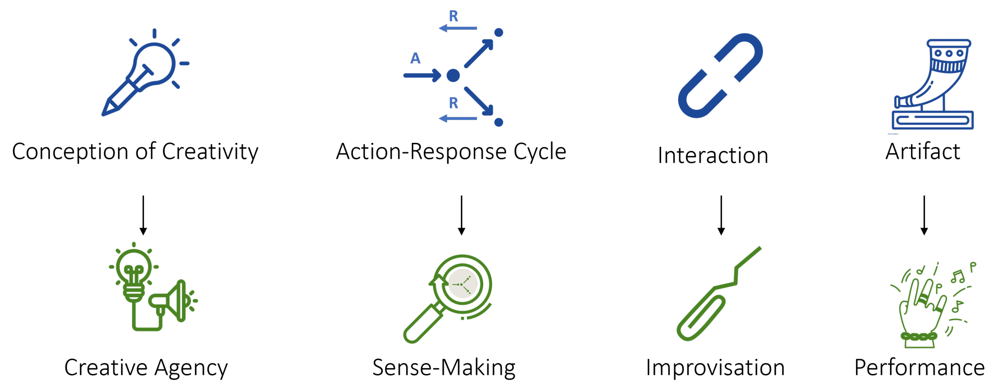

Figure 3: Elements of Reframed Computational Co-Creativity

a mere action-response cycle and must encompass the principle of embodied sensemaking, reflecting the physical and contextual nuances of collaboration. Additionally, our focus should extend from the final creative artifact to include the improvisational and performative aspects of the co-creative process.

Based on all the foundational theories of humans, technology, and creativity we discussed earlier, we propose that co-creativity can be defined as when –

> ”Human(s) and AI agent(s) engage in an **open-ended improvisational interaction** involving **continuous negotiation of creative agency** through **collaborative sensemaking** to create a **shared artifact or performance**.”

From this perspective, in computational co-creativity, human participants and AI agents engage in an ongoing, improvisational interaction where both parties actively engage in a process of collaborative sensemaking. This interaction is characterized by a continuous negotiation of creative agency rooted in the principles of embodiment. The process is open-ended, allowing for the emergence of creative ideas and solutions through the dynamic interplay of human and AI contributions. This approach aligns with the third wave of HCI, emphasizing the nuanced and contextual nature of human-AI interactions in creative endeavors. Next, we will explore these aspects in relation to the foundational theories.

Open-ended improvisational interaction:

Co-creativity involves a dynamic and adaptable exchange between humans and AI agents, where the creative journey is not pre-scripted. This concept draws from Sawyer's improvisational approach to creativity (Sawyer 2018), characterized by an emergent nature that allows both human and AI to spontaneously offer new ideas. This concept aligns with the improvisational HCI framework (Magerko and Long 2020), which stresses the importance of flexible, real-time responses in the creative process, informed by diverse forms of knowledge. Additionally, Ihde's idea of multistability — the notion that technology's meaning and function vary based on context and user — applies here (Ihde 1990). In co-creative systems, AI's role and input in the creative process are variable, changing according to the interaction dynamics, the specific creative field, and the goals of the human collaborator.

Continuous negotiation of creative agency:

Building upon Suchman's notion of human-machine reconfiguration(2007), co-creativity can be understood as a novel form of interaction between humans and AI, capable of extending our collective capability. In alignment with Hutchins' distributed cognition theory (Hutchins 2000), co-creativity involves a fluid sharing and negotiation of creative agency between humans and AI. This approach recognizes creativity as a joint endeavor, where both humans and AI agents actively contribute and guide the creative process. Furthermore, Idhe's postphenomenological viewpoint, coupled with Haraway's concept of the cyborg, emphasizes the integral role of technology in our lived experiences (Haraway 2010; Ihde 1990). Within co-creative systems, this translates to perceiving AI not merely as a tool or an independent entity but as an engaged collaborator, actively influencing and being influenced by the creative exchange.

Collaborative sensemaking:

Incorporating the concepts of participatory sensemaking and enactivism, this definition of co-creativity emphasizes that creativity arises from collaborative interaction and collective sensemaking (De Jaegher and Di Paolo 2007). In this framework, both human and AI agents actively engage in interpreting, responding, and co-creating meaning within the creative domain, resonating with Dourish's concept of embodied intersubjective meaning construction (Dourish 2004). This perspective highlights the embodied and contextual nature of creativity, as delineated by Glaveanu (2010), where meaning and ideas evolve through interactions within a shared space, demonstrating the dynamic and intersubjective nature of the creative process.

Creation of shared artifact or performance:

The result of the co-creative process extends beyond just creating a shared artifact; it can also encompass a performance born from collective creative efforts. This outcome, resonating with Haraway's notion of material-semiotic figuration (Haraway 2010), dissolves the distinctions between human and machine, as well as between the physical and digital realms, illustrating the integrated and interconnected aspects of contemporary creativity. It represents a departure from traditional barriers and the emergence of novel forms of expression enabled by the collaborative synergy between humans and AI. This reflects Suchman's idea of reconfiguration, where new capabilities and possibilities are unlocked through this new reconfiguration (Suchman and Suchman 2007).

Case Studies

In this section, we critically analyze two AI systems in light of our newly proposed co-creativity definition. The first system we consider is LuminAI, an existing embodied co-creative dance AI system. The second system we evaluate is a text-to-image generative AI, such as MidJourney[1], Stable Diffusion [2], or DALL-E[3], assessing how these platforms align with our understanding of co-creative interaction.

Case Study: Evaluating Text-to-Image Generative AI Systems through Co-Creativity Lens

Introduction: This case study examines text-to-image AI systems like Midjourney, DALL-E, etc., assessing their capabilities and interactional limitations in the context of co-creativity. The interaction with these systems typically involves users giving the system a detailed text called prompts, describing the image, and the AI system generates a few options closely aligned with the prompt.

Analysis: ***Open-ended Improvisational Interaction:***

- Current State: The systems generate images based on user prompts but lack real-time interaction or adaptation to user feedback within a single session.
- Recommended Improvements: Implement feedback loops where user responses can guide the AI system to modify or refine the output, facilitating a more interactive creative process.

Continuous Negotiation of Creative Agency:

- Current State: Users provide initial inputs, but there's limited scope for ongoing engagement or decision-making in the creative process.
- Recommended Improvements: Develop interfaces that allow users to adjust the AI system's suggestions and engage in a dialogic creative process, ensuring mutual influence on the creative output.

Collaborative Sensemaking:

- Current State: The AI system does not adapt its output based on an understanding of user intent or past interactions, missing out on deeper collaborative potential.
- Recommended Improvements: Integrate adaptive learning capabilities to allow the AI to interpret and respond to user feedback more contextually, enhancing joint sensemaking.

Creation of Shared Artifact or Performance:

- Current State: The focus is on producing static outputs without engaging in an iterative or performance-based creative process.
- Recommended Improvements: Expand the system's capabilities to support ongoing creative activities, enabling the AI system to contribute dynamically to the creative process, not just the end product.

Conclusion: By addressing these areas, text-to-image AI systems could advance significantly toward true co-creativity, fostering richer and more meaningful human-AI collaboration in creative endeavors.

Case Study: Analyzing LuminAI in the Context of Co-Creativity

Introduction: LuminAI is an interactive installation that features a virtual AI agent capable of improvising movements in collaboration with human participants (Jacob and Magerko 2015; Long et al. 2020). This system leverages computational models based on improvisational theories from theater and dance. LuminAI's design has notably evolved from a simple wall projection in ViewpointsAI (Jacob and Magerko 2015) to a sophisticated setup tailored for interaction with professional dancers (Trajkova et al. 2023).

Analysis: ***Open-ended Improvisational Interaction:***

- Current State: LuminAI's improvisational framework enables dynamic interaction with users, fostering a real-time creative exchange through dance.

Continuous Negotiation of Creative Agency:

- Current State: The system's design facilitates a reactive engagement with dancers, responding to their movements in a collaborative performance.

Collaborative Sensemaking:

- Current State: LuminAI interprets and responds to human movements, like an action response cycle, without any sensemaking.
- Recommended Improvements: Incorporate sensemaking ability by keeping track of interaction history and responding based on that.

Creation of Shared Artifact or Performance:

- Current State: LuminAI and human dancers co-create a unique performance, integrating AI-generated movements with human creativity.

Conclusion: LuminAI is an example system that embodies most of the aspects of co-creativity that we have discussed.

[1] www.midjourney.com
[2] www.stability.ai/stable-image
[3] www.openai.com/dall-e-3

Discussion

Synthesizing Co-Creative AI Frameworks with the Theoretical Lenses

While we borrowed theories from various fields, the prominent frameworks in the computational co-creativity literature resonate deeply with the foundational theories in human-technology interaction we described previously. Researchers like Nakakoji (2006), Maher (2012), and Kantosalo (2016) have proposed various roles for AI in creative tasks, ranging from supportive tools to equal creative partners. These roles reflect the core principles of Suchman's human-machine reconfiguration and Hutchins' distributed cognition theory, emphasizing the dynamic and shared nature of creative agency between humans and AI agents. Particularly, Kantosalo's suggestion of co-creative agents being either pleasing or provoking aligns with Ihde's post-phenomenological perspective, highlighting the adaptability and context-specific responses of AI agents in creative collaborations.

Further, the interaction strategies outlined by Deterding et al. (2017), including ideating, constraining, and producing, mirror the principles of embodied sensemaking and enactivism. These strategies suggest a continuous and dynamic interaction between humans and AI, which aligns with the collaborative sensemaking aspect of co-creativity. Both agents actively participate and influence the creative process, aligning with Dourish's concept of embodied interaction, where meaning is co-created intentionally and intersubjectively. Additionally, Muller et al.'s (2020) expansion of this framework with actions like learning and curating supports a more nuanced, contextually rich engagement between humans and AI agents, further enriching the co-creative experience.

The role of bi-directional communication, as highlighted by Guzdial & Riedl (2019), and Rezwana & Maher (2022), ties into the theory of enactive social cognition. This approach emphasizes the importance of interactive and reciprocal communication, a key aspect in an intersubjective framework like participatory sensemaking. The differentiation between interactions through a shared product and interactions among collaborators reflects the multifaceted nature of creativity, as described in Glaveanu's five A's framework involving actors, actions, artifacts, audiences, and affordances, each playing a critical role in the creative process.

The collaborative roles and interaction frameworks in co-creativity provide practical, concrete models that embody the theoretical insights of various foundational theories we have discussed. By incorporating these specific roles and interaction strategies into the broader conceptual framework, the redefined concept of co-creativity gains depth and practicality, bridging the gap between theoretical understanding and the real-world application of human-AI co-creative systems.

Embodiment and Social Cognition in Co-Creativity Research

While the definition of co-creativity lacks embodiment and social cognitive aspects, recent work in the field is focused on addressing this issue. Davis et al. designed the Creative Sensemaking (CSM) framework as a video analysis tool to quantify and evaluate open-ended creative collaboration. CSM comes with a qualitative coding scheme focused on sensemaking. The authors describe that CSM is based on the enactive cognitive framework of PSM and the free energy principle (Davis et al. 2017). CSM is a framework that can quantify sensemaking in the co-creative system like the Drawing Apprentice. Similarly, Deshpande et al. proposed Observable Creative Sensemaking (OCSM), which builds on CSM by focusing on observable behavioral states and interactions within creative processes, especially in nuanced, non-verbal, and embodied co-creative contexts (Deshpande et al. 2023).

Kantosalo et al. (2021) investigate AI and creativity through 18th-century literature, asserting that past conceptions of human-machine interaction offer valuable insights for contemporary co-creativity research, particularly stressing the roles of embodiment and agency. Guckelsberger et al. (2021) analyze embodiment's influence on creativity within computational contexts, identifying six embodiment types crucial for computational creativity and emphasizing the need for further exploration. Moruzzi (2022) discusses the synergy between agency and creativity in AI-human collaborations, promoting a distributed approach that appreciates contributions from both entities, enhancing the depth and impact of co-creative practices.

Conclusions

In this paper, we redefined computational co-creativity, focusing on embodiment, intersubjectivity, and dynamic human-AI interactions essential for fruitful collaboration. By reviewing and critiquing existing definitions and incorporating insights from multiple disciplines, we offered a nuanced perspective that resonates with the complexity of human interactions. The redefinition aims to broaden the scope of computational co-creativity, integrating human experiences, technological progress, and creative practices to improve co-creative AI system design.

Our theoretical exploration served as a foundation, emphasizing the relevance of creative agency, embodied sensemaking, and performative elements in co-creativity. Analyzing case studies like LuminAI and text-to-image AI systems, we demonstrated the real-world application of our redefinition, identifying technological shortcomings and suggesting enhancements. We also discussed how our redefinition correlates with existing computational co-creativity frameworks, advocating for a more comprehensive approach to foster richer, more effective human-AI co-creativity.

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