# The (Artificial) Physicality of Creativity: How Embodiment Influences Perceptions of Creativity

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**Abstract**

The generation of artifacts through computational creativity (CC) systems is hitting the headlines with increasing frequency. Although impressive, this paper will not focus on the outcomes achieved by these systems, but rather on a specific dimension of artistic processes: embodiment. I discuss the results of a recent factorial survey study aimed at testing the influence that embodiment has on the evaluation of creativity. These findings show that the physical dimension of artificial systems interacting with human artists contributes to the perception of the interplay between artificial and human agents as a *creative* collaboration. I propose that a closer study of the dynamics of interaction between embodied machines, human artists, and the public can facilitate progress in both the artistic and the technology sector.

## Introduction

In the last decades, computers and Artificial Intelligence (AI) systems have been increasingly involved in the field of creativity, by generating creative artifacts or by assisting human artists in their creative processes (Lubart 2005; Marks 2015): composing music in the style of Bach (Huang et al. 2019), creating paintings sold for hundreds of thousands of English pounds at renowned auction houses, and even having their say in the fashion industry (Byers 2020). The rapid technological development of AI systems and the advances in the computational creativity (CC) field demand a more detailed and overarching analysis of the impact that the deployment of technology in the arts can have on different aspects of the creative world.

This paper discusses the results of a recent study on the influence of embodiment on the perception of creativity in human and artificial systems. In the design of, and aims behind, the study, I assumed the validity of the hypothesis made by Guckelsberger et al. (2021) that "furthering our insights into embodied computational creativity (CC) will play a critical role in advancing the goals of CC more generally." With a few exceptions (Sharples 1994), the role of embodiment in creativity has arguably not been investigated in depth in the literature, and even less so in connection with AI. Still, the perception of the artists' embodiment is generally deemed to be a key aspect of the observer's response to the artwork (Freedberg and Gallese 2007). The aim of the paper and of the study here reported is, thus, to contribute to closing this gap by reporting empirical findings on the influence of embodiment on perceptions of creativity. [1]

Rather than just focusing on *artistic* creativity, the study examined perceptions of creativity also in the context of *scientific* practices. This was done in accordance with the belief that creativity is not limited to artistic practices, but should instead be investigated in a wider spectrum of fields and disciplines, including science (Pease et al. 2019).

## Background and Related Works

Sensory-motor intelligence is a crucial aspect of human and animal intelligence, and a key requirement to develop common sense knowledge (Pfeifer and Iida 2004). In social science, the influence of the embodiment factor in shaping cognitive processes, is strongly advocated by the embodied mind paradigm (Foglia and Wilson 2013; Varela, Thompson, and Rosch 2017). Since the promotion of research in embodied intelligence in the Nineties by Rodney Brooks (Brooks 1991), and the arguments against cognitivism and neuro-reductionism which started to gain traction in many fields, the field of robotics has been involved in the development of AI as a discipline in an increasingly substantial way.

Robotics and embodied intelligence are employed for a wide range of tasks, from space exploration to industrial manufacturing, including applications in the creative sector. Already in the eighteenth century, the fascination for creating art through and with robots started with the creation of, among other robotic systems, the humanoid automata created by the watchmaker Pierre Jaquet-Droz (Leymarie, Bessette, and Smith 2020). Recently, the interest of both artists and computer scientists for 'creative' machines increased, for example with the creation of 'painting robots' (Cohen 1995; Deussen et al. 2012; Jean-Pierre and SaId 2012; Smith and Leymarie 2017; Srikaew et al. 1998; Tresset and Leymarie 2013; Yu and Chen 2018).

[1] The notion of embodiment that will be assumed is that of 'physical' embodiment, namely "characterizing systems with a physical body that can interact with the environment by being subjected to and by exercising physical force" (Guckelsberger et al. 2021).

The embodiment dimension introduces constraints that may not be present in purely computational settings, and these constraints may contribute to enhancing creativity (Costello and Keane 2000; Johnson-Laird 1988). Still, a general reluctance at attributing creativity to AI, irrespective of whether it is embodied or not, is well-known and addressed in the literature (Mumford and Ventura 2015; Colton 2008; Jordanous 2012; Natale and Henrickson 2022). Previous studies aimed at investigating this phenomenon, by focusing on the evaluation of perceptions of creativity (Jordanous 2012; 2016; Karimi et al. 2018). The present study inserts itself into this dialogue, contributing to the investigation of creativity attribution through empirical insights resulting from the manipulation, made possible by a factorial survey methodology, of the dimension of embodiment and other dimensions (Simo Linkola and Kantosalo 2022).

## Study on the Influence of Embodiment on Perceptions of Creativity

### Aims

Answering whether artificial systems can be deemed creative is not among the scopes of the study. Acknowledging the contested nature of the concept of creativity, this paper will not be trying to propose a definition of creativity, either (Jordanous 2016; Jordanous and Keller 2016; Moruzzi 2021). Rather, the discussion will focus on the influence of embodiment on evaluations of creativity.

The starting hypothesis of the study is the following:

> **Hypothesis.** Between the attribution of creativity and the embodied presence of the actor performing the process under examination, there is a positive correlation.

Namely, artificial systems possessing physical actuators through which to perform an action can be considered more creative than systems that reach the same result but with no physical intervention on the surrounding environment.

This hypothesis is motivated by some studies carried out in online and live contexts (Herman and Hwang 2022), and by past surveys conducted by the author on creativity perceptions of the process and products by generative art algorithms (Moruzzi 2020b). Participants to these surveys expressed the belief that an essential dimension for creativity is the physical presence of the artist during the creative process, a dimension that was deemed as lacking from the systems under examination.

In their overview of academic publications on embodied computational creativity in the last ten years, Guckelsberger et al. (2021) indicate some directions for future work in the field of computational creativity. In particular, they suggest to (i) "conduct qualitative and quantitative empirical studies on the impact of a specific embodiment, treated as independent variable, on (the perception of) creativity", in order to produce generalizable and empirical studies on the effect of embodiment on artificial creativity and its perception, (ii) employ objective and not subjective measures of creativity when conducting these studies, and (iii) avoid ambiguous uses of the concept of creativity. This paper responds in particular to suggestion (i), reporting the results of an empirical study conducted through online factorial survey experiments on perceptions of creativity in human and artificial agents.[2]

In addition to the exploration of the impact of the embodiment dimension, the study presented in this paper was designed also to test the influence of other dimensions on perceptions of creativity: agency, explainability, and the artificial or biological nature of the actor performing the action. In the interest of the focus of the present paper, the analysis of the influence of these other dimensions will not be addressed.[3]

### Procedure

Participants were recruited online through academic newsletters in philosophy, art, and computer science. Data collection took place over three weeks in July 2021. Participation to the online questionnaire was voluntary and no information has been collected that could directly or indirectly identify a survey participant. After successful participation in the survey, respondents have been asked for their email address in a separate survey to participate in a raffle for one of three €50.00 e-commerce vouchers as an incentive for participation.

The time needed for completing the online survey was of around 15 minutes. Participants first completed an online consent form and a demographic questionnaire that included questions about their age, level of education, field of studies, and current occupation.

In the second part of the study, participants were asked questions regarding their intuitions about features of agency and creativity. Results regarding agency attribution will not be reported here as they are not relevant in respect to the focus of this paper.

Regarding creativity, respondents were presented with the question: "Which of these concepts do you associate with the notion of 'creativity'?" and they were asked to choose all the features that applied from the ones reported in the list of Table 1. These attributes were chosen among the ones that are more commonly associated to creativity in the literature on the topic (Jordanous and Keller 2016; Moruzzi 2021). In brackets is the number of the times that each attribute has been selected by respondents.

### Factorial Survey Experiment

The central section of the questionnaire consisted in a factorial survey experiment, an approach which presents study participants with different vignettes which describe hypothetical scenarios (Auspurg and Hinz 2014). In this study, vignettes were in the form of a short text, but they can also be images or videos. The situations outlined in the vignettes have different attributes (dimensions) and participants are

[2]With 'agent' I understand in this paper "anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators" (Russell and Norvig 2011). I will use the term 'actor' in the instances in which I do not assume that the individual necessarily possesses agency, as the latter was one of the independent variables of the study.

[3]These other dimensions will be investigated in a paper in the proceedings of the xCoAx 2022 conference, currently in press.

| Creativity Attributes |
| --- |
| Novelty (128) |
| Problem-solving (87) |
| Surprisingness (66) |
| Value (52) |
| Instinctiveness (5) |
| Serendipity (22) |
| Unexplainability (20) |
| Genius (33) |
| Pleasantness (4) |

Table 1: *Creativity.* List of creativity attributes, participants had to choose from. In brackets is the number of times each attribute has been selected.

asked to express their judgement regarding them. The values (levels) of the dimensions are varied in order to test the impact that they have on the participants' evaluation. The factorial survey design was particularly beneficial in this context, as it enables to test the effect that the manipulation of independent variables (in this case, embodiment) has on the dependent variable (in this case, creativity perception). In Table 2 are the variables that had been included in the experiment:

| Variables | |
| --- | --- |
| Independent | Identity of the actor |
| | Agency |
| | Embodiment |
| | Explainability |
| Dependent | Agency Attribution |
| | Creativity Perception |
| | Authorship Attribution |
| Control | Process performed |

Table 2: Independent, dependent, and control variables used in the factorial survey experiment.

Results in respect to the influence of the dimensions of Agency and Explainability on creativity will not be reported as they are not relevant to the focus of the present paper.

The process of creation, performed in the experiment, was kept constant, as control variable. The focus on the role of the body in both the creation and the appreciation of creative processes centers the discussion around creativity as a process rather than a product. While there is no doubt that machines can produce artifacts that are aesthetically appealing, more critical is the question of whether the process they undertake in order to create the latter can be deemed creative. By focusing on the process, it is possible to assess the experience behind the creation of an artifact and, thus, compare human and machines that engage with creative processes (Leymarie, Bessette, and Smith 2020).

Different vignettes resulted through the combination of the different levels of the variables, or dimensions, above mentioned. Figure 1 shows the dimensions and variables of the 8 vignettes present in this study. A random selection was programmed into the survey to determine which vignettes to present at the beginning of the survey to each respondent.

Each respondent was assigned two vignettes, constructed on the basis of two scenarios: Scenario A. Painting a canvas, and Scenario B. Discovering a vaccine. In reading the text of the vignettes, participants were asked to engage in a thought experiment. They could not actually perceive the process described in the vignette and were required instead to imagine the process and the properties involved. The following is the structure used for the vignettes. Between brackets are the dimensions, the value of which is manipulated.

**Scenario A: Painting a picture**

[Actor] is/are in the Royal Moondust Academy of Arts to paint a canvas. The process [actor] undertake/s is the following:
*(If Displaying agency:)* First, [actor] [agencyattribute1adv] selects the color palette and tools needed to paint the picture, then starts painting on the canvas. Lastly, [actor] [agencyattribute2adv] observe/s the picture and decide/s to stop painting, as the current state is the best possible result that can be obtained.
*(If Not displaying agency:)* First, [actor] randomly pick/s some colors and tools, then starts painting on the canvas. Lastly, [actor] all of a sudden, lift/s the brushes from the canvas and stop/s painting.]
The final painting is considered to be visually pleasing by a general audience.
*(If Explainable:)* A faithful record of the process of the painting of the canvas is published in an open-access journal. All the processes made to achieve the result are explicitly reported and clearly explained in a language understandable to a non-specialist audience.
*(If Not explainable:)* No record of the creation of this painting is available because a full report of the processes that led to the final result could not be produced by [actor].

**Scenario B: Vaccine discovery**

[Actor] work/s in the Research Laboratory of Sundance University to perform experiments to find a vaccine against COVID-19. The process [actor] undertake/s is the following:
*(If Displaying agency:)* First, [actor] [agencyattribute1adv] generate/s hypotheses from the available background knowledge and models, then carry/ies out the experiments in the Lab. Lastly, [actor] [agencyattribute2adv] analyze/s and interpret/s the results obtained.
*If not displaying agency:)* First, [actor] automatically tries all combinations of the available background knowledge and models to generate hypotheses, then carries out the experiments in the Lab. Lastly, Dr. Miller generates the results by performing mathematical calculations and selecting the more statistically relevant answer.
With success! Through the experiment [actor] find/s out a specific feature of the protein shell of the SARS-CoV-2 virus. This allows [actor] to develop a vaccine that is able to train the immune system to combat not only the

known variants of the virus but also every possible future mutation of it. And what's more, the vaccine works against all influenza viruses! The vaccine goes through rigorous testing and it is finally approved and licensed.
*(If Explainable:)* A faithful record of the experiment is published in an open-access journal. All the passages of the experiment and the processes made to achieve the result are explicitly reported and clearly explained in a language understandable to a non-specialist audience.
*(If Not explainable:)* No record of the experiment is available because a full report of the processes that led to the discovery could not be produced by [actor].

Participants had to read the vignettes and provide their impression of the levels of agency and creativity displayed by the actors in the presented scenarios.

In what followed, respondents were then asked to motivate their answers through a free response field, compulsory to move on with the questionnaire. Comments have been first organized in an Excel spreadsheet according to the scenario and vignette they were referring to. Within the single vignettes, they have then been arranged in descending order, according to the corresponding rating of creativity and agency that had been given by the respondent (Tables 6, 7) The content of the responses was then qualitatively analyzed using a grounded theory methodology (Charmaz 2006; Martin and Turner 1986). This method was chosen as opposed to the method applied in the analysis of the rest of the survey. Instead of starting with a hypothesis, e.g., the hypothesis on the correlation between embodiment and perceptions of creativity, the comments were analyzed without starting from any assumption, in order to test whether what emerged from the comments confirmed the results of the other sections of the survey.

# Results

## Demographics

The final sample consisted of 161 participants. The mean age is of 39.1 years. 157 out of 161 participants have a university-level education. 126 participants have a humanities, 22 an artistic, 15 a scientific, and 11 a technology educational background (selection was not mutually exclusive). The current occupation of most of the participants is in the education sector (Student 44, Academic 66, Engineer 3, Teacher 10, Admin 7, Retired 6, Other 25). The prevalence of participants with an educational and/or academic background and occupation is due also to the channels through which the survey has been advertised.

## Factorial Survey

After carefully reading the vignettes, respondents were asked to rate the process of, respectively, the creation of a painting (Scenario A) and the discovery of a vaccine (Scenario B) for their creativity on a 7-points scale from 'Not at all creative' to 'Very creative'. In both Scenario A and Scenario B, the average creativity was evaluated at 0.6 points, slightly above the mid-point of the scale.

What is more interesting, though, is to examine how the perception of creativity is affected by the manipulation of the different dimensions. Table 3 shows how the participants' evaluation of creativity changes by varying the Actor dimension, namely by presenting the process as performed by a human, an AI, a team of a human with an AI, or a team composed of two AIs. Values are rounded to the nearest hundredth, and they are reported in respect to the baseline (0) which corresponds to an individual human actor.

Statistically significant results, i.e., when the "p-value" ($Pr(>|z|)$) is inferior to 0.05, are marked in Table 3 with an asterisk.[4] Just for the fact of not being a human, but rather an artificial actor (other dimensions being equal), the AI is judged as 0.88, 1.00 and 0.98 points less creative than an individual human actor. What may come as a surprise, is that also the Human+Human team has been judged as 0.54, 0.74, and 0.68 points less creative than an individual human actor.

| | **Est.** | **Std. err** | **z value** | $Pr(>\|z\|)$ |
|---|---|---|---|---|
| | *Painting scenario* | | | |
| Human | 0 | 0 | 0 | 0 |
| AI | -0.88 | 0.43 | -2.00 | 0.04* |
| Hum.+Hum. | -0.54 | 0.37 | -1.44 | 0.15 |
| Hum.+AI | -0.18 | 0.38 | -0.48 | 0.63 |
| | *Vaccine scenario* | | | |
| Human | 0 | 0 | 0 | 0 |
| AI | -1.00 | 0.43 | -2.31 | 0.02* |
| Hum.+Hum. | -0.74 | 0.37 | -2.01 | 0.04* |
| Hum.+AI | -0.58 | 0.43 | -1.36 | 0.17 |
| | *Combined scenarios* | | | |
| Human | 0 | 0 | 0 | 0 |
| AI | -0.98 | 0.32 | -3.08 | 0.002* |
| Hum.+Hum. | -0.68 | 0.25 | -2.68 | 0.007* |
| Hum.+AI | -0.39 | 0.27 | -1.46 | 0.14 |

Table 3: *Actor Dimension.* The table shows the impact of the manipulation of the Actor dimension on the perception of creativity.

Table 4 shows how the participants' evaluation of creativity changes by varying the Embodiment dimension in respect to the baseline, which corresponds to the actor being not embodied. Only the results where Actor = AI are reported, as it is assumed that all humans are embodied.

In both Scenario A and B, when the actor is described as embodied (i.e., as a robot acting through robotic arms), the evaluation of creativity is lower than in the case of the actor being a computer software. Specifically, the agent is evaluated 0.14 and 0.27 points less creative than the software in Scenario A and B, respectively.

Somewhat disappointingly, the results concerning the influence of embodiment on the evaluation of creativity are not statistically significant. Indeed, in both cases the p-value is higher than 0.05, i.e., the value under which the p-value

[4]If the p-value is more than 0.05 there is no strong evidence against the null hypothesis, i.e. the hypothesis that there is no relationship between the variables being considered. From this, however, does not necessarily derive that the alternative hypothesis (i.e. the independent variable does affect the dependent one) is false.

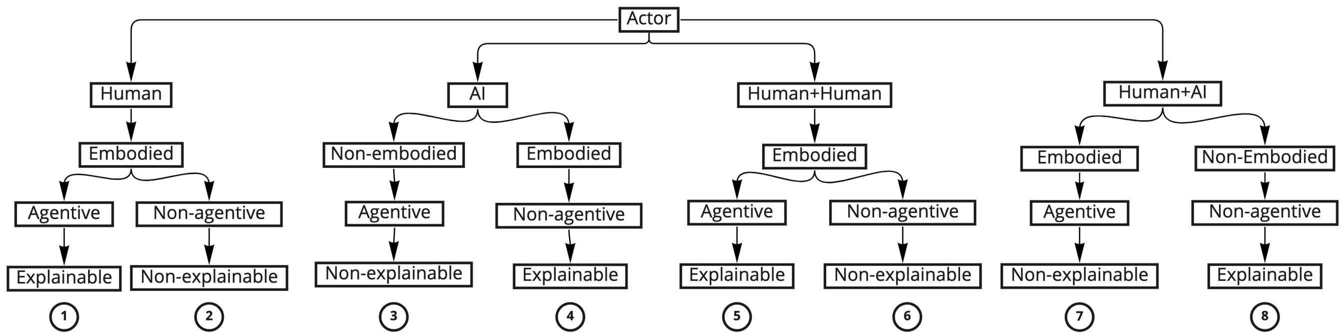


Figure 1:
*Vignettes distribution.* The scheme shows the distribution of the four dimensions (actor identity, embodiment, agency, and explainability) with their respective levels in the factorial survey experiment. From the distribution resulted 8 distinct vignettes.

| | **Est.** | **Std. err** | **z value** | $Pr(>\lvert z\rvert)$ |
|---|---|---|---|---|
| | *Painting scenario* | | | |
| **Actor=AI** | | | | |
| Not embod. | 0 | 0 | 0 | 0 |
| Embodied | -0.14 | 0.36 | -0.39 | 0.70 |
| | *Vaccine scenario* | | | |
| **Actor=AI** | | | | |
| Not embod. | 0 | 0 | 0 | 0 |
| Embodied | -0.27 | 0.45 | -0.61 | 0.54 |
| | *Combined scenarios* | | | |
| **Actor=AI** | | | | |
| Not embod. | 0 | 0 | 0 | 0 |
| Embodied | -0.18 | 0.30 | -0.62 | 0.54 |

Table 4: *Embodiment Dimension.* The table shows the impact of the manipulation of the Embodiment dimension on the perception of creativity. Baseline is the absence of the attribute.

indicates that the relationship between two variables is statistically significant. Thus, these results give us ground to neither confirm, nor disconfirm the starting hypothesis. Still, while the quantitative analysis of the influence of embodiment on creativity resulting from the factorial survey experiment is not conclusive, more interesting results emerge from the comments to the scenarios left by participants.

## Free Response Field

Tables 6 and 7 report some of the participants' comments left in the free response field after completing the factorial survey experiment. Here, respondents were asked to motivate the reasons behind the evaluation of the creativity exhibited by the actors in the scenario they were presented with. When possible, for each vignette (Vig.) are reported comments that are representative of the full range of creativity evaluation scores (Creat.).[5] Keywords are marked in bold by the author, and the categories under which each comment has been collected are indicated in column 2. The list of the categories that emerged from comments is reported in Table 5:

| **Categories** |
|---|
| Anthropomorphism |
| Autonomy |
| Collaboration |
| Data crunching |
| Problem solving |
| Randomness |
| Tool |
| Training |

Table 5: *Categories.* List of categories that emerged from the analysis of the participants' comments through grounded theory methods.

**Scenario A (Painting)** Considering the painting scenario performed by an individual artificial actor (Vignettes 4 and 3), no meaningful difference emerges between the comments relative to the vignette in which the actor is embodied (Vig. 4) from the ones relative to the vignette in which the actor is a software (Vig. 3). In the comments following a positive evaluation of creativity, 'Autonomy' seems to be the prevailing feature that is attributed to the actor and that, consequently, led to a high rating of creativity (Table 6).

On the other hand, comments following a negative evaluation of creativity, identify the robot or software as a 'Tool' that is, and should, be controlled by human agents. None of the comments relative to these first two vignettes refer to the role that the physicality of the robot might or might not play in performing the action, aside from the action of 'picking colors and tools' that is ascribed to it by participant 1532983358 and that follows a declaration of autonomous decision-making process from the side of the robot itself.

More interesting observations can be made by considering the comments to the vignettes in which human and artificial

[5] Vignette 4 presented an embodied AI (robot), vignette 3 a disembodied AI actor (software), vignette 7 a human and an embodied AI, vignette 8 a human and a disembodied AI (Fig. 1).

| Scenario A (Painting) | | | |
|---|---|---|---|
| **Vig.** | **Category** | **Creat.** | **Comment** |
| 4 | Autonomy | 7 | The robot was trained and now decides based on the training data. So, it has undergone a process similar to a human learning how to paint. Id. 679187182 |
| | Autonomy | 6 | The research team did not interfere with the process and Omega decided itself about the process (**picking** colors and tools). Id. 1532983358 |
| | Tool | 2 | The robot is only an **extension** of the intentions and goals of the human researchers. Id. 1072971333 |
| | Random. | 1 | The work can be satisfying but cannot count as creative: this is similar to a child who spills paint on a floor in a constellation that looks nice by **accident**. Id. 1727392082 |
| | Tool | 0 | A robot cannot be creative: it should merely be a **slave for humans**. Id. 1078614007 |
| 3 | Autonomy | 6 | The final painting seems to be novel and valuable and produced in a **fairly autonomous way** by Omega. Id. 633966012 |
| | Anthrop. | 4 | Even though the painting is pleasant, some inner motivation (in the sense of intuition) is missing **bc [sic] it is a software**. Id. 1440542658 |
| | Tool | 1 | Omega is more like a **tool** rather than an autonomous agent. Omega's agency is limited by the researchers' design goals and intentions. Id. 1072971333 |
| 7 | Autonomy, Collab. | 7 | They decided what to do and **acted together**. Id. 178982639 |
| | Collab. | 7 | **Helen and Omega** created a painting. Together they applied paint on canvas in such a way that they found satisfied their taste and intention. Id. 178982639 |
| | Collab. | 6 | The **participation of each one of them** and the **interaction between them** is necessary to perform the work. Id. 1702380099 |
| | Collab. | 6 | There was **collaboration and communication** of some sort between Helen and the robot and I think that is creative. Id. 1206682464 |
| | Tool | 4 | Helen uses the robot as a **tool**, both for the painting process and for the input for the colour palette. Id. 1724824616 |
| 8 | Anthrop. | 6 | Helen clearly has creativity, as for Omega, that would depend upon the underlying architecture. Id. 785499956 |
| | Anthrop. | 4 | I don't believe we are yet at a stage to give equal ratings to Helen and Omega, the rating is above average **because the human is involved**. Id. 1361386133 |
| | Anthrop. | 0 | **Software is not creative**. Id. 1150045635 |

Table 6: *Free responses; Painting scenario.* The table reports some participants' comments in the free responses field after the vignettes based on the painting scenario. Comments have been organized according to creativity score given by respondents and by categories, following a grounded theory method.

actors are collaborating (Vignettes 7 and 8). When the human is presented together with an embodied artificial agent (Vig. 7), the rating of creativity is higher (the lowest rating is 0) and participants explicitly refer to a high level of 'Collaboration' (Collab.) and cooperation that is not indicated in the case of the software and the human as joint actors (Vig. 8). Indeed, when the artificial actor is not embodied, the creativity, when at all recognized, is attributed to the human actor alone (i.e., Helen, see participant 785499956). A categorical refusal at acknowledging the possibility for software to be creative (participant 1150045635) is contrasted in Vig. 7 by a description of the robot Omega as a tool that Helen can use to express her creativity (participant 172482461).

**Scenario B (Vaccine)** In the comments relative to the scientific discovery scenario, there is no mention of the collaboration that was instead deemed happening between humans and machines in scenario A. The relatively small sample of participants to the study and the low number of significant comments do not allow us to draw a conclusion regarding whether this disparity between the two scenarios is indicative of the fact that human-machine collaboration is deemed more relevant for creativity in artistic than in scientific scenarios. Still, the comments confirm the estimate results obtained from the factorial survey experiment (Table 4) which show that the embodiment of the artificial actor is, slightly, less relevant to creativity in the scientific than in the artistic scenario.

In the vignette presenting the human interacting with the software (Vig. 8) the comments following a positive evaluation of creativity ascribe the latter to the human actor who uses Alpha as a 'Tool' or as a useful, but not autonomous, support (participants 680035971, 2070596251). In the vignette depicting Dr Miller working with robot Alpha (Vig. 7), the robot is recognized as a 'person' by one participant for its creative contribution (participant 1017771618). In general, hesitation at attributing creativity to the artificial actor is observed as coming together with the observation that the action performed is not creative but rather systematic 'Data crunching' (Table 7).

| Scenario B (Vaccine) | | | |
|---|---|---|---|
| **Vig.** | **Category** | **Creat.** | **Comment** |
| 4 | Data crunching | 6 | There is no bootstrapping by the robot, only exhaustive try-out, computation that is. Still its application worth some creativity. Id. 101174398 |
| | Tool | 4 | It is using a **tool** (a self-learning machine) to undertake a task. I see this as little more creative than using a supercomputer to break a coded message using brute force. Id. 2006543588 |
| | Data crunching | 0 | The robot is **systematically** trying all possible combinations of background knowledge, which is the opposite of creatively doing anything. Id. 1100858543 |
| 3 | Collab. | 6 | All of this strikes me as hugely creative and **collaborative problem-solving**. Id. 240767967 |
| | Data crunching | 5 | I don't know if creativity or **computational power** is the better term. Id. 1361386133 |
| | Data crunching | 0 | I think it is **sophisticated data crunching**, the creativity comes from the initial ideas of the designers. Id. 1724824616 |
| 7 | Prob. solving | 7 | A huge amount of creative problem-solving is needed to produce the results described in the story. If a robot is participating creatively, then that robot is, de facto, a **person**, and unambiguously exhibits creativity. Id. 1017771618 |
| | Training | 6 | They use a lot of **background knowledge and models**, it's a less intuitive process but more logic-based so it's not that creative as the painter. Id. 111980832 |
| | Anthrop. | 4 | Dr. Miller was indeed creative, but it is difficult to know the role by the robot. Id. 1078614007 |
| 8 | Tool | 7 | If we consider Alpha to be a **mathematical structure** (which it is) and if we suppose that Dr. Miller had instead used a different sort of mathematics (and pencil and paper) then we'd not hesitate to ascribe creativity to Miller. By parity of reasoning, this case if creative also. Id. 680035971 |
| | Tool | 7 | The doctor is utilising Alpha as a **tool, a sophisticated tool** - but in essence no different than a painter's brush. Id. 2070596251 |
| | Tool | 4 | I think it is not a lot about creativity in this scenario, but about a clever use of a **new (and sophisticated) tool** called Alpha by the scientist. Id. 1440542658 |
| | Data crunching | 0 | The generation of hypotheses and the evaluation of experiments seems to be things **'canned' algorithms** could do. Id. 2066630687 |

Table 7: *Free responses; Vaccine Scenario. Free responses; Painting scenario.* The table reports some participants' comments in the free responses field after the vignettes based on the vaccine scenario. Comments have been organized according to creativity score given by respondents and by categories, following a grounded theory method.

## Discussion

The reflection on the role of embodiment for the perception of creativity in computational systems is included in a wider discussion on the reception of the engagement of AI systems in the creative sector.

As mentioned, a generalized skepticism against AI engaging in creative activities is well-known and reported by the literature (Moruzzi 2020b; Mumford and Ventura 2015). The acquisition of problem-solving skills, agency, and other features of general intelligence has been indicated as a possible way for AI to gain the appreciation of the public (Bown and McCormack 2009; Gizzi et al. 2020; Moruzzi 2020a; Natale and Henrickson 2022), while other studies report how only the possession of anthropomorphic qualities and a general humanization of technology can lead AI to be perceived as creative (Moruzzi 2020b; Mumford and Ventura 2015; Wyse 2019).

Two obvious limitations of the present study need to be pointed out here: (i) the embodiment dimension comes in degrees, namely the grade of the physical presence of agents and of their interaction with the surrounding environment can vary. In order to conduct a more compelling test on the influence of embodiment on creativity, it would, therefore, be necessary to use more levels in the embodiment dimension and to vary them more accurately. The wider aim of the study that has been presented prevented a more detailed variation of the embodiment dimension. In addition, (ii) in order to obtain more representative and significant results, a bigger and more diverse sample of participants would be necessary. Notwithstanding the value of factorial research methods for assessing the influence of variables on the testing hypothesis, a drawback of this methodology is, indeed, the need for high numbers of participants in order to obtain statistically relevant results for each of the vignettes presented (Auspurg and Hinz 2014). Follow-up research starting from the results of this study will explore the impact that the language used to describe artificial actors has on creativity perceptions (e.g., tool vs collaborator). During the workshop 'The Role of Embodiment in the Perception of Human and Artificial Creativity', as part of ICCC'22, we will expand the methodology followed in the survey presented in this paper, allowing participants to the workshop to assist to live performances by the digital illustrator Renaud Chabrier and by the artist Daniel Berio, who will conduct a procedural generation of graffiti through robotic applications. This 'on-site' study will allow us to obtain more precise and detailed results on the role of embodiment in the judgment of the aesthetic value of an artifact and on the evaluation of the creativity of the process behind its creation.

## Conclusions

This paper started with the suggestion made by Guckelsberger et al. (2021) that conducting empirical research on the influence of embodiment on the perception of creativity could contribute to the field of computational creativity as a whole. The paper replied to this suggestion by presenting the results of a recent empirical study on perceptions of creativity in artistic and scientific processes performed by human and artificial agents. The study started with the hypothesis, motivated by previous research, that embodiment positively influences perceptions of creativity. This hypothesis has been tested in the central part of the study through a factorial experiment and the corresponding modulation of the levels of the embodiment dimension. From the results of the evaluation of vignettes in both the artistic and scientific scenario, however, no significant observation could be made. Indeed, the dimension of embodiment had a statistically irrelevant weight on evaluations of creativity.

As partial compensation for the non-conclusive results following the quantitative analysis of the influence of embodiment on creativity, more interesting results have been obtained from the qualitative analysis of the comments left by participants in the free responses section. In particular, what emerges from this study is a higher propensity of respondents in acknowledging collaboration and creative exchange between the human and the artificial actor when the latter is embodied (in the form of a robot). This tendency is observed only in the artistic scenario (Scenario A). What is common to both scenarios, is the description of the artificial actor as a 'Tool' in comments associated to low ratings of creativity.

This indication of the relevance of embodiment in the artistic collaboration between human and artificial actors suggests the importance of exploring the creative potentialities that may emerge from human-machine interaction in the context of artistic processes in further research. The increasingly frequent use of technology in the art sector, indeed, is inevitably bringing with it a modification and development of the relationship between artists, technology, artifacts, and the audience. Importantly, the nature of the human-machine collaboration, as well as the ascription of different characteristics to the machines that may interact with human artists, are dependent on the viewers' perspectives: some may attribute more autonomy to the machine, others may see it as just a tool (Audry and Ippolito 2019).

This, in conclusion, is the ultimate reason for the relevance of the recommendation by Guckelsberger et al.(2021): empirically investigating the perception of creativity and the influence of embodiment on it is crucial for illuminating and suggesting fertile new grounds for co-creativity opportunities. Different kinds of embodiment may generate different modalities of human-machine and machine-machine co-creativity (Davis et al. 2019; Kantosalo and Toivonen 2016; Kantosalo and Takala 2020; Karimi et al. 2018; Saunders and Bown 2015), and this in contrast to the vision of art and artworks as dis-embodied and devoid of any consideration about the context in which they emerge (Audry 2021).

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## Author contributions

CM ideated and wrote the paper alone.

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