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Perceptions of Creativity in Artistic and Scientific Processes

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This paper presents the results of a factorial survey research on perceptions of artistic and scientific creativity in humans and AI. A general reluctance at attributing creativity to artificial systems is well-documented in the literature on the theme. Aim of this survey is to test whether this reluctance is equally strong when participants evaluate scenarios where human and artificial agents are involved in processes of scientific discovery and scenarios where they are engaged in artistic creation processes. The starting hypothesis of the study is that participants should be less hesitant at attributing creativity to artificial agents when the latter engage in scientific discovery processes. Findings, however, disconfirm this assumption, showing that participants attribute significantly less creativity to artificial actors than to human ones, and even more so when they are involved in scientific processes.

Keywords creativity, AI, factorial survey, discovery, art, science

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1. Introduction

State-of-the-art Machine Learning (ML) systems are expanding their reach toward a field that, by many, is considered to be a paradigm of humanity: creativity. From composing music in the style of Bach, to creating paintings sold for hundreds of thousands of English pounds at renowned auction houses, to having their say in the fashion industry (Byers 2020), algorithmic programs are raising excitement and awe in the public but also a great deal of critiques and indignation (Hertzmann 2018, 2020; Jones 2019). The question of whether artificial systems can also be creative has been rapidly gaining attention since the 1990s, when Margaret Boden shared her work on computational creativity (Boden 1998). In the last decades, many programmes were designed with the aim to build systems that exhibit creativity in visual arts (Colton 2012), music (Eigenfeldt and Pasquier 2011, Moruzzi 2020), and poetry (Gatti et al. 2012). Easily accessible web platforms allow users to create their own art through generative algorithms, without the need for them to learn technical terminology or programming languages.[1]

Cutting-edge developments in ML do not involve only the artistic but also the scientific sector. Indeed, in recent decades, relevant research has been conducted with the goal of developing Artificial Intelligence (AI) systems that can assist humans in scientific research and discovery.[2] Debates on the creative skills that might be displayed by artificial agents range from the academic to the industrial sector, and almost everyone agrees with the claim that creativity can be observed both in arts and in the sciences (Gaut 2010). The disanalogies arise when considering that, while artistic creativity often has an open goal, scientific creativity is more goal-oriented (Dutton 2001; Leddy 1990),[3] and while for the first it is more usual to talk about 'creation', for scientific creativity we normally talk about 'discovery'.

The question of whether it is possible for automated systems to make scientific discoveries goes back to the debate about induction and how it is possible to identify a logic of discovery when chance and insight play a relevant role in scientific discovery processes (Alai 2004; Hempel 1985; Hume 2000; D. F. Norton and M. J. Norton 2007; Popper 1998). A framework for creativity in science, developed in the philosophical and psychological literature (Darden 1997; Feyerabend 1987; Getzels and Csikszentmihalyi 1967; Miller 2012; Sawyer 2011; Simonton 2003), is a necessary starting point for discussions that concern machine discovery programs and to what extent they can facilitate scientific research (Colton and Steel 1999).

This paper aims at contributing to address this need by presenting the results of a study on perceptions of artistic and scientific creativity in human and artificial actors. A general reluctance at attributing creativity to artificial agents is well-documented in the literature on the theme (Colton 2008; Lamb, Brown, Clarke 2018).

1. See, for example, https://app.wombo.art and https://www.playform.io

2. For example, Dalton, Stahl, AlphaFold, BACON, metaDENDRAL, and others, see (Sparkes et al. 2010).

3. This observation was made also by several participants in the free responses, see section 2.3.

The contribution that this paper aims to bring to the debate is to offer an additional quantitative and qualitative analysis of this phenomenon and to test whether the attribution of creativity to artificial systems that engage in processes of scientific discovery would meet the same amount of resistance to the one registered by previous studies on the evaluation of 'artistic' creativity displayed by artificial systems (Hristov 2020; Moruzzi 2020; Natale & Henrickson 2022).

The study presented in this paper addresses some of the limitations that past surveys on perceptions of artificial creativity by the author had, making a clear distinction between 'creativity' and 'art', notions that originated confusion in previous studies (Moruzzi 2020). In so doing, this study explicitly refers only to the *process* of creation of an artefact, excluding the evaluation of the features of the *outcome* from the dimensions addressed in the survey. This decision was made in agreement with the claim that the consideration of the process through which an agent creates can have a stronger influence on the overall creativity evaluation than the mere perception of the outcome (Colton 2008). In addition, the focus on the process is motivated by the observation that, while the evaluation of creativity based on the outcome undoubtedly has the advantage of being more easily measurable and identifiable, it is also more often subject to implicit assumptions and biases on the linearity of creativity (Glaveanu & Beghetto 2021).

2. Survey on Creativity in Science and the Arts

2.1. Aims

Results obtained from a survey conducted by Moruzzi (2020), aimed at investigating the public perception in respect to the possibility for AI to be 'creative', revealed a generalised discontent and, almost, and aggressive fear in respect to the application of artificial intelligence systems in the creative sector. The uneasiness displayed by participants to the study emerged from the belief that automated systems do not, and *could* not, possess the empathy and charisma that are necessary for performing creative processes. When considering what is that AI lacks to be creative, a vast array of elements was listed by participants: feelings, emotions, personal narrative, intentionality, memories, intuition, autonomy, emotional need, unpredictability, emotional understanding, social identity, passion, experience, imagination, consciousness, desire to make art, charisma, among others. Rather than being motivated by a lack of technical capabilities, this opposition toward the attribution of creativity to artificial systems was grounded on a resolutive belief that AI cannot, and *should* not, be creative since it lacks the necessary personality, feelings, and emotions that are a requisite of creative agents.

The emphasis on aspects of sensibility, individuality, taste-expression, and emotions in creative processes is part of the legacy of the Romantic view of creativity (Feyerabend 1987; Hills & Bird 2018). In the literature about scientific discovery, instead, there is arguably less emphasis on creativity as

expression of emotional participation and personality and more on creativity as goal-orientedness and problem-solving (Sawyer 2011; Simonton 2003). The standing point from which the survey presented in this paper – a follow-up of the previous study by the author - starts is not completely neutral. Indeed, starting from the consideration of the features that participants to the study in (Moruzzi 2020) identified as prerequisites of creativity, and based on the mentioned different characterisation of artistic and scientific creativity in the literature, the starting hypothesis of the survey is that the attribution of creativity to artificial systems could meet less resistance when the latter engage in scientific discoveries than when engaging in artistic processes. Indeed, the personality, feelings, and emotions that artificial systems were deemed as lacking in the previous study are, arguably, not pre-eminent requisites of scientific creativity.[4]

4. Additional aim of the survey is to study the mutual influences between the attribution of agential and creative skills to human and artificial actors. For the sake of the present discussion, however, I will focus here only on the dialogue between artistic and scientific creativity, leaving further considerations to later analyses.

2.2 Methodology

2.2.1 Procedure

The survey was conducted in the form of an online questionnaire with 53 questions in total. Respondents were recruited online through academic newsletters in philosophy, art, and computer science. The final sample of the study consisted of 161 participants. At the start of the questionnaire, participants completed an online consent form and a demographic questionnaire that included questions about age, level of education, and current occupation. No question about the gender and ethnical background of the participants was asked. The mean age of participants is 39.1 years. As predictable from the platforms in which the survey has been advertised, most of the participants have a university-level education (157 out of 161). In particular: 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 the participants is distributed as follows: Student 44, Academic 66, Engineer 3, Teacher 10, Admin 7, Retired 6, Other 25.

Participants were then asked questions regarding their intuitions about creativity and agency (results in section 2.3). The core section of the questionnaire consisted in a factorial survey experiment which will be described in detail in what follows. After successfully completing the questionnaire, participants were asked for their E-Mail address to participate in a raffle for one of three 50,00€ vouchers to use on an E-commerce platform chosen among the ones within a given list.

2.2.2 Factorial Survey

The central section of the survey included two vignettes designed according to the factorial survey method (Auspurg and Hinz 2014). The latter is a multidimensional

approach that presents survey respondents with vignettes which describe hypothetical situations with various attributes (dimensions). Respondents are then asked to form judgments about them. The values (or levels) of the dimensions of the vignette are experimentally varied so that the impact of these levels on participants' judgments can be tested.

The relevant dimension for the discussion carried out in this paper, is the 'Actor' dimension, namely the identity attribute of the individual/s performing the action. The values used in the survey for this dimension are:

(i) Human
(ii) AI
(iii) Human + Human
(iv) Human + AI

Systematic differences in creativity ratings for human or artificial actors given by participants are analysed to illustrate the influence that the 'Actor' dimension has on the evaluation of creativity. Other dimensions included in the survey design, which will not be addressed in this paper, are Agency, Embodiment, and Explainability.

Eight vignettes resulted from the random combination of all the dimensions and values involved (Table 1). Vignettes 1-4 are about individuals (human or AI), while 5-8 are about multiple actors (human+human or human+AI). A random selection was then programmed into the survey to determine which vignettes to present at the beginning of the survey to each participant.

Table 1. Distribution of dimensions in vignettes.

Vig.	**Identity**				**Agency**		**Embodiment**		**Explainability**	
	Human	AI	Human+Human	Human+AI	Yes	No	Yes	No	Yes	No
1	x				x		x		x	
2	x					x	x			x
3		x			x			x		x
4		x				x	x		x	
5			x		x		x		x	
6			x			x	x			x
7				x	x		x			x
8				x		x		x	x	

Participants were asked to read and evaluate two hypothetical scenarios: A. Painting a picture, B. Developing a vaccine. They had to read through the described scenarios carefully and provide their impression of the displayed levels of agency and creativity by the actors in these scenarios.

Scenario A (Painting) described an actor/multiple actors in the process of painting a canvas. According to the level of the different dimensions, the actor/s

are described in the process of painting the picture by "randomly picking some colors and tools" (Not displaying Agency) or by "observing the picture and deciding to stop painting" (Displaying Agency). If the level of the dimension Embodiment is positive, the AI is referred to as a robot, if not as a software. Lastly, if the process undertaken is explainable, the vignette closed with the "record of the process of painting the canvas [...] published in an open-access journal", if not the vignette reported that "no record of the creation of this painting is available because a full report of the processes that led to the result could not be produced".[5]

Scenario B (Vaccine) described an actor/multiple actors in the process of making experiments to find a vaccine against the SARS-CoV-2 virus. If the actor/s displayed agency, they were presented as "generating hypotheses" and carrying out experiments accordingly, if not as trying "all combinations of the available background knowledge and models to generate hypotheses" and "selecting the most statistically relevant answers". The dimensions of Embodiment and Explainability were treated similarly to Scenario A.[6]

2.3 Results

2.3.1 Creativity Dimensions

Prior to engaging with the factorial survey experiments, participants were asked to answer questions aimed at testing their intuitions regarding the two key concepts of agency and creativity. Here will be reported only the results concerning the notion of creativity.

To the question: "Which of these concepts do you associate with the notion of 'creativity'?", participants were asked to choose among the following features all the ones that applied: Novelty (128), Problem-solving (87), Surprisingness (66), Value (52), Instinctiveness (50), Serendipity (22), Unexplainability (20), Genius (33), Pleasantness (4). Novelty, problem-solving, and surprisingness are features of creativity that are attributed to creativity not exclusively in the artistic field, but also in other domains (Miller 2012; Sawyer 2011; Simonton 2003). A detail that should be noted is that, while the attribute 'Pleasantness' was selected just by 4 participants, in the free response field of the factorial survey section, many participants referred to the relevance of the final product for the evaluation of creativity. Here are some examples:

- I really don't think I can answer any of the below questions (strongly agree vs. strongly disagree) without having actually seen the painting. [participant n. 2028249815]

- Unable to decide without knowing the content of the painting. Not every painting is equally creative. I would need to see the painting. [participant n. 1246012058]

5. I acknowledge that the choice of using painting as the representative of 'Art' is controversial, as it can be seen as a reduction of the richness of other art forms. This decision was made on the basis that the survey was designed with a non-specialist audience in mind, for which the association between painting- and art would arguably result more immediate. In addition, the space for the scenario description was limited and less traditional artistic processes would have taken longer to contextualise and explain. I thank an anonymous reviewer for bringing this observation to my attention.

6. Text of the survey available at: https://www.dropbox.com/s/3gfppuae12jn8aj/Survey_Agency_Creativity.pdf?dl=0

× The level of creativity will partially depend on the finished product. [participant n. 1557038500]

× I'd need to see the result to tell how creative it is. [participant n. 1737371147]

The low score achieved by 'Pleasantness' here, thus, should not be confused with participants identifying the process rather than the product as the site of expression of creativity.

No specific methodology for the evaluation of creativity is adopted in this study. Namely, in the factorial survey participants were not asked to provide a rating of the creativity exhibited by the human and artificial actors with reference to determinate features, such as imagination, skill, novelty, value, etc. (Colton 2008; Jordanous 2012; Moruzzi 2021). Being asked to indicate the concepts that they usually associate to 'creativity' in the initial phase of the questionnaire, participants are rather primed to reflect on their own intuitions about the topic and to follow these intuitions when assessing creativity in the scenarios presented in the vignettes. This was done with the intent of avoiding constraining the assessment of creativity made by participants to a pre-existing model.

2.3.2 Evaluation of Creativity

After reading each of the two vignettes, participants were asked how they rated the process of creation of a painting (in scenario A) and the process of discovery of the vaccine (in scenario B) for their creativity on a scale from -3 to +3, where -3 was 'Not at all creative' and + 3 'Very creative'. In both scenarios, the average creativity was evaluated as 0.6 (Figure 1).

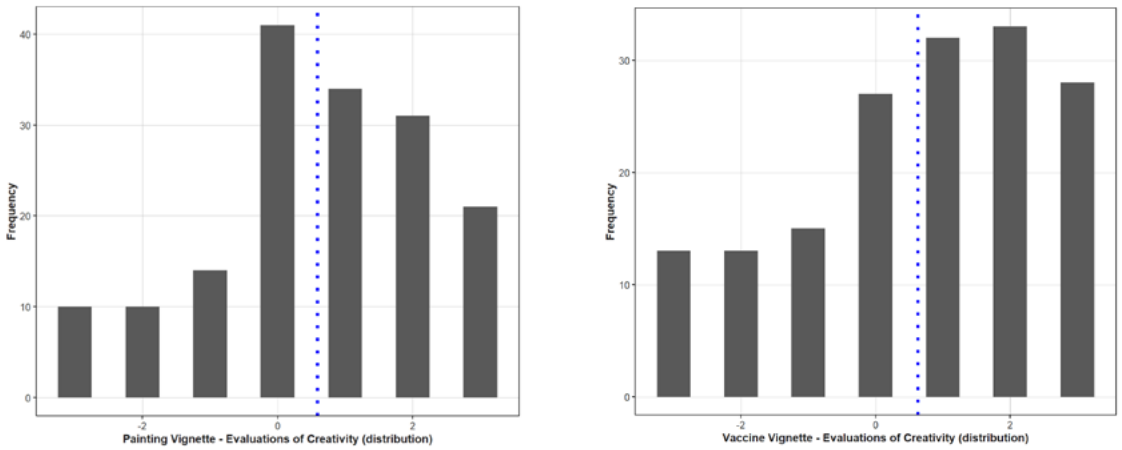


Fig. 1. Creativity distribution in the vignettes.

The creativity displayed by different actors in the process of painting a canvas, thus, has been evaluated by participants equally to the creativity exhibited in the process of making a scientific discovery. This result already carries a partial relevance in

respect to the initial hypothesis of the study, i.e., overall, there does not seem to be a difference between the evaluation of creativity in artistic endeavours and in scientific discovery processes. Still, in order to more thoroughly test whether the starting hypothesis is disputed, it is worth considering the factors that influenced the evaluation of creativity displayed by human and artificial agents in both scenarios.

The focus of this paper lies on the impact that the identity of the actor performing the action, namely whether the actor is human or artificial, has on attributions of creativity. This is the analysis that will be reported in what follows, leaving aside the consideration of the influence of the other dimensions (i.e., Agency, Embodiment, Explainability) on the evaluation of creativity. Table 2 shows how the participants' evaluation of creativity change by varying the levels in the Actor dimension in respect to the baseline (corresponding to the actor being a human individual). Values are rounded to the nearest hundredth.

Table 2. Factors impacting perceptions of creativity.

	Actor Dimension			
	Human (baseline)	AI	Human & Human	Human & AI
	Painting scenario			
Estimate	0	**-0.88**	-0.54	-0.18
Std. err.	0	0.44	0.37	0.38
z value	0	-2.00	-1.44	-0.48
Pr(> |z|)	0	0.04	0.15	0.63
	Vaccine scenario			
Estimate	0	**-1.00**	**-0.74**	-0.58
Std. err.	0	0.43	0.37	0.43
z value	0	-2.31	-2.01	-1.36
Pr(> |z|)	0	0.02	0.04	0.17
	Combined scenarios			
Estimate	0	**-0.98**	**-0.68**	-0.39
Std. err.	0	0.31	0.25	0.27
z value	0	-3.07	-2.68	-1.46
Pr(> |z|)	0	0.002	0.007	0.14

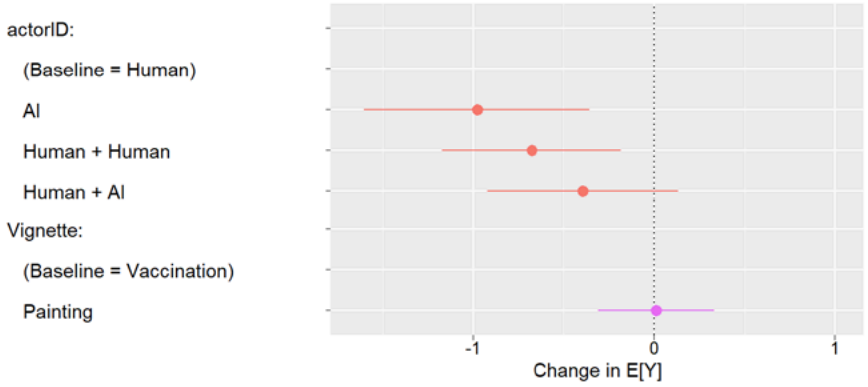
From the Estimate row, it is possible to see that in both scenarios, just for the fact of not being a human, but rather an artificial actor (other dimensions being equal), the AI is judged as 0.88 or 1.00 point less creative than humans.[7] What is more surprising is that in the case of the vaccine scenario also the team composed of two humans (-0.74) results significantly less creative than an individual human (0), and even less creative than the team composed of a human and an artificial intelligence (-0.58). Combining the results of the two scenarios, similar results are obtained: both AI (-0.98) and the team composed by two humans (-0.68) are deemed significantly less creative than a human individual.

7. In Table 2 the significant estimates are indicated in bold, where the significance is indicated by the Pr(> |z|), the so-called 'p-value'. The latter is a number between 0 and 1 which describes how likely it is that the null hypothesis is true, where the null hypothesis states that there is no relationship between the variables being studied. To be statistically significant, the p-value should be less than 0.05. This value indicates strong evidence against the null hypothesis, as there is less than a 5% probability that the null hypothesis is correct and that there is no relationship between the variables studied. It should be noted that from the fact that the p value is significant, does not automatically follow that the alternative hypothesis that the independent variable did affect the dependent variable, and the results are significant in terms of supporting the theory being investigated, is true.

Figure 2 presents the results of the combined scenarios reported in Table 2 graphically.

Fig. 2. Factors impacting perceptions of creativity in combined scenarios.

Attribute	Level	Estimate	Std. Err	z value	Pr(>|z|)
actorID	AI	-0.9772672	0.3177047	-3.0760241	0.0020978 **
actorID	Human + Human	-0.6767014	0.2522837	-2.6823034	0.0073117 **
actorID	Human + AI	-0.3928324	0.2692261	-1.4591168	0.1445330
Vignette	Painting	0.0129099	0.1629443	0.0792291	0.9368504



The hypothesis that there should be less resistance against artificial creativity in the context of scientific discovery has not been confirmed. Rather, by looking at the estimated values, in the vaccine scenario AI has been judged 1 point less creative than a human actor, while in the painting scenario it has been judged 0.88 point less creative than a human actor. Even if the difference between the two estimates is minimal, AI is recognised less creative when engaging in a scientific discovery than in an artistic process.

Instead of ascribing the low rating of creativity attributed to AI to just the identity of the actor, other reasons could be argued for. For example, it can be claimed that the two scenarios described do not allow a generalisation of the results and to conclude that, in general, AI is deemed less creative than humans in any artistic or scientific endeavour. Another possible argument is that the creativity rating was lower in the scientific discovery scenario because creativity is arguably more often associated to artistic than to scientific processes. The motivations behind the low level of creativity ascribed to artificial actors, as well as to the team composed by two humans, can be investigated further by considering the comments given by participants in the free response field in the factorial survey section.

2.3.3 Free Responses

After being asked to evaluate the level of agency and creativity in both scenarios, participants also had to elaborate their answers through a free response field (compulsory to move forward in the questionnaire).

The possibility that the low attribution of creativity to artificial systems in scenario B (vaccine) could be motivated by a more general hesitation to recognise science as a field where creativity can be expressed, does not seem to be supported by the participants' comments. Despite acknowledging that creativity in science is a different kind of creativity to the one displayed in the artistic sector, none of the participants categorically refuses to recognise that creativity is an important skill for scientific discoveries. The following are some of the relevant comments to scenario B:

- All I'm trying to say is that the creativity needed for a scientific discovery is a different type of creativity, oriented toward problem-solving and teamwork, compared to the creative process in other fields. [participant n. 1902441942]

- [...] in contrast to the arts, creativity in science should be under control of the agent. Ideas might come uncontrolled, but the actual results should be under control. [participant n. 1939986821]

- Science requires creativity, since imitation and methodology rarely are enough discovery. [sic!] [participant n. 819642924]

- I consider that behaviour creative. However, during the process of true (artistic) creativity the goal itself is open. [participant n. 1501662647]

- In scientific experiments, the space for creativity would be low, especially one involving finding a vaccine against COVID-19. [participant n. 996487393]

The attitude expressed by participants in the comments in respect to the consideration of artificial actors as creative in the context of both artistic and scientific processes is similar. While some are favourable to the attribution of creativity to AI and recognise artificial actors as capable of expressing both agential and creative skills:

- [Alpha] did just what a creative, insightful scientist would have done. [participant n. 1167425615]

- There was collaboration and Communication of some sort between Helen and the robot and I think that is creative. [participant n. 1206682464],[8]

8. Dr Miller and Alpha are the names, respectively, of the individual human and of the artificial actor in scenario B. Helen and Omega are the names, respectively, of the individual human and of the artificial actor in scenario A.

most of the comments refer to the artificial actor as a 'tool', both when it is acting alone and in collaboration with humans. The debate around whether AI systems should be deemed tools for the human artists, or rather artists themselves, is well addressed in the literature (Hertzmann 2018, Loman 2018). The tendency at not attributing autonomy to the artificial actor, holding instead the human programmers behind it as responsible for the creative capabilities expressed, can be observed in equal measure in both scenarios, thus disputing the assumption that a more positive attitude toward the attribution of creativity in scientific discoveries would have been observed.

The following are some of the relevant comments to scenario B:

- 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. [participant n. 2006543588]

- The doctor is utilizing Alpha as a tool, a sophisticated tool - but in essence no different than a painter's brush. [participant n. 2070596251]

- 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. [participant n. 1440542658]

- Dr Miller is agent, Alpha is a tool. [participant n. 1923077464]

Here are a few of the relevant comments to scenario A:

- Helen uses the robot as a tool, both for the painting process and for the input for the colour palette. [participant n. 1724824616]

- Omega is more like a tool rather than an autonomous agent. [participant n. 1072971333]

- A robot cannot be creative: it should merely be a slave for humans. [participant n. 1078614007]

- On the one hand, if the action displayed above had been performed by a human, I would have had no problem to give an answer tending to the creativity side. On the other hand, the fact that the action above displayed is performed by a machine and so, by something which acts according to the program implemented in it by humans make me quite reluctant to attribute any level of creativity above the neutral midpoint. [participant n. 2021552982]

It has been mentioned above that the team composed of two humans was evaluated as less creative than the individual human and the team of human + AI in the vaccine scenario. No relevant observation is provided by participants that could help understand the motivations behind this evaluation. Rather, some comments express the importance of teamwork for creativity in the science domain. Here is an example:

> × I don't doubt that Dr Miller has exercised scientific creativity necessary for all scientific discoveries. But it is highly unlikely that Dr Miller has acted solo. Scientific discoveries require teamwork, at least at one leg of the journey or another, if not at every stage. [participant n. 1902441942]

This observation would seem to go against the estimates resulting from the vaccine scenario. The lack of other significant results in respect to the difference between the attribution of individual vs. collective creativity, thus, does not allow to support a conclusion in this respect.

3. Conclusion

This study sought to investigate participants' perception of human and artificial creativity in artistic and scientific scenarios. Based on results of previous research by the author (Moruzzi 2020), the study started with the hypothesis that participants would have been more inclined to attribute creative skills to artificial actors that engage in scientific discoveries rather than to actors that are involved in artistic processes.

Results obtained from the factorial survey experiments of the survey, however, disconfirm this hypothesis. The evaluation of the overall creativity displayed by actors in the artistic and in the scientific scenarios is almost equivalent. In addition, by observing the factors influencing the participants' assessment of creativity in each scenario, the findings indicate that participants attribute significantly less creativity to artificial than to human actors, and even more so when they engage in scientific discoveries. From the consideration of the free responses provided by participants it has been observed that participants refer to artificial actors as 'tools', hesitating to attribute them the necessary autonomy required to be deemed agents of creative processes. The suggestion that the low creativity attributed to artificial systems in the scientific scenario could be a result of a general reluctance at associating creativity to the scientific domain has been countered by participants' comments that acknowledge the relevance of creativity for scientific discoveries.

This paper focused on the influence on creativity attribution that the variation of the actors performing the process and of the field of application have.

Further work based on the factorial survey experiments will analyse the influence of other dimensions, such as agency attribution, explainability, and embodiment, on the evaluation of creativity. A limitation of the present study that could be addressed by more careful follow-ups is that it does not allow for straightforward generalisations of the results to the whole spectrum of art and science. This limitation is a consequence of, partly, the necessarily short and partial descriptions of the artistic and scientific scenarios and, partly, of the small and biased sample of participants. Succeeding studies can elucidate the motivations that lie behind the reluctance that this research illustrated, by varying more meticulously the different variables that are involved in a creative process and by recruiting a larger and more diverse sample of respondents.

The observations resulting from this study can pave the way for a deeper and more careful consideration of the dimensions that influence the attribution of creativity to human and artificial systems engaging with different kinds of processes. The provisional considerations that can be derived from the results obtained is that the hesitancy and unwillingness at attributing creativity to artificial systems is not limited to the artistic domain, traditionally recognised as the place where human emotions and feeling are expressed at their best, but it extends also to the more exact and rational field of science. This and follow-up research can then contribute to debates on the topic of creativity and technology in general, and at the same time inform the artistic practice and the technological developments in the field of human-machine collaboration.[9]

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