

CHILDREN'S GRI-CREATIVITY: EFFECTS OF LIMITED RESOURCES IN CREATIVE DRAWING

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Children’s GrI-creativity: Effects of limited resources in creative drawing

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Abstract

We define GrI-creativity as the specific creative cognition process resulting in green innovation, i.e., directed toward the generation of green rather than non-green products.

In this work, we developed an operational way to investigate the GrI-creativity process and its determinants through a lab-in-the-field experiment with primary school children aged from 7 to 11 years old. Subjects performed a common drawing task, but with different means: only a black marker, any color among twelve (including black), or three among the same twelve color set. Our findings show that (i) freedom of choice in the used tools is boosting creativity, (ii) limited resources do not boost creativity, but they are not detrimental either. According to our results, GrI-creativity can be enhanced by providing fewer resources, but ensuring that individuals are given some discretion when it comes to choosing which of them to use.

Therefore, we combine our experimental method with insights from social psychology. We provide evidence of a highly significant positive effect on creativity of three personal traits of the subjects, namely: a high score at the Cognitive Reflection Test, self-perception of creativity and the practice of sport in daily life. All these results are in line with the existing literature investigating the determinants of creativity. More surprisingly, we do not find evidence of a role of the risk preferences.

JEL codes: C91, D91, O31, Q50

Keywords: Creativity, Green Innovation, Experimental Economics, Social Psychology

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1 Introduction

Creativity represents one of the main drivers of development in any field, being it the foundation of any idea which made human civilization as it is. Creativity's central role has been recognized both at a micro and at a macro scale, as it is seen as accountable for the well-being and self-determination of individuals on the former [see, e.g., Dolan and Metcalfe, 2012] and for technological progress on the latter [see, e.g., Mokyr, 1992]. The key link between what it may look like a pure psychological trait and economics lies on the fact that creativity is a key building block for innovation. Nevertheless, innovation and creativity are two different concepts. Creativity is a human act that involves the generation of novel and useful ideas [see Amabile, 1983]. Innovation, as observed by Charness and Grieco [2019], greatly depends on the human ability to create, entailing the implementation of these ideas into new products and processes.

In the recent decades, pressures for more environmentally and socially sustainable technologies were made, driven from the fact that not all innovations are “viable”. In fact, some innovation might be not market-driven and might require the adoption of expensive technologies in order to comply with political requirements. In this context, academics started to focus on a type of innovation that have attracted the attention of policy makers all over the world, also due to environmental concerns encouraging firms to specialize on the production of environmentally friendly products: the so-called *green innovation* [see, e.g., Chapple et al., 2011]. The purpose of green innovation is to generate - with limited natural and energy resources - durable products with lower energy consumption and/or improved environmental quality.

In this work, we investigate the preliminary stage of such process: we focus on creativity resulting in green innovation, i.e. the specific creative cognition directed toward green rather than non-green products. We will refer to it as *GrI-creativity*¹. In particular, we develop an operational way to investigate the GrI-creativity process and its determinants through a lab-in-the-field experiment with primary school children aged from 7 to 11 years old. The aim is to provide insights into whether there are differences in the creative outcome depending on the means given, i.e., to investigate on the effect of performing the same task, but with slight variations in the tools made available to the participants. The research question of our work may be resumed in investigating on whether limited resources are detrimental or, on the contrary, beneficial for the creative process, and on the effects of letting the subjects decide about their own, eventually limited, resources, when dealing with a creative task.

In our experiment, children were asked to perform a drawing *à la* Charness and Grieco [2019]², i.e., a

¹As defined in the scientific proposal of the GrICRiS project, the ANR project who founded our research.

²This task was present in a working paper version of the work, but it was not included in the final published version.

creative drawing, including at least nine geometric figures (three circles, three triangles and three squares), in our implementation within a 5 minutes time limit. The difference in the means has been reproduced by allowing the kids in the first treatment to perform the task only with a black marker, while in a second treatment kids could choose any color among twelve (including black), and a third treatment group had the possibility of choosing three among the same twelve color set. An incentive scheme was provided in the form of a tournament, where the best among approximately 20/25 members (randomly matched) of the same treatment group was awarded a €20 coupon for a sport franchising store.

Our experimental evidence confirms the findings of Amabile and Gitomer [1984], who showed higher levels of creativity in preschool children aged from 2 to 6, when given the chance to choose which materials to use for a collage. Similarly, in our experimental setting kids perform significantly better when they are given the possibility of making a choice (either one or three colors), when compared to the performances of the children who had no freedom and were obliged to use a black marker. This finding supports the idea that freedom of choice in the used tools is boosting creativity. More surprisingly, our experimental subjects endowed with the choice of a single color present similar creative levels with respect to those who could choose three. This finding seems to be in favor of GrI-creativity: limited resources do not boost creativity, but they are not detrimental either. Namely, subjects are capable of performing similarly while “consuming” less.

We argue that some inner features of our creativity task seem to fill this means’ gap in the creative performance. We propose three different possible explanations. Firstly, a simple reading key may reside in the fact that having to choose and use more materials rather than less makes the task more difficult. This is particularly true when performing a task in a very short time (only 5 minutes, in our implementation). Second, this mechanism is likely to be boosted by the fact that the available tools are in themselves some source of inspiration and that a more immediate source of inspiration may be provided by a single color rather than many. We refer here to a *color as a Gestalt* interpretation (see Pomerantz [2006], where the author argues that color perception meets the customary criteria applied to Gestalts). Gestalt phenomena are a cornerstone of perceptual psychology³. As a Gestalt, color serves as a psychological primitive and so it may lead to pop-out in visual search. For instance, taking the case of our experiment, a child choosing the yellow color may immediately be inspired in drawing a lemon. On the contrary, no immediate association may occur if the colors are three. This intuition is confirmed by the obvious relationships between some

³Gestalt psychology is a school of thought that emerged in Austria and Germany in the early twentieth century. We refer to Rock and Palmer [1990] for a better understanding of the Gestalt psychology.

drawings' subjects and the colors chosen, particularly across the one-color group, where, for example we have a red Santa Claus or a blue ship in a tempest (see Appendix D for some examples of task executions). Third, some fixation effect in the creative process [see Agogu  et al., 2014] may have occurred, having that those who had three colors just focused on the immediate solution of our creative task (i.e. using the three colors in the same proportion) without realizing how mainly using a subset of the means given (1 or 2 colors) could have resulted in an easier task.

The reading of our results suggests that, regardless of the specificity of the creativity task implemented in our experiment, similar cognitive mechanisms can still apply to different creative problems. Our findings play in favor of GrI-creativity, with the take-away message of our paper being that creativity of individuals may be enhanced by giving the opportunity of choosing their own tools. On the contrary, the amount of such tools is not having any effect on the final creative outcome.

Therefore, we combine our experimental method with insights from social psychology. We investigate for some individual cognitive traits that could play a role in GrI-creativity (or in creativity, in general) by proposing a questionnaire to the children taking part in our experiment. We provide evidence of a highly significant positive effect on creativity of three personal traits of the subjects, namely: a high score at the Cognitive Reflection Test, self-perception of creativity and the practice of sport in daily life. All these results are in line with the existing literature investigating the determinants of creativity. More surprisingly, risk preferences do not play any role (but it is important to remark that the existing literature has a very lukewarm opinion on the possible correlation between creativity and this trait).

The rest of the paper is organized as follows. Section 2 presents some related works. Section 3 illustrates our experiment in three cities in the center of the Italian Peninsula. Section 4 discusses the results of our experiment. Section 5 concludes. Some additional material is presented in the Appendix.

2 Background and related works

In the earliest studies in psychology, creativity was labeled as a special quality of unusual people. With this perspective, for a long time, the main issue of researchers has been to validate instruments to detect creative ability and personality. Some sophisticated behavioral tests have been defined to assess creative thinking, such as in the work by Guilford [1950], or in the most famous *Torrance tests of creative thinking*, introduced few years later by Torrance [1966]. It is only in the 80s, with the works of Amabile [1982a,b, 1983, 1985] and Simonton [1975, 1980], along with their interaction in the so-called *social psychology of*

creativity, that such a simplified vision of the problem became obsolete. Researchers started to investigate on how various social, cultural and political factors affect creative success, in addition to the more evident ability and personality traits. Since then, other disciplines started to get some interest into the topic. During the last century, creativity became a very hot subject, which has been studied from different perspectives by scientists working in different social and cognitive sciences, e.g., anthropology, sociology, psychology, management and economics

Despite this growing success, experimental economics literature has never shown much interest towards the study of the determinants of creativity until quite recently. In the last decade, various authors have presented works where investigations on the drivers and motivations to creativity through the experimental approach from an economical perspective were carried out [see Attanasi et al., 2020, for a review of this literature]. These works have mainly focused on the impact on creativity of some extrinsic incentives (non-monetary or low vs high monetary incentives), on the effect of the specific experimental design (e.g., investigating the consequences of group cooperation or competition) or on the cultural and personal traits determinants of creativity. All these works are also extremely heterogeneous in terms of tasks, payment schemes or subject pools. Between the many, our experimental task builds upon the work of Charness and Grieco [2019] (in particular, upon their “open with constraints” drawing task⁴). In this work, the authors analyze whether incentives act differently in stimulating creativity when implemented on open or open with constraints tasks. A similar experimental setting was also proposed by Attanasi et al. [2019a,b], who investigate on the interplay between monetary incentives and group cooperation and on the culture impact on creative performances. These works have also in common with our investigation an incentive scheme in the form of a tournament.

A peculiarity of our study is represented by the subject pool, namely primary school kids. In fact, the specific task, requiring experimental subjects to perform a drawing, and the treatments we considered, based on the employment of colors, seemed to us particularly suitable for a children’s audience. Even if a very recent survey by Sutter et al. [2019] has shown how economics experiments with children have a history which is pretty recent, but which is becoming more and more prolific, it is still quite rare to find works in economics where experiments’ participants are not graduate or undergraduate economic students, in particular in the domain of creativity⁵. On the contrary, experiments with children represent a standard

⁴As already mentioned, this task was present in a working paper version of the work, but it was not included in the final published version. Note that the authors refer to this task as “closed”. Here, we adopt the classification proposed in Attanasi et al. [2020] and refer to it as an “open with constraints task”. Such kind of task provides a specific goal with constraints, but correct answers may be variegated.

⁵With some exceptions of works which relate to non-standard subject pools, such as in Ariely et al. [2009], who recruited for

practice in studies in psychology, in particular with respect to creativity. In support of our choice, we refer to a work by Keegan [1996], where the author states, employing an analogy with Darwin's *Descent of Man*, how the difference in creativity among children and adults, equivalently to the difference in intelligence between mankind and other animals, does not relate to its kind, but to its degree. Hence, it is concluded how, despite adults are recognized as more creative, their creativity is not different from that of children, it is just more intense, or, putting it with Darwin's words, it is of higher degree. So, one should assume that any factor stimulating or crowding out children's creativity, just like any cognitive trait having analogous effects, is likely to be same for adults.

3 The experiment

3.1 The experimental context

Our study was conducted as a lab-in-the-field experiment. The subject pool was formed by 109 children aged from 7 to 11 years old, attending the third, the fourth or the fifth class, which correspond to the last three years of primary school in the Italian system. The experiment was set in three schools and it was carried out during three regular schooldays in December 2019. The chosen schools are all located in the province of Fermo, Italy - where one of the author is originally from - in the region of Marche, specifically, in the towns of Campofilone, Monterubbiano and Lapedona. This province is one of the most underpopulated in Italy, with craftsmanship as the main economic sector, predominantly producing leather accessories and shoes. The three schools' municipalities are all in the Valdaso area, which on the contrary is economically characterized by agricultural enterprises⁶. As for the schools' town's population, they range from around 1200 to 2200 residents, which is no exception in the province's context, where 33 out of the 40 municipalities do not exceed the 5000 resident's threshold. It is also worth mentioning that not all the kids reside in the schools' municipalities, as some towns do not have primary schools, or their territories are quite vast, resulting in families having the nearest school from their home in another town. Table 1 summarizes the number of participants for each school and Table 2 the participants for each town. The difference in size of observations per school only depends on the number of kids enrolled in the third, fourth and fifth years who were present the day of the experiment. Regardless the fact that data were collected in different schools (in order to have enough observations), the three experimental locations are extremely homogeneous.

their experiment some residents of a rural town in India.

⁶A question on parental occupation was not included in the survey that will later be better illustrated. However, one could safely assume that a sizable part of the kids' parents is employed in the above mentioned sectors

School	Participants	(percentage)
Campofilone	49	(44.95)
Monterubbiano	42	(38.53)
Lapedona	18	(16.51)
Total	109	

Table 1: Number of participants for each school

Town	Participants	(percentage)
Campofilone	40	(37.04)
Pedaso	5	(4.63)
Monterubbiano	40	(37.04)
Moresco	6	(5.56)
Lapedona	14	(12.96)
Cupra Marittima	1	(0.93)
Altidona	2	(1.86)
Total	108	

Table 2: Number of participants for each town

Our experiment consisted of two phases: a questionnaire and a creativity task. Given the subject pool, and given the fact that the experiment was conducted during some regular lecture time, both the phases were kept as short as possible in terms of time. Then, some days after the experiment, some external judges were asked to independently evaluate the creative performances of the kids, and each best between approximately 20/25 (randomly matched) children of the same treatment group was awarded the prize.

3.2 The questionnaire

Before starting the experiment, the 109 children taking part in the experience were asked to fill a questionnaire. They were told that their performance in the following creativity task evaluation would not have depended on the provided answers. The questionnaire consisted of eleven questions: gender, age, city, nationality, leisure activities, hand preference, risk attitude, self-perception of creativity and three Cognitive Reflection Test (CRT) questions. A blank survey is reported in Appendix B. Note that no questions about socio-economic status were included. The main reason of this choice is concerned to the fact that kids are not likely to have precise or even vague information on their parents' income or education.

Questions about gender, age, city and nationality are meant to define some idiosyncratic variables to perform a standard demographic analysis about the subjects. Previous literature in experimental economics on creativity agrees that these characteristics have in general non-significant effects on the creative per-

formances (with very few exceptions, such as for Charness and Grieco [2019], who discuss a marginally significant gender effect of a higher creative score for males). We include these questions to define some control variables on the subject pool.

The question on the hand preference is introduced in order to confirm, or eventually contradict, a large literature, according to which left-handed usually demonstrate more creativity than right-handed. Such difference is explained as a consequence of the fact that left-handed are daily challenged by an environment mostly organized for the right-handed and are somehow obliged to make special adaptations that may signal creative behavior [see, e.g., Morris and Leung, 1981].

The leisure activities section of the questionnaire comprises a list of activities in which children usually employ their free time. Children could check one or more activities. The proposed list included “sport”, “dance”, “music and/or singing”, “theater and/or acting”, “drawing/handwork” and “video games”. An option “others” was allowed, where kids had the possibility of specifying a different leisure activity. We add this question based on some recent literature, which has shown a significant positive correlation between creativity and leisure activities [see, e.g., Trnka et al., 2016].

Investigating on the relation between risk attitude and creativity is pretty standard in both psychological and economics literature, but a general consensus about a possible correlation with creativity is missing [see Attanasi et al., 2020, for a review of previous results on the topic]. In this work, we elicited risk preferences by asking children how much they love risk, on a scale from 1 to 10. The choice of eliciting risk preferences in such way was made necessary by the previously mentioned timing issues. However, such a procedure is now pretty common, since a high correlation between standard risk-eliciting approaches (such as bets and lotteries) and the preferences directly revealed by the answers to this simple question was shown by Dohmen et al. [2011].

The self-perception of creativity question refers to the kids’ own perception of their creative potential. According to some literature, people that perceive themselves as creative individuals, are indeed creative [see, e.g., Farmer et al., 2003]. We elicited self-perception of creativity by asking children how much creative they perceive themselves, on a scale from 1 to 5.

The CRT questions are often included in experimental economics surveys as a measure of cognitive ability (see Frederick, 2005). Even if they cannot be considered a reliable measure of human IQ, given the extreme complexity and multi-dimensionality of human intelligence, they have been proven to be a very useful approximation of such a personal trait in many experimental economics works. Being the subject pool composed by kids, in our opinion standard CRT questions, which are originally meant for adults, looked too

difficult and did not seem to be adequate for our purpose. Instead, we chose three questions (with slight variations) from Young et al. [2018], where a series of CRT questions adapted for kids are proposed and both kids' and adults' answers are analyzed. Again, we refer to Appendix B for the complete and detailed questionnaire. Some contradicting relations between CRT scores (or IQ) and creativity have been stated in some previous works [e.g., Hocevar, 1980, Russo, 2004].

3.3 The creativity task

The experimental design consisted of three between-subject treatments, namely a *Control* (42 observations), a *One-color* (42 observations) and a *Three-color* (25 observations) treatment. These treatments share the common open with constraints task *à la* Charness and Grieco [2019], which asks the subject to make a creative drawing using at least nine geometric figures (three circles, three triangles and three squares), in our implementation within a five-minutes time limit. Specifically, the children received a sheet with the following instruction: "Make a drawing using any form you want: the only constraint is that you must use all of the following forms. You have 5 minutes." This statement was then followed by the already mentioned 9 figures printed on (see Appendix C). No strings were attached to either the contents of the drawing nor to the figures and shapes one could draw, as long as the nine figures were included. The difference between the treatments was in the tools made available to the participants. In the *Control* group, the subjects were given a black marker to perform the task; in the *One-color* treatment, each subject had the possibility to choose a color among twelve (including black); in the *Three-colors* treatment the possibility was to choose three among the same twelve color set. The children were told orally that their creativity would have been evaluated by some experts through a tournament scheme. In particular, they were told that they would have been randomly matched with other kids in groups of 20/25 children approximately, including students from other schools, and that the most creative drawing, as evaluated by a jury of experts of the field, would have been awarded a €20 coupon to be spent in a known sport franchising store. Giving a coupon instead of money, as it is usually done in experimental economics, was dictated by ethical issues, as giving money to elementary school kids could possibly be perceived as something wrong. The experiment started only after the experimenters had replied to all the kids' questions and made sure all the participants had understood the rules.

3.4 The assessment of creative performances

In order to evaluate the children’ creative performances, we relied on Amabile’s *consensual assessment technique*, according to which a construct is creative as long as some expert raters independently agree upon this judgment [see Amabile, 1982a]. This technique applies to sufficiently open-ended tasks that do not require special skills for which there is a wide variation in the target population (as it is the case of our task). Judges are intended as external observers with experience in the target domain, who should use their own subjective judgments of creativity to independently rate the creative outputs, with an acceptable inter-judge reliability fixed at 0.70 or higher (the most used measure of such reliability is the Cronbach’s alpha).

The drawings of our experiment were evaluated by four judges on a 1 to 10 scale and creativity was evaluated in ascending order, i.e. the higher the level of creativity expressed in the judge’s opinion, the higher the grade, and they were presented to the judges in different orderings to control for potential ordering effects⁷. Judges’ characteristics are reported in Table 3. To avoid that having chosen a color and not a black marker could be seen to be creative in itself, the judges were made aware of treatment distinctions.

Judge	Gender	Profile	Job
1	Male	Architect	Real estate agent
2	Male	Opera and theater singer	Accountant
3	Female	Architect and model-interiorism	Master degree in interiorism student
4	Female	Street artist	Unemployed

Table 3: Judges’ characteristics

4 Discussion of the results

4.1 Judges’ evaluation of creativity

In this section, we compare the patterns of creative scoring across judges and we provide some preliminary statistics about our dependent variable.

Figure 1 exhibits kernel density estimates of the four judges’ scores in each treatment. Note as even at very first sight there is a clear common pattern, as all judges, except judge 3, follow a similar distribution indifferently of the treatment. Comparing the treatment, we may notice as for all judges but 3, both the *One-color* and the *Three-colors* curves are shifted on the right.

⁷Judge 1, 2, 3 and 4 saw, respectively, the drawings in the following orders: control, one color three colors; one color, three colors, control; three colors, control, one color; three colors, one color, control.

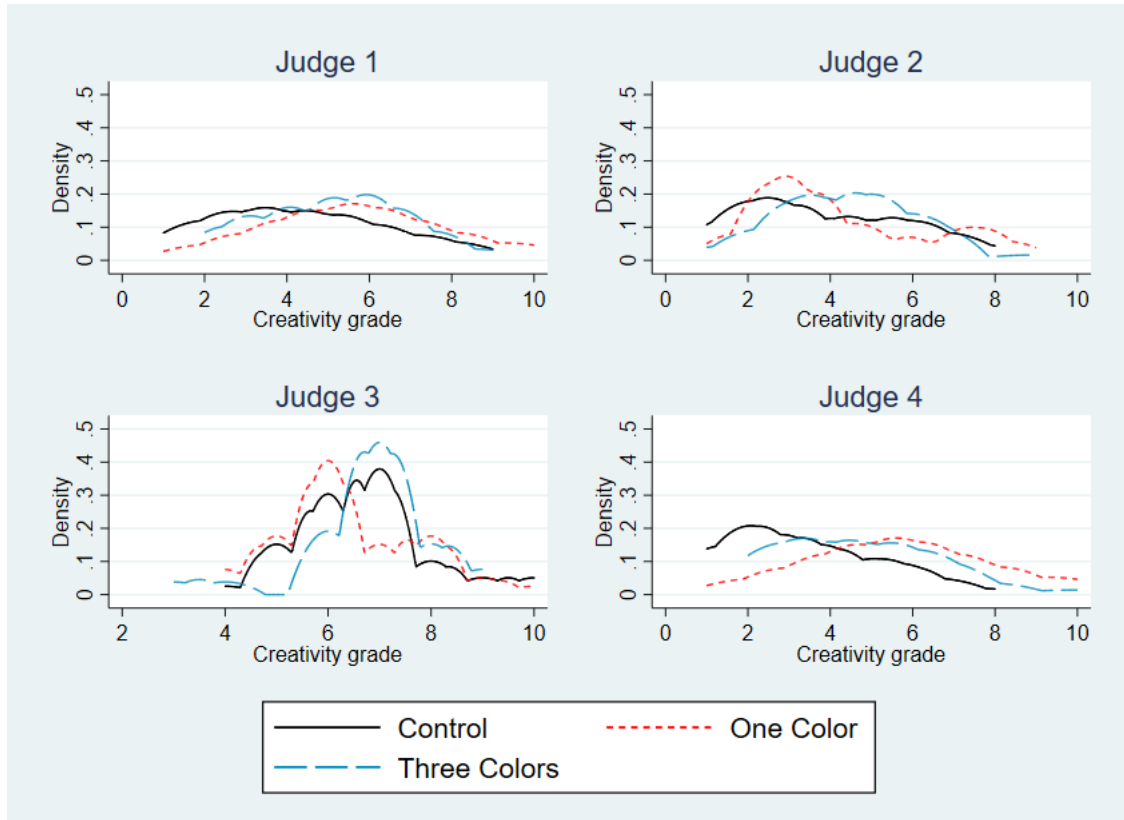


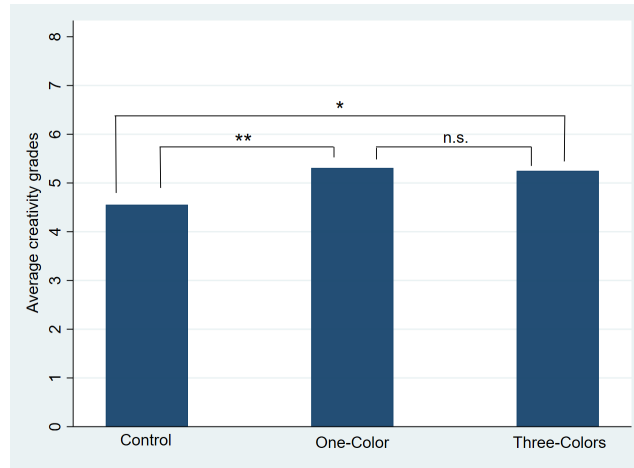
Figure 1: Judges' creativity grades for all treatments

Table 4 provides information about the Cronbach Alpha test for the consistency of external evaluations among the four judges (remember that, according to Amabile's consensual assessment technique, an acceptable inter-judge reliability is fixed at 0.70 or higher). The four evaluations exhibited a very good degree of correlation (Cronbach's alpha = 0.857).

Judges	item-test correlation	item-rest correlation	average interim correlation	alpha
Judge 1	0.877	0.744	1.953	0.804
Judge 2	0.864	0.743	2.129	0.800
Judge 3	0.786	0.683	2.842	0.843
Judge 4	0.849	0.705	2.136	0.818
Test scale			2.266	0.857

Table 4: Cronbach Alpha and Related Statistics

The dependent variable of the regression analysis presented in Section 4.3, *Creativity*, is defined as the arithmetic mean of creativity grades across the four judges. In our investigation, we are concerned about the existence of a treatment effect in the jury grades. Figure 2 reports the average *Creativity* of the 109 subjects in our experiment, disentangled by treatment.



Wilcoxon rank sum test; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, n.s. non significant.

Figure 2: Average creativity grade for all treatments

Figure 2 shows that both treatments have higher grades with respect to the *Control* treatment (with a p-value for the *Control* vs *One-color* comparison equal to 0.043, and for the *Control* vs *Three-colors* equal to 0.066; two-sided Wilcoxon rank sum test). Therefore, the following result can be stated.

Result 1: *Having the choice of which tools to use to perform a creative task increases Creativity.*

The significant treatment effects between the *Control* vs either the *One-color* or the *Three-colors* reinforces the idea that allowing children to make a choice seems to foster creativity. This result is in line with the findings of Amabile and Gitomer [1984], who showed higher levels of creativity in preschool children aged from 2 to 6, when given the chance to choose which materials to use for a collage.

Still Figure 2 shows that there is not a statistically significant difference in the mean creativity between the *One-color* and the *Three-colors* treatments. Therefore, the following result can be stated.

Result 2: *Being provided with fewer tools to perform a creative task does not decrease Creativity.*

The absence of a significant treatment effect between the *One-color* and the *Three colors* treatments shows that providing children with more resources does not lead to better creative performances. Pushing forward the interpretation of our results, we can underline that, without significance, but the average grade for the *One-color* treatment is even slightly higher than for the *Three-colors* one. Result 2 is in support of

the so called GRI-creativity, as it provides evidence of the fact that limited resources do not boost creativity, but they are not detrimental either. As already mentioned in the Introduction of the paper, our explanation to this result is manifold. At first, one may guess that having to choose and use more materials rather than less makes the task more difficult, and this is particularly true when performing a task in a very short time, such as the 5 minutes of our experiment. Second, this mechanism is likely to be boosted by a *color as a Gestalt* effect [see Pomerantz, 2006], in which children may have an immediate source of inspiration by having to make a creative task using only one color, rather than many. Third, some fixation effect in the creative process [see Agogu   et al., 2014] may have occurred, having that those who had three colors just focused on the immediate solution of our creative task (i.e. using the three colors in the same proportion) without realizing how mainly using a subset of the means given (1 or 2 colors) could have resulted in an easier task.

4.2 Explanatory variables

Recall that the questionnaire distributed at the beginning of the experiment contained 11 items. Here, we present the explanatory variables defined from the questionnaire and used in the following analysis of this paper. We pay particular attention to the ones that are candidate to be important determinants of creativity according to the literature in experimental economics.

Gender takes value 0 when the subject is male and 1 when female. *Age* takes the exact value as indicated by each child. *Hand preference* takes value 1 when a kid declared to be right-handed or ambidextrous, 0 if left-handed. From the leisure activities questions, we retained the variables *Sport*, *Videogames*, *Drawing and handwork*, *Dance*, *Music* and *Others activities*. We assign value 1 when a child indicated the corresponding leisure activity and 0 otherwise.

From the risk elicitation question *  la* Dohmen et al. [2011], we create the variable *Risk-loving*, which takes a value from 1 to 10, according to the responses of the children. Analogously, the variable *Self-perception of creativity* takes value from 1 to 5, according to the responses. We define the variable *CRT* as a value from 0 to 3, depending on the number of correct answers over the three questions.

In Table 5 we show a summary of the descriptive statistics of both our dependent and our independent variables.

Our experimental results show a clear gender effect on risk preferences, with females being less risk loving than males (the p-value is 0.016; two-sided Wilcoxon rank sum test). This finding is supported by a very large literature on the topic [see, e.g., Eckel and Grossman, 2008]. Surprisingly, this result reverses

Variables	N	mean	s.d.	min	max
Creativity	109	5.005	1.626	2.25	8.5
Treatments	109	0.844	0.772	0	2
CRT	109	1.018	0.913	0	3
Self-perception of creativity	109	4.000	1.102	1	5
Risk loving	109	5.472	3.361	1	10
Gender	109	0.532	0.501	0	1
Age	109	8.963	0.860	7	11
Hand preference	109	0.056	0.230	0	1
Sport	109	0.560	0.499	0	1
Videogames	109	0.220	0.416	0	1
Drawing and handwork	109	0.138	0.346	0	1
Dance	109	0.138	0.346	0	1
Music	109	0.092	0.290	0	1
Theater	109	0.009	0.096	0	1
Other activities	109	0.101	0.303	0	1

Table 5: Summary of the Descriptive Statistics

when restricting our analysis on females with a high *CRT* score. In such case, we report mild evidence of girls with higher *CRT* correctly responses as being more risk loving (the p -value=0.071; Kruskal-Wallis equality-of-populations test). We recall that risk preferences have been elicited through a direct question *à la* Dohmen et al. [2011] rather than by means of more standard ways (such as bets and lotteries). Even if it has been shown that these approaches for eliciting risk preferences are highly correlated for adults, one may question the validity of such a method when facing a subject pool of children. In fact, in our opinion, the concept of risk itself is something they may not be familiar with.

Self-perception of creativity has a positive correlation with average creativity, embedeed in control (the p -value=0.011 and the ρ =0.394; Spearman’s rank correlation test) and one-color (the p -value=0.013 and the ρ =0.380; Spearman’s rank correlation test) treatments.

Preliminary descriptive statistics do not present further evidence about significant effects of our independent variables on our main interest of research, *Creativity*. Therefore, in this analysis, we enjoy the advantage of isolating and capturing more accurately the “pure” treatment effect, without any distortion of the explanatory variables.

4.3 Regression analysis

To provide econometric support to Results 1 and 2 (shown in Figure 2) and to study the eventual marginal effect of some of our independent variables, we develop a regression analysis. In Table 6, we report the

results of an ordinary least squares regression⁸.

Variable	Average Grade (1)	Average Grade (2)	Average Grade (3)	Average Grade (4)
One-color	0.756** (0.362)	0.570* (0.322)	0.547* (0.327)	0.559* (0.332)
Three-colors	0.696* (0.373)	0.682* (0.366)	0.654* (0.385)	0.555 (0.402)
CRT		0.458*** (0.165)	0.470*** (0.172)	0.435** (0.178)
Self-perception of creativity		0.468*** (0.118)	0.437*** (0.131)	0.421*** (0.132)
Risk loving		0.005 (0.045)	0.014 (0.048)	0.015 (0.053)
Gender			0.235 (0.328)	0.246 (0.380)
Age			-0.050 (0.169)	-0.100 (0.187)
Hand preference			-0.050 (0.169)	0.049 (0.801)
Sport				0.760** (0.354)
Videogames				0.285 (0.398)
Drawing and handwork				0.450 (0.541)
Dance				0.346 (0.493)
Music				0.744 (0.488)
Other activities				-0.026 (0.5108)
Constant	4.554*** (0.251)	2.285*** (0.502)	2.687* (1.532)	2.581 (1.701)
Observations	109	107	107	106
R-squared	0.049	0.200	0.205	0.250

Robust standard errors in parenthesis ***p<0.01, **p<0.05, *p<0.1

Table 6: Marginal effects from ordinary least squares regressions, explaining average judges' score

First of all, we observe that the regression analysis confirms a treatment effect for both the *One-color* and the *Three-colors* treatments, when compared to the baseline *Control*. This finding supports Result 1, according to which giving a certain freedom in the choice of the tools to perform a creative task has a positive significant effect on average *Creativity*. Not surprisingly, the inclusion of additional explanatory variables reduces the weight of such treatments effect. However, the effect is always more evident for the *One-color* treatment than for the *Three-colors*. This observation strengthens our Result 2 in support of GrI-creativity.

Regarding the *CRT* score, we find robust evidence that a higher number of correct responses to the CRT

⁸In Appendix A, we report the results of the censored model in the left and right extremes by the Tobit regression. Such additional analysis confirms that the results of the OLS estimation are robust, as no different causality is found with censored values in the extremes.

questions leads to a greater average grade of around 0.4 points. Hence, kids with higher IQ seem to be more creative. This finding is consistent with Hocevar [1980], who shows a relationship across verbal intelligence and creativity, and contradicts the findings of Russo [2004], who shows that students with average marks perform better in a creative task with respect to high-IQ kids.

Self-perception of creativity has a very significant and sizable effect on predicting creativity scores, approximately of 0.4 points. This is consistent with the results in Attanasi et al. [2019b], where the authors found such personal feature to be relevant in the context of creativity in a eastern country (namely, Vietnam), even if no such relationship was found for a western country (France).

As for *Sport*, we observe that children who practice sport in their free time are more creative, by 0.75 points. This result is in line with the findings of Trnka et al. [2016]. Nevertheless, we have to emphasize that such result may be influenced by the fact that subjects knew that the prize was in the form of a €20 coupon to be spent in a well-known sport store. Hence, kids who like sport had objectively higher incentives to do their best in the proposed task.

Finally, we remark that, according to our data, being left-handed does not have any effect. However, this is likely to be linked to the fact that over a total of 108 kids who replied to this question, only 6 of them declared to be left-handed. Therefore, it was not possible to run a meaningful causality analysis related to this variable. For the rest of explanatory variables, no effect is found over average creativity scores.

Therefore, the following result can be stated.

Result 3: *CRT, Self-perception of creativity and Sport have a very significant positive effect on Creativity.*

5 Conclusions

In the last years, creativity has been recognized as one of the principal drivers of growth and development in many fields. In this work, we focus on the so-called green innovation, i.e., the innovation with the purpose of generating durable products with limited natural and energy resources, and, in particular, on the preliminary creative process, that we call GrI-creativity, i.e., the creative cognition directed toward green products. The objective of our investigation is to provide evidence of how providing limited resources and, possibly, some freedom in the choice of such resources may affect the performance of a creative task.

From our data, two main results arise. First, the freedom of choosing resources seems to foster creativity.

In fact, both the *One-Color* and the *Three-colors* treatments, report higher levels of creativity with respect to the *Control* group and such gap is even larger for the *One-color* treatment. This finding is in line with the work of Amabile and Gitomer [1984], who also reported higher levels of creativity in preschool children when given the chance to choose which materials to use for a collage.

Our second result is related to the fact that limited resources seem to have no effect on creative outputs, since our results do not report any significant difference in *Creativity* between the *One-color* and the *Three-colors* treatments. Hence, our findings are consistent with GrI-creativity, supporting the fact that equal levels of creativity may be reached while consuming less. We provide three possible explanations to this second result, related to our specific task. First, having to choose and use more materials rather than less makes the task more difficult, in particular when facing a strict time constraint of only 5 minutes. Second, following a Gestalt interpretation [see Pomerantz, 2006], this mechanism is likely to be boosted by the fact that children may have an immediate source of inspiration when having to carry out a creative task using only one color rather than many, since the associations between a color and the images it evokes may occur much faster than in the case where colors are three. Third, the fact that the *Three-colors* task can be seen as more difficult may also relate to some fixation effect in the creative process [see Agogu   et al., 2014]. By this interpretation, those who had three colors just focused on the immediate solution of our creative task (i.e. using the three colors in the same proportion) without realizing how just drawing small details with one or two colors and carrying out the rest of the drawing with the remaining ones may have resulted in an easier task.

According to our results, GrI-creativity can still be boosted by providing fewer resources, provided that individuals are given some discretion when it comes to choosing which of them to use.

The interpretation of our experimental results is specific for the given task, but it provides some important hints to generalize our findings. In particular, the main idea is that human beings are possibly capable of filling a means gap, when having limited resources at their disposal. Also, it is meaningful to observe how the Gestalt view of the perception process is not specific to colors, but such theory relates to anything the human senses may perceive, so that, for instance, any material that may be used in any innovation process could be object of the just described perception effect.

The results of our simulated scenario may help to solve some of the uncertainties resulting from investing in the green innovation process. In fact, policymakers and entrepreneurs can apply our intuition in order to foster the creation of green ideas and to enhance the correct implementation of those ideas towards green innovation. In a R&D context, researchers may be compelled to deal with limited resources in order to come out with greener products. Our investigation contributes by demonstrating that limited resources will

not alter the idea creation, and remarking the importance of the freedom of choice in order to foster their creativity.

A particularity of our inquiry is represented by the subject pool, which is composed by primary school children. One may argue that differences exist on creativity depending on the age of the individual considered. Specifically, related to our work, the freedom of choosing materials was found to boost creativity in preschool children [see Amabile and Gitomer, 1984], while the freedom of choosing the specific task was beneficial for adolescents [see Gu et al., 2014]. In addition, the paper of Joyce [2009] is about how constraint -as restrictions to freedom that limit and direct search- influences creativity with an adults subject pool. Their results suggest that while some amount of choice is important for encouraging creativity, too much can be counterproductive. As for the creativity-age relationship, a study on an elderly subject pool shows as creativity skills seem to decline with age [see Weihuanu, 2013]. However, all these works dealing with different populations are very heterogeneous in terms of experimental setting. Despite having provided a number of reasons to believe that our results do not depend on the age of our participants, a follow up analysis may consist in having children, adolescents, adults and elderly all perform a similar task, so that any further doubt relative to a generalization of our results to any population can be cast away.

As for additional future researches, it may be interesting to consider an extension of the study of the Grl-creativity controlling for different incentives schemes and cultural factors. Moreover, other than the effect of limited resources, in line with the concept of green innovation, it may also be interesting to analyze if and how the resources given to participants are wasted depending on the initial endowment provided in a creative context. Additionally, a worthy extension of this study could entail a different creative task which does not relate to a drawing, such as a verbal or a mathematical task [see, e.g., Charness and Grieco, 2019].

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A Tobit regression

Conclusions presented in Table 7 present the results of the Tobit regression. The results are in line with the conclusions detailed in subsection 4.3. This additional analysis is reported to demonstrate the robustness of OLS regression study for censored data.

Variable	Average Grade (1)	Average Grade (2)	Average Grade (3)	Average Grade (4)
One-color	0.811** (0.370)	0.620* (0.353)	0.591* (0.354)	0.602* (0.355)
Three-colors	0.725* (0.428)	0.705* (0.403)	0.666 (0.404)	0.576 (0.398)
CRT		0.510*** (0.179)	0.523*** (0.184)	0.482** (0.187)
Self-perception of creativity		0.513*** (0.140)	0.471*** (0.146)	0.459*** (0.154)
Risk loving		0.013 (0.047)	0.025 (0.048)	0.024 (0.048)
Gender			0.315 (0.320)	0.337 (0.359)
Age			-0.053 (0.181)	-0.103 (0.182)
Hand preference			-0.050 (0.170)	-0.013 (0.686)
Sport				0.827** (0.382)
Videogames				0.347 (0.416)
Drawing and handwork				0.468 (0.506)
Dance				0.373 (0.523)
Music				0.711 (0.539)
Other activities				0.043 (0.513)
Constant	4.498*** (0.261)	1.95*** (0.667)	2.366 (1.775)	2.201 (1.778)
Observations	109	107	107	106

Robust standard errors in parenthesis ***p<0.01, **p<0.05, *p<0.1

Table 7: Tobit regressions, explaining average judges' score

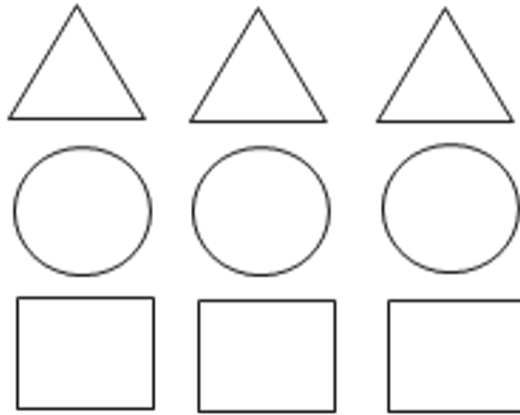
B Blank survey

As translated from the original in Italian:

1. **Gender** ☐ male ☐ female
2. **Age** _____
3. **City** _____
4. **Nationality** _____
5. **Which activities are you involved in during your free time?**
 - ☐ Sport
 - ☐ Dance
 - ☐ Music and/or singing
 - ☐ Theater/Acting
 - ☐ Drawing/use in the hand
 - ☐ Videogames
 - ☐ Other _____
6. **Are you right-handed, left-handed or ambidextrous?**
 - ☐ right-handed ☐ left-handed ☐ ambidextrous
7. **On a 1 to 10 scale, how do you evaluate your risk attitude: are you a person who always avoids risking (1) or you like taking risks (10)?**
1 2 3 4 5 6 7 8 9 10
8. **On a 1 to 5 scale, where 1 stands for "not creative at all" and 5 for "very creative", by what measure do you believe you are creative?**
1 2 3 4 5
9. **If you are participating on a race and you go past the person in second position, in what position are you in?** _____
10. **A shepherd has 5 sheeps, all but 3 run away, how many are left to him?** _____
11. **Which one weights more, a kilo of lead or a kilo of feathers?** _____

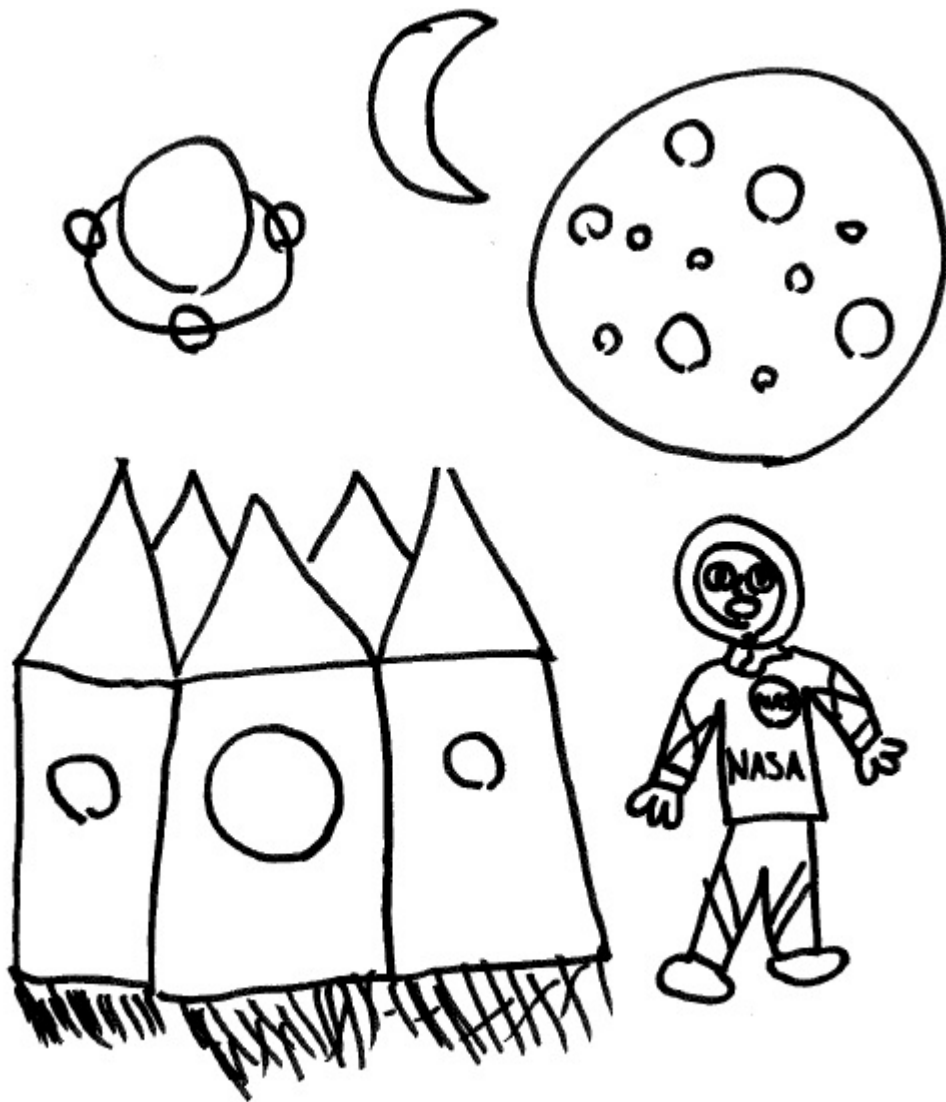
C Blank task

Make a drawing using any shape you want: the only constraint is to use all the sequential shapes. You have 5 minutes.



D Examples of creative performances

D.1 Control task creative performance



D.2 One-color task creative performance



D.3 Three-color task creative performance



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