Creativity and Financial Incentives

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Abstract: Creativity is a complex and multi-dimensional phenomenon with tremendous economic importance. A crucial question for economists and for firms is the interplay of incentives and creativity, which may very well vary across dimensions of creativity. In an analytical model, we examine the relationship between creativity output, incentive structure, and the precision of the goal. We present experiments where subjects face creativity tasks where, in one case, ex-ante goals and constraints are imposed on their answers, and in the other case no restrictions apply. The effect of financial incentives on creativity is then tested. Our findings provide striking evidence that financial incentives affect "closed" (constrained) creativity, but do not facilitate "open" (unconstrained) creativity.

Keywords: creativity; experiment; incentives; constraints.

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1. Introduction

Creativity is a vital input into the well-being and success of a society, contributing in economic, social, and aesthetic dimensions. According to Henri Poincaré, creativity represents the "ability to unite pre-existing elements in new combinations that are useful". Creativity implies (a) a *combination* of existing things that should be (b) *recognized in its utility by peers* (Mumford, 2003).

One focus in economics has traditionally been on innovation and economic growth. According to Feinstein (2009), "innovation is widely recognized to be the source of much, if not most, economic growth." Since creativity is central to research endeavors, facilitating creativity (and therefore innovation) would appear to be an important component in the design of economic institutions. Because technical progress drives the long-term growth of advanced economies, a central goal of growth theory has long been to get inside the black box of innovation (Weitzman, 1998). Not only does drastic innovation represent a crucial device for a firm to establish a performance gap with its competitors – increasing perspective profits and market share – but it also enhances social welfare and promotes expected long-term growth by introducing new products, satisfying unaddressed needs, and pushing process efficiency.

The stock market appears to value innovators, since stock prices typically reflect these expectations. Forbes annually publishes a list of the most innovative companies by calculating the "innovation premium" the stock market gives a company because investors expect it to launch new offerings and enter new markets that will generate bigger income streams. Management and strategy consulting firms like Booz & Company have shown over the past years that what matters for a firm's financial performance is how companies "spend money and resources on innovation efforts, as well as the quality of their talent, processes, and decision making" (from booz.com).

Historically, prizes have been used to stimulate many discoveries. These include Archimedes' method for measuring the volume of the king's crown, the canning process to preserve food needed by Napoleon's troops, the invention of margarine that was triggered by Napoleon III, who offered a prize to any chemist who would develop a cheap butter substitute to feed France's armies, and the smallpox vaccine that was developed in pursuit of a financial prize offered by the English Parliament. In the same vein, the patent system was developed with the aim of providing a strong incentive to produce novel ideas and products without the gains from doing so being appropriated by other entities.

Creativity extends into expressive and performance activities such as art, music, dance, and writing. It may be the case that artists and perhaps even academic researchers do not need financial incentives to produce creative art or research, respectively: perhaps ideas arrive at their own rate, independently of direct incentives.[1,2] On the other hand, environmental factors might be crucial in stimulating creativity: "All human societies contain inventive people. It's just that some environments provide more starting materials, and more favorable conditions for utilizing inventions, than do other environments" (Diamond, 1997, p. 408). There is also the notion from social psychology (see for example the seminal work by Deci and Ryan, 1985) that extrinsic reward can crowd out intrinsic motivation, so that providing financial rewards can be

[1] Kremer (1993)'s model assumes that each person's chance of inventing something is not affected by interaction with others. Even if individual research productivity is independent of population, total research output is shown to increase in population due to the non-rivalry in technology.

[2] In fact, until 2007, French artists could benefit from a form of subsidy that was reserved to the so-called "*intermittent du spectacle*" (an arts and entertainment industry worker who receives payments and benefits during periods of unemployment), that was aimed to sustain French culture and that has been criticized for being unable to promote quality.

counterproductive.[3] Thus, the effect of economic incentives on creativity is not clear *ex ante*. Empirical evidence is clearly needed, and there is very little work linking creativity and incentives. Since it is difficult to perform clean tests using field data, controlled experiments provide a promising avenue for exploring this issue.

We wish to emphasize that there are many different conceptualizations of creativity. We wish to emphasize that the way that we parse creativity is just one approach. We consider a particular dimension of closed creativity (inbox) versus open creativity (blue sky), depending on how well-defined is the task at hand. In problem-finding research, scholars examine the degree to which the problem has been formulated before the creator begins the process. With closed creativity, there is a specific and delineated goal. Examples could be finding a way to decrease the size of a computer or developing a new drug for a specific purpose. Instead, open creativity could be painting an abstract painting, representing unfettered thinking outside the box without any obvious underlying *ex-ante* goal or direction.

Our first contribution consists of presenting a model that derives individual optimal creativity effort under two payment schemes: 1) flat payment and 2) tournament incentives based on a performance ranking within a group of peers. The heart of the model is in viewing individual's creativity effort as being driven not only by idiosyncratic factors, but also by incentives. The effectiveness of incentives in stimulating higher creative output crucially depends on the precision of the task definition: we show that people are uncertain as to what to do when the task is open, so that incentives are ineffective. Giving a well-defined structure to the task lowers this uncertainty and allows scope for incentives to effect behavior.

[3] Hennessey and Amabile (2010) review the creativity literature in social psychology and state (p. 581) that historically: "High levels of extrinsic motivation were thought to preclude high levels of intrinsic motivation; as extrinsic motivators and constraints were imposed, intrinsic motivation (and creativity) would necessarily decrease."

Our second contribution is to provide an experimental test of the effects of incentives on creativity. In our 2x2 between-subject design, we vary whether a task is "open" or "closed" and randomly assign participants to either receive a flat payment for completing the task or be paid according to tournament incentives. Our results are rather striking and confirm our model's predictions. On the one hand, we find that monetary incentives are effective in stimulating creativity when *ex-ante* goals are specifically set and the nature of the task is more well-defined. So when society has a clear objective in view, it does appear useful to reward creativity that helps to achieve this objective. On the other hand, incentives for performance with respect to open creativity provide no benefit in our setting.[4] To the best of our knowledge, there has been no previous evidence regarding the relative benefit of incentives depending on the type of creativity involved.

The remainder of this paper is organized as follows. We discuss related literature in Section 2, and illustrate the model in Section 3. The experimental design and experimental results are presented in Section 4. Section 5 provides a discussion and Section 6 concludes.

2. Related literature

2.1 Definitions and dimensions of creativity

Until the middle of the 20th century, creativity was studied as a minor topic within a number of various disciplines such as psychology, sociology, and cognitive science. The turning point for the emergence of creativity as a separate sphere of study can be traced back to the seminal works of Guilford (1950) and Torrance (1962, 1974, 1989), who attempted to measure

[4] However, an exception applies to ambiguity-averse people, who tend to otherwise avoid the less-defined open-creativity tasks. Even though ambiguity-averse individuals might be very creative in such tasks, the uncertainty surrounding them might cause them to simply not take them on. Incentives could potentially overcome this reluctance, so that ambiguity-averse people might effectively be influenced by extrinsic rewards in this context.

creativity from a psychometric perspective. The Torrance test of creative thinking compares "convergent" to "divergent" thinking and is still a reference tool for measuring creativity. At the same time, personality tests were developed with the aim of identifying potentially-relevant traits as characteristics of creative people, such as independence of judgment, self-confidence, openness to experience, balanced personalities, attraction to complexity, aesthetic orientation, and risk taking (see, e.g., Sternberg, 1985). While certain aspects of creativity studies are still being debated, significant advancements have been made (Simonton, 2000). The challenge of investigating creative potential using conceptual and experimental approaches towards problem-solving processes is more recent, beginning with Nielsen et al. (2008)'s research.

For our purpose, creativity can be defined as "the production of novel and useful ideas in any domain" (e.g. Stein, 1974; Woodman et al., 1993). In contrast, innovation represents the successful implementation of creative ideas within an organization; creativity by individuals and teams is therefore the starting point for innovation. Given the necessity of generating creative ideas repeatedly, firms have traditionally relied on an internal staff of professional inventors in R&D labs (Schulze and Hoegl, 2008). More recently, many organizations have turned to employee suggestion schemes (Ohly et al., 2013) or to outsourcing of creative ideas in an attempt to get fresh hints (Surowiecki, 2004).

Galenson (2004)'s research on creativity identified two creative methods or styles: conceptual and experimental. The former relates to the generation of a new idea (a kind of deductive process), the latter is a new combination of existing items (an inductive or synthetic process that relies on experience). The former corresponds to divergent thinking, while the latter is a form of convergent thinking. Convergent tasks require a single correct response, whereas divergent tasks require producing many different correct answers (Hudson, 1966; Runco, 2006 and 2007). Although creativity tasks are usually categorized as either convergent or divergent, most creative problems contain elements of both (Nielsen et al. 2008).

In general, researchers propose a continuum ranging from closed to open problems (Getzels and Csikszentmihalyi, 1967; Wakefield, 1991; Eysenck, 2003): a true closed problem is one that is presented to the participant, when the method for solving the problem is known (convergent, in Torrance's terminology); open problems occur when the participant is required to find, invent, or discover the problems (divergent). In the perspective of Dual Process Theory (e.g. Stanovich and West, 2000; Kahneman, 2011), closed tasks – characterized by specific directions to follow – could exert a signal to use the cognitive system to proceed rationally, slowly and according to logical standards. Open tasks, on the contrary cause one to proceed in a much more unplanned and unaware manner. Dillon (1982) argues that most artistic endeavors generally represent open problems; responses to a suggestion scheme illustrate outcomes of organizational open problems.

Our measure of this form of creativity has some overlap with previous definitions of conceptual creativity. An interesting example of incentives to "open" vs. "closed" creativity in the realm of academic life-sciences funding is represented by Azoulay et al. (2011)'s study of the careers of investigators of two health institutes: the former gives wide freedom to experiment, tolerates early failure, rewards long-term success, whereas the latter gives investigators multiple sources of constraints, imposing short review cycles, predefined deliverables, and renewal policies unforgiving failure.

2.2 Motivation and incentives to creativity

A big question underlies involvement in the creative process. *Why* do people engage in creative activity? Motivations might depend on internal sources, such as a need for selfactualization or simply the joy one receives from being creative. In general, skills like tenacity, self-discipline and perseverance are important traits for success in life (Heckman and Rubinstein, 2001); since intrinsic motivation positively influences self-efficacy (Walls and Little, 2005), individuals with higher levels of such skills are expected to exert greater effort and be more engaged in creative tasks.

Alternatively, creative behavior might be a response to an external demand perhaps reflecting a job description, an experimental requirement, or environmental needs. Both intrinsic and extrinsic motivations appear to play roles as determinants of creative behavior. A number of studies show the importance of high intrinsic motivation consisting of the excitement and challenge of engaging in a creative activity. On the other hand, there is little agreement among scholars on the effectiveness of financial incentives (and, more generally, rewards and extrinsic motivations) on creative performance.

Despite the conventional wisdom in economics, financial incentives are not always helpful and may even be counterproductive. Deci and Ryan (1985) report an experiment in which children's intrinsic motivation to engage in an activity is undermined by financial rewards. Similarly, Gneezy and Rustichini (2000) show that paying only a small wage for charitable work can lead to lower productivity than relying completely on intrinsic motivation and paying nothing. Paying an excessive amount can also lead to poor outcomes due to a sense of pressure, as suggested by the aforementioned results in Ariely et al. (2009).

Amabile (1989, 1996)'s seminal studies both on children and adults show that crowding out can occur in the presence of monetary incentives, which seem to undermine intrinsic motivation and affect creative performance negatively. According to Kohn (1993): "It is simply not possible to bribe people to be creative" (p. 294). In the same vein, Hennessey and

Amabile (1998) conclude "the preponderance of the evidence demonstrates that working for reward, under circumstances that are likely to occur naturally in classrooms and workplaces every day, can be damaging to both intrinsic interest and creativity" (p. 675).

Nevertheless, some empirical research shows positive effects of rewards on creativity (Eisenberger *et al*, 1998; Eisenberger and Rhoades, 2001), although these results seems to be driven by very specific contexts or derived under experimental conditions not fully consonant with the methods of modern experimental economics. The use of reward has been possibly confounded with the presence of cues indicating the appropriateness and desirability of a creative performance (Winston and Baker, 1985). In addition, many studies in psychology use the *promise* of a reward (aimed at establishing reward expectancy).[5]

Since establishing purpose and intention to be creative is important for creative accomplishment (Nickerson, 1999), rewards given explicitly to prize creativity may foster such a creative orientation and push the focus on the creative question. Consistent with this notion, Collins and Amabile (1999) show that rewarding children's creativity can be successful if combined with intensive cognitive training designed to encourage a focus on the assigned task rather than on the reward. Rewards can be used for directing adults' attention and stimulating their effort in engaging in information search and other tedious procedures necessary to deal with long-term creative projects.

Crucially for our investigation, financial incentives are shown to lead to enhanced performance when the pattern of solution is clear and straightforward, i.e. in what Collins and Amabile (1999) call "algorithmic" task (such as, for instance, making a collage after being told precisely how to make a creative one). Closed tasks may be viewed as those in which the path to

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[5] However, it is possible that the credibility of these promises was undermined by an expectation of deception.

a solution is apparent and people have learned how to generate solutions. It has been argued in the literature that incentives increase the tendency to produce dominant, well-learned responses (Zajonc, 1965): closed tasks may represent situations where dominant responses help. Alternatively, open tasks could be interpreted as those in which there is no learned way to reach a solution, and no dominant response. McCullers (1978) highlights that incentives increase performance when this involves making "simple, routine, unchanging responses," (p. 14) but that incentives are less effective in situations that depend on flexibility, conceptual and perceptual openness. McGraw (1978) identifies two conditions under which incentives will even have a detrimental effect on performance: "first, when the task is interesting enough for subjects that the offer of incentives is a superfluous source of motivation; second, when the solution to the task is open-ended enough that the steps leading to a solution are not immediately obvious" (p. 34).

Erat and Krishnan (2012) develop a model to examine the relationship between problem specification, award structure, and breadth of solution space for a firm that manages a contest for outside agents working on the solution of open-ended problems: the model predicts that, as the problem becomes better specified, the searchers will perceive limited risk that their evaluation of solution quality does not match the principal's evaluation, and thus even small prizes can induce search. Both Collins and Amabile (1999)'s and Erat and Krishnan (2012)'s contributions suggest that, whereas monetary incentives might promote creativity in closed tasks, directly incentivizing open creativity would be ineffective or even counter-productive. The prediction that incentives should hurt idea generation seems consistent with the assumption that – in open tasks – creativity relies primarily on random variations in the search process. However, in closed tasks, structure (and not randomness) is the key to creativity (Goldenberg et al., 1999), so that idea generation appears as a more algorithmic task, likely to be enhanced by incentives.

2.3 Literature in experimental economics

Many real-effort tasks have been used in experimental economics in recent years (for a review, see Charness and Kuhn, 2011). Some of these involve solving a puzzle with a specific and clear insight that may not be immediately obvious. Rütstrom and Williams (2000) used a Tower of Hanoi puzzle, which involves three rods and a number of disks of different sizes that can slide onto any rod. The puzzle starts with the disks in a neat stack in ascending order of size on one rod, the smallest at the top, thus making a conical shape. The objective of the puzzle is to move the entire stack to another rod, following some simple rules. Ariely et al. (2009) used the "Packing Quarters" game: participants are asked to fit nine metal pieces of quarter circles into a frame within a given time. To fit all nine, the pieces must be packed in a particular way.[6] Toubia (2006) recruited subjects at an anti-war walkout and asks them to generate ideas on a specific problem: "How can the impact of the UN Security Council be increased?". He finds that, in presence of incentives, participants try harder to generate ideas and did not give up as easily.

There are several recent experimental papers (some of which are contemporaneous to our experiments) that consider aspects of incentives on creativity. Overall, the results are rather mixed. Chen et al. (2012) examine whether the efficacy of either individual- or group-based creativity-contingent incentives depends on the form (piece-rate or tournament) they take: individual intragroup tournament pay increases individual efforts, but is not effective in enhancing the creativity of group solutions relative to individual piece-rate pay: reward systems result to be more likely to promote group creativity through collaborative efforts rather than independent individual efforts.

[6] Here very large financial incentives led to poorer performance than did more modest stakes

Eckartz et al. (2013), in a within-subject design, ask subjects to form words out of letters under three incentive schemes: a flat fee, a linear payment and a tournament; they also use two control tasks (the Raven test and adding numbers). There was no real effect of any incentives on performance. They also find no effect of gender on tournament entry, in contrast to Niederle and Vesterlund (2007).

Bradler et al. (2014) compare the effects of financial incentives on performance on a routine task and a creative task. The routine task is the slider task (Gill and Prowse, 2012), while the creative task is the "Unusual Uses task" (Guilford, 1967; Torrance, 1968) – subjects are asked to name as many different and unusual uses as possible for a routine object. The payoffs are structured as a tournament prize for above-average effort.
They find that tournament incentives work well and have similar effect sizes in these tasks, and estimate that concern for relative rank accounts for about one-fourth of this effect. An interesting sidelight is that unconditional gifts lead to a form of reciprocity in the routine, but not in the creative, task; Bradler et al. conclude that it is uncertainty about one's performance (and so the exact transfer back to the first mover) that makes such reciprocity difficult.

Erat and Gneezy (2015) examine the effect of piece-rate and competitive incentives (as well as two different time limits) on performance on a task involving a rebus. This is "a puzzle made with words and/or pictures with a hidden and non-obvious solution," so that there is a unique correct response. Even though financial incentives lead to greater effort (time spent on the rebus), incentives do not improve the creative output relative to the case in which participants are not offered any external monetary incentives for creativity; moreover, the type of incentives matter, and competitive incentives reduce creativity relative to piece-rate incentives.

Laske and Schroder (2015) study the effect of incentives on different dimensions of creative work, introducing incentives either for quantity alone or for quantity in combination with usability or novelty and comparing performance in these treatments to a baseline with fixed incentives. Incentivizing quantity alone or quantity in combination with novelty results in an increase in quantity and novelty, but decreases the average quality compared to the baseline. Combining incentives for quality and quantity does not significantly affect any of the dimensions of creativity.

Our design differs from each of these in that we test for the effect of incentives with two different forms of creativity tasks that differ only in that one is somewhat more of an closed task than the other. We are unaware of any study that considers the effect of financial rewards on two different types of creativity tasks. Our tasks do not have a unique and correct solution, which some might say is not quite the same as a richer form of creativity, and they allow a full range of open-ended personal expression on blank sheets of paper. We do find a dramatic effect of incentives for the closed task but no effect at all for the open task, despite the fact that we deliberately chose these to differ only slightly.

3. The model

Subject *i* has an observable creativity output q_i, which is summarized by the following equation:

$$q_i = q(s_i, e_i, \varphi) \qquad (1)$$

where s_i represents the subject's intrinsic creative skill, e_i is the subject's effort in the creative task, and φ is a common "environmental" variable capturing the characteristics of the creative task.

Since s_i can be interpreted as "individualistic noise" (where G is the distribution of s_i and g its density) and φ depends on the task, q_i is a random function of e_i. We consider a simple special case where:

$$q_i = \varphi e_i + s_i$$

The variable $\varphi \geq 0$ captures the precision in goals definition of the specific creative task faced by the subject: the larger φ, the tighter the constraints characterizing the task, the higher the precision in goal definition and the smaller the set of possible solutions (closed tasks); when $\varphi \rightarrow 0$, the task is loosely-defined and allows for a very broad range of solutions (open tasks).

3.1 Flat payment (no incentives)

If the experimenter observes a creative output $q_i > 0$, the subject receives a flat payment Y. With a flat payment, the subject maximizes the following expected utility W, which is additively separable in payment and effort.

$$W = E[U(Y) - V(e_i, s_i)]$$

The marginal utility of payment is positive: U' > 0. The disutility of effort is U-shaped: since intrinsically-creative people enjoy taking part in creative tasks, the disutility of effort decreases as long as subjects have to exert "low" levels of creativity (with respect of their skill). However, when they have to push beyond their "natural" creative level, disutility increases in effort.[7]

[7] Contemporary work in psychology assumes that most individuals are capable of producing at least moderately creative work (Amabile, 1996).

Let's assume $V(e_i, s_i) = \frac{e_i^2}{2} - s_i e_i$. This functional form respects the properties illustrated above: $\frac{\partial V(e_i, s_i)}{\partial e_i} < 0$ if $e_i < s_i$ and $\frac{\partial V(e_i, s_i)}{\partial e_i} > 0$ elsewhere; $\frac{\partial V(e_i, s_i)}{\partial s_i} < 0$.[8]

The subject chooses the optimal level of effort e_i^* by maximizing W. The first-order conditions lead to $\frac{\partial V(e_i, s_i)}{\partial e_i} = e_i - s_i = 0 \rightarrow e_i^* = s_i$. In the case of flat payment, the subject chooses a positive level of effort in the creative task that increases in s_i.

3.2 Tournament (incentives)

For the sake of simplicity, we consider the simplest case of a two-subject tournament in which the winner gets a fixed prize $\overline{Y} = Y + x$ and the loser gets a fixed prize $\underline{Y} = Y - x$ with $x > 0$ that can be interpreted as the risk or reward to be added to the safe payment Y. Both parties' creativity production functions follow equation (1) and the winner of the tournament is determined by the largest creative output q. In contrast to the flat-payment condition, now the payment is no longer deterministic. The probability P of winning depends on both contestants' effort, on the distribution of s, and on the variable φ reflecting the characteristic ("closeness") of the task: the more the task is "closed", the higher the subject's probability of understanding how to win the contest.

Consider contestant 1's problem and denote the opponent by 2. Subject 1's expected utility is:

$$P(e_1, e_2, \varphi)\left[U(\overline{Y}) - V(e_1, s_1)\right] + \left(1 - P(e_1, e_2, \varphi)\right)\left[U(\underline{Y}) - V(e_1, s_1)\right]$$

or

[8] The results presented in the text are robust to all specifications that reflect the notion that the disutility of effort is U-shaped.

$$P(e_1, e_2, \varphi)[U(Y+x) - U(Y-x)] - U(Y-x) + V(e_1, s_1)$$

Subjects will supply effort until their marginal disutility from exerting creative effort (attenuated by creative skill) is compensated by the increase in the chance of winning the prize. Subjects observe the characteristics of the task φ and choose creativity effort in accordance with

$$\frac{\partial P(e_1,e_2,\varphi)}{\partial e_1}\Delta U - \frac{\partial V(e_1,s_1)}{\partial e_1} = 0 \qquad (2)$$

where $\Delta U = U(Y+x) - U(Y-x)$.

In order to compute $\frac{\partial P(e_1,e_2,\varphi)}{\partial e_1}$, we recall that subject 1 wins the contest if $q_1 > q_2$, i.e. if $\varphi e_1 + s_1 > \varphi e_2 + s_2$. For a given s_2, the probability that $s_1 > \varphi(e_2 - e_1) + s_2$ is equal to $1 - G(\varphi(e_2 - e_1) + s_2)$. The total probability of winning is obtained by integrating over all the possible values of s_2, weighted by the density of s_2, $g(s_2)$. Hence:

$$P(e_1, e_2, \varphi) = \int [1 - G(\varphi(e_2 - e_1) + s_2)] g(s_2)\, ds_2$$

In the symmetric solution (when $e_1 = e_2$ and $P = \frac{1}{2}$), subject i's increased chance of winning by raising creative effort is

$$\frac{\partial P(e_1,e_2,\varphi)}{\partial e_1} = \varphi \int g(s_2) g(s_2) ds_2 = \varphi \tilde{g} \qquad (3)$$

where $\tilde{g} = E[g(s)]$. Substituting (3) into the first-order conditions in (2) leads to:

$$\varphi \tilde{g} \Delta U = \frac{\partial V(e_1, s_1)}{\partial e_1}$$

In equilibrium, the marginal disutility of creativity effort (mitigated by the pleasure of being creative) equals the utility of winning the prize. Note that in tournaments (and not in case of flat payment), creativity effort varies with φ.

Assuming, as above, $V(e_i,\ s_i) = \frac{e_i^2}{2} - s_i e_i$, we obtain:

$$\varphi \tilde{g} \Delta U = e_i - s_i$$

This leads to a level of optimal creative effort in tournaments that equals

$$e_i^{**} = \tilde{g} \varphi \Delta U + s_i \quad (4)$$

The expression above illustrates that optimal effort increases in: (a) own creativity skill s (as in case of flat payment), (b) the average creativity skill of subjects taking part into the tournament $\tilde{g}$, (c) the closeness of the task φ, (d) the distance between the utility deriving from winning the contest and the utility deriving from losing it, ΔU.

Two main implications derive from (4):

I) The monetary incentives provided by the tournament are effective in stimulating creativity effort: subjects increase their creativity effort with respect to flat payments ($e_i^{**} > e_i^{*}$) in the aim of raising the chances of winning the contest. More specifically, with risk-neutral subjects, $\Delta U = 2x$ and $\frac{\partial e_i^{**}}{\partial x} > 0$: creativity effort rises in the monetary gap between the winner's and the loser's payment.

II) When $\varphi \to 0$ (i.e. in case of open tasks with very loosely-defined goals), $e_i^{*} \to s_i$ as in case of flat payments. Thus, the characteristics of the task determine the effectiveness of incentives in stimulating creative effort: when a task is loosely-defined, subjects perceive lower probability to win the task and become less sensitive to monetary incentives.

4. The experiment

Our experiment involves asking individuals to perform a task in a creative manner. The experiment has a 2x2 design, consisting of two real-effort tasks (closed vs. open) and two treatments (incentives vs. flat payments). Each participant was assigned to only one of the four treatments. The relative creativity of each participant is evaluated by peers and by externals judges (blind to treatments and conditions), in line with Poincaré's definition emphasizing that the "new combination" should be recognized in its utility by peers and with Amabile's notion of "social consensus". We provided no guidance concerning evaluating creativity; when asked, we simply stated that this was for each participant to judge.

4.1. Tasks

We capture closed creativity by using "combination" tasks, and open creativity by asking for the development of a totally new product or vision. Subjects had 20 minutes to complete the chosen task. While these tasks are consistent with our notion of open versus closed creativity, we certainly do not claim that these specific tasks are fully representative of all dimensions of creativity. In fact, as mentioned above, we chose our tasks in part to be a modest difference on the open-versus-closed dimension.

Closed task

In the closed condition, people were asked to choose from the following questions:[9]

1. "Choose a combination of words to create an interesting story." The words supplied are: house, zero, forgive, curve, relevance, cow, tree, planet, ring, send. Participants were told that they must use these words along with any other combination of words that they wished.
2. "Starting from the number 27, obtain the number 6 by using at least two different numerical operations. Possible answers include: (27:3) – 3 = 6, or [(27 + 3): 2 – 12]! = 6."

Open task

In the open condition, people were asked to choose from the following questions:

1. "If you had the talent to invent things just by thinking of them, what would you create?"
2. "Imagine and describe a town, city, or society in the future."

[9] We gave subjects the possibility of choosing the task because we wanted them to be more likely to face an endeavor with which they were comfortable.

Participants were told that the creativity of their output would be ranked in relation to that of the other four people in the group. People in another mutually-anonymous five-person group (in order to avoid strategic effects on the evaluations) performed this ranking.

Again, we consider our treatments to be something of a minimal intervention, in the sense that the tasks, while different in some dimensions, are not dissimilar in others.

4.2. Treatments

Incentives treatment

In the incentive treatment, we paid people on the basis of the assessments made. In each group, the person with the best ranking received an additional $15, the second-best received an additional $12, the third-best received an additional $9, the fourth-best received an additional $6, and the worst received an additional $3; these payments were made in addition to the standard $5 payment for showing up on time to the experiment). We note that these are relatively "soft" tournament-style incentives, with a marginal change in earnings of only $3 per ranking.

No-incentives treatment

In the no-incentive treatment, we paid people a flat amount of $9 (plus the $5 show-up fee) for completing the response, so that the average earnings were the same as in the incentives treatment. The tasks were identical to those in the incentives treatment. In both cases, people were told that the five individuals in another group would anonymously rank the creativity of their work.[10]

One may wonder why we paid subjects according to how they are ranked relative to their peers. One practical consideration is that we wished to pay them at the time of the session and

[10] We ranked people in the no-incentives condition to control for the possibility that people care about their rank *per se*,, as in Charness et al. (2014); people were aware that they were being ranked.

having raters come to the session would have led to considerably longer sessions and would have also made it impossible for one to rate creativity in more than one treatment (since they would no longer be blind to the treatment.   Second, a major advantage of having evaluations by peers is that they are most likely to be attuned to what is perceived to be creative in the relevant reference group (recall that "creativity should be recognized in its utility by peers"). Of course, to perform rankings across sessions, it was necessary to later have the responses evaluated by external judges, who were blind to treatments and conditions. As we shall see, the correlation across rankings by students and raters was high.

4.3. Risk and ambiguity attitude

In our questionnaire (presented after completing the task), we requested demographic information and also asked subjects to answer two incentivized questions on risk and ambiguity attitude (Gneezy and Potters, 1997; Charness and Gneezy, 2010): each individual is endowed with 100 units and could invest any portion in a risky asset that had a 50 percent chance of success and paid 2.5 times the amount invested if successful and nothing if unsuccessful; the individual retains whatever units were not invested. Participants were told that two different people (one for the risk-aversion question and one for the ambiguity-aversion question) would be chosen at random in each session for actual payoff implementation of these choices, and a random mechanism would be used after the session to determine success or failure for these investors. This procedure provides a measure of risk aversion for each individual: the higher the investment, the less risk averse is the individual. The question on ambiguity attitude is identical except that we did not tell people the probability that the investment would be successful.

4.4. Questionnaire

The questionnaire is comprised of:

- 10 questions on creative and cognitive style and sensation-seeking attitude, based on Nielsen at al. (2008)'s questions on creative style and on Zuckerman et al. (1964)'s questions on sensation-seeking attitude. Zuckerman et al. (1964)'s sensation-seeking scale was originally comprised of 34 items written on a forced-choice form. We consider only a selection of the items pertaining to preferences for the new and unfamiliar as opposed to the familiar, preferences for irregularity as opposed to regularity and routine, social values based on the stimulation value of other persons as opposed to their reliability and predictability, preferences for security as opposed to adventure, and need for general excitement.

- Seven questions on demographic features: gender, age, major, number of siblings, birth-order, right or left-handed, married/divorced/unmarried parents plus other six questions on past involvement in creative activities, as in Hocevar (1980). This inventory originally included a list of 77 activities and accomplishments that are commonly considered to be creative (e.g., painted an original picture, wrote an original computer program, excluding school or university work); for each item, participants indicated the frequency of the behavior in their adolescent and adult life. The scoring rule was to sum up each participant's ratings for the activities included in the inventory. In our questionnaire, the inventory is scored for creativity in six areas: art, crafts, performing arts, math-science, literature, and music.

4.5. Procedures

The experiments on individual creativity were conducted at the University of California, Santa Barbara. There were 14 sessions, with a total of 236 participants. There were 97 people who faced the closed task, with 53 in the no-incentives condition and 44 in the incentives condition; there were 139 people in the open task, with 70 in the no-incentives condition and 69 in the incentives condition.[11] The subjects were undergraduate students (42% from Social Sciences, 40% from STEM disciplines and 18% from Humanities), with 57.2% females. We employed a between-subjects design: no individual participated in more than one session. In each session, the participants were paid a $5 show-up fee, plus their earnings from the experiment. At the beginning of each session, written instructions were distributed to the participants and read aloud by the experimenter. All subjects completed a final questionnaire containing demographic information, personality details, and the two incentivized questions measuring risk and ambiguity aversion. The sessions took one hour, with average earnings of about $15.

5. Results

5.1. Creativity evaluation

As mentioned, people in one group evaluated and ranked the individual responses from people in another group: rankings exhibit a fair degree of consistency (Cronbach's alpha = .536; Cronbach's alpha computes the inter-item correlations or co-variances for all pairs of judges' evaluations). To make comparisons across treatments, we had two external judges – blind to treatments – assess all of the answers on a 1-10 scale with no indication of any specific criteria to be followed but to their own taste for creativity: the two judges' evaluations exhibited a good degree of consistency (Cronbach's alpha = .619).[12] Our creativity score is the average of the two independent evaluations and is highly correlated with the group ranking (Spearman correlation test, with coefficient = .518, p = 0.000).[13]

[11] The number of people recruited for the experiment was 240, but we end up with 236 answers because: (a) one subject's answer in Session 3 was unreadable; (b) one subject in Session 6 did not give us back the sheet containing his answer; and (c) two subjects in Session 14 did not show up.
[12] We also calculated consistency using Interclass Correlation Coefficients and obtained the same values (details available upon request).
[13] Throughout the paper, we round all p-values to three decimal places.

In addition to subjective evaluations, we introduce two objective measurements of creativity effort that reflect the number of words used in the answers to the verbal task and the number of operations used in the answers in the math task: these measures univocally capture the "size" of the creative output and are summarized by a variable labeled "count". With closed creativity, participants used an average number of 200 words (std. dev. = 95.60) or 51 mathematical operations (std. dev. = 68.36); with open creativity, answers had an average of 210 words (std. dev. = 81.23).

For the closed task, we also sought objective determinants for creativity assessments. We had two other judges (different from the ones who assigned the creativity score) classify the answers according to the two-fold taxonomy shown in Appendix A. For the verbal task, the judges used this taxonomy to identify the specific meaning according to which each of the words the subjects had used, and to assign a score reflecting the degree of originality of the meaning they selected.[14] For the math task, the judges assigned a score that reflected the complexity of each operation used.[15]

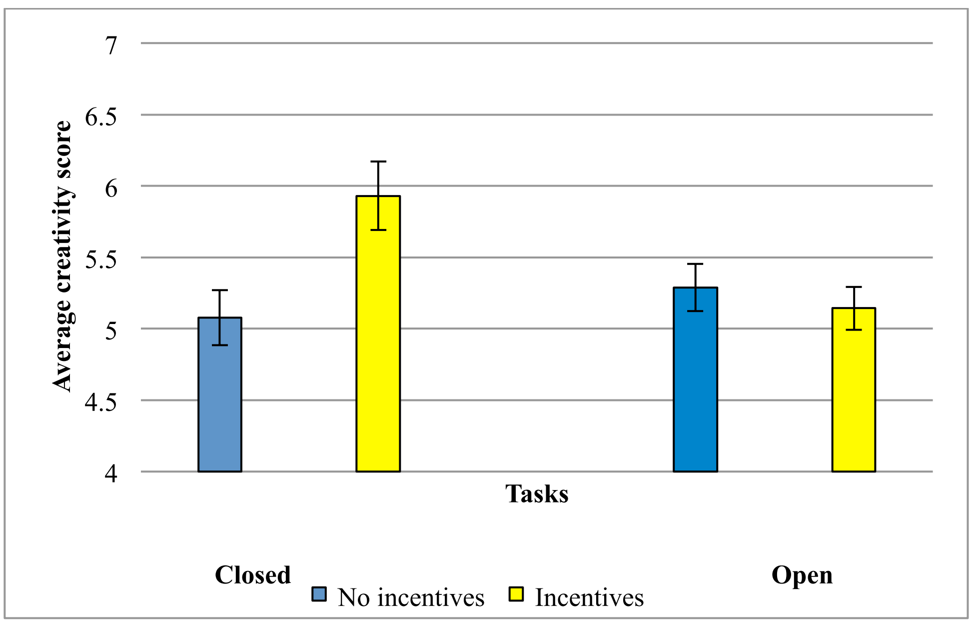
In the case of closed verbal creativity, participants obtained an average taxonomy score of 17.75 (std. dev. = 9.41); for closed math creativity, the taxonomy score was on average 8.67 (std. dev. = 6.13). The taxonomy score is significantly correlated with our creativity score (Spearman correlation test, with coefficient = .346, $p = 0.001$). This implies that the subjective creativity coding is indeed meaningful and the taxonomy score offers an objective metric that can be used in this environment.

[14] Meanings are ordered according to WordReference.com's ranking in use frequency: for each word, the score increases in the originality of the meaning used.
[15] Operations are grouped and ordered according to the school level in which they are typically taught: the subject earns the score corresponding to the maximum level she reaches, no matter the number of operations in each set.

5.2. Role of financial incentives

The introduction of financial incentives has a positive effect on the level of creativity when the task is characterized by the presence of *ex-ante* goals and constraints. In the closed condition, participants whose pay depended upon their ranking[16] (incentives treatment) are more creative than subjects who receive a flat payment (no-incentives treatment): the average level of creativity score increases with incentives from 5.075 to 5.909 and this difference is significant (Wilcoxon rank-sum test on individuals, $Z = -2.673$, $p = 0.007$).[17] There is no significant difference between the creativity scores for incentivized and non-incentivized open tasks or between these scores that of non-incentivized closed creativity.[18,19]

Figure 1. Effects of financial incentives on individual creativity



[16] Our payoff structure is a relatively soft tournament scheme. We might expect to find even stronger results with sharper marginal differences in payoffs.

[17] All statistical tests are two-tailed unless otherwise specified.

[18] The respective test statistics are $Z = 0.532$, 0.298 and -0.195, with p-values 0.594, 0.832 and 0.845.

[19] The closed condition gives subjects a choice between a math task and a verbal task, while the open condition only offers a choice of verbal tasks. In principle, this could lead to higher creativity scores in the closed condition, since people who are more math-oriented might score higher on a creativity task that is mathematical. However, in fact the scores on the math task were not higher than those on the verbal task. Note that there is no difference in the average creativity score across open and closed non-incentivized conditions.

Figure 1 provides a graphic summary of the results, Figure 2 shows the distributions, and Table 1 reports summary statistics according to the task and the treatment.

Figure 2: Distributions of creativity scores

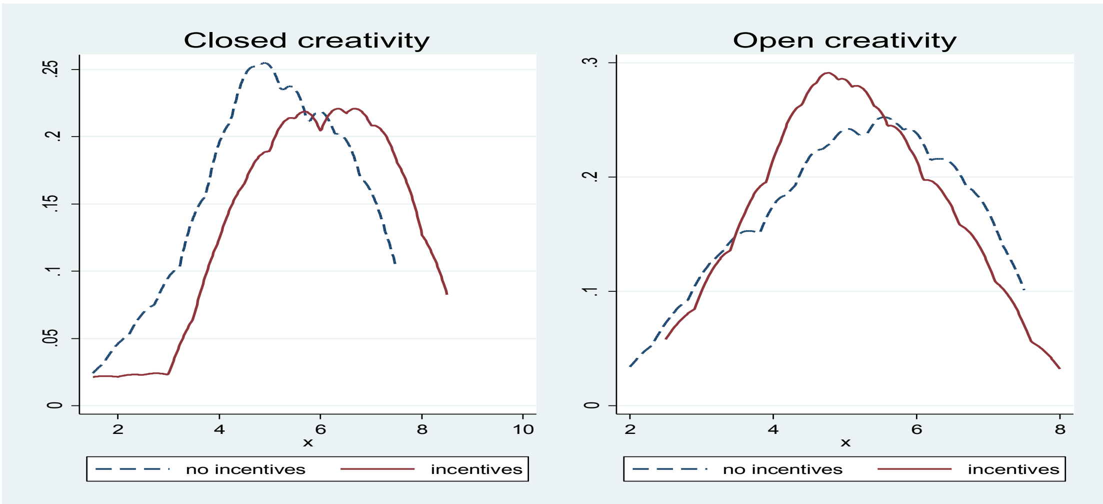


Table 1. Creativity score by treatment: summary statistics

Treatments	Closed with no incentives	Closed with incentives	Open with no incentives	Open with incentives
Average	5.075	5.909	5.150	5.079
Standard error	0.193	0.240	0.165	0.152
Min	1.5	1.5	2	2.5
Max	7.5	8.5	7.5	8.0
Obs.	53	44	70	69

We see a dramatic and distinctive effect of incentives on individual creativity with a more-defined task. To the best of our knowledge, this is the first study to find such an effect.[20]

[20] Eckartz et al. (2012) use a scrabble-type task, finding that incentives have very small effects and that differences in performance are predominantly related to individual skills. On the contrary, Bradler et al. (2013) provide evidence that routine as well as creative task performance increase significantly under the tournament scheme, whereas unconditional gift triggers higher effort only in tasks while creative performance is not affected.

It is worth noting that, whereas incentives matter in determining the creativity score, neither the count nor the taxonomy score is fostered by incentives. For the verbal task, the average count is 222.0 with flat payment and 171.38 with incentives ($Z = 1.889$, $p = 0.058$, Wilcoxon rank-sum test using individual averages); the average taxonomy score is 18.44 with flat payment and 16.82 with incentives ($Z = 0.826$, $p = 0.408$). For the math task, the average count is 66.00 with flat payment and 91.90 with incentives ($Z = -0.418$, $p = 0.675$, Wilcoxon rank-sum test using individual averages); the average taxonomy score is 9.19 with flat payment and 7.60 with incentives ($Z = 0.496$, $p = 0.620$).[21] One interpretation is that it is the subjective component of creativity evaluation – difficult to capture by means of objective criteria such as the ones we introduced – that is fostered by financial incentives. Other explanations can be related to the effectiveness of financial incentives in promoting the "quality" of the creativity effort instead of the creativity effort itself.

In the open condition, the average creativity score with incentives is not significantly different from that in the no-incentives treatment: the average level of creativity score is 5.079 and 5.150, respectively, with no significant difference (Wilcoxon rank-sum test on individual averages, with $Z = 0.532$, $p = 0.594$). Note also that the creativity scores in both parts of the open condition are nearly the same as the score in the closed condition without incentives ($Z = 0.060$ and $p = 0.952$, respectively), as predicted by our model. As per Dillon (1982), most artistic endeavors generally represent open problems so that perhaps a true artist cannot be incentivized; artistic talent may simply be lacking. But "thinking harder" with open tasks does not help and could conceivably hurt (via the so-called creative blockage); furthermore, increasing output in

[21] While it may seem that there should be a significant difference for the math task, the lack of significance is driven by extreme values and by the limited number of observations. The lack of statistical significance is also found with the median test and the Kolmogorov-Smirnov tests ($p = 0.903$ and $p = 0.586$, respectively).

open-ended creativity may be more limited by current creative talent and skill levels than doing so with closed creativity.

Our explanation of the ineffectiveness of incentives in the open task is that incentives are likely to work better if the task objectives are defined more precisely and are consequently perceived as clearer (as happens with closed creativity) because the evaluation process is easier to forecast for the subject who will experience it. Some further support is provided by the fact that the evaluations of the external judges show a slightly higher degree of consistency and stronger correlation in the closed condition than in the open condition (Cronbach's alpha = .646 in the closed condition and .617 in the open condition; Spearman correlation test with coefficient = .481, p = 0.000 in the closed condition and coefficient = .448, p = 0.000 in the open condition). Delfgaauw et al. (forthcoming) conduct a field experiment in a retail chain to test the prediction of tournament theory and find that noise dilutes incentives to perform because it reduces the marginal effect of effort on the probability of winning.

5.3. Incentives and risk/ambiguity aversion

This section examines the role of incentives and attitudes towards risk and ambiguity. We characterize investment choices in the ambiguous lottery in terms of risk aversion and ambiguity aversion. Furthermore, we consider the interaction between the presence of monetary incentives and risk/ambiguity aversion. One hundred and thirteen people showed no ambiguity-risk gap; of the rest, 99 people invested more with risk than with ambiguity, while 24 people invested less with risk than with ambiguity. This is significantly different from random behavior (Z = 6.763, p = 0.000, binomial test). Overall, the average investment with risk was 63.34 and the average investment with ambiguity was 51.04, a considerable difference (t = 6.899, p = 0.000, one-sample t test).

Table 2. Closed creativity: Determinants of creativity score

Creativity score	(1)	(2)	(3)	(4)	(5)
Incentives	2.068***	1.655**	2.533***	1.722**	1.876**
	[0.754]	[0.760]	[0.949]	[0.756]	[0.741]
Count	0.005***	0.004***	0.006***	0.003*	0.005***
	[0.001]	[0.001]	[0.002]	[0.002]	[0.001]
Risk aversion	-0.018	-0.018	-0.018	0.017	-0.017
	[0.011]	[0.011]	[0.011]	[0.011]	[0.011]
Ambiguity aversion	0.004	0.009	0.004	-0.007	0.002
	[0.010]	[0.010]	[0.010]	[0.010]	[0.010]
Incentives*risk	-0.020	-0.019	-0.022	-0.019	-0.012
	[0.014]	[0.014]	[0.014]	[0.014]	[0.015]
Incentives*ambiguity	0.003	0.009	0.002	0.007	-0.003
	[0.012]	[0.012]	[0.012]	[0.012]	[0.013]
Experimental creative style					0.172
					[0.302]
Sensation seeking					0.142
					[0.201]
Male					0.294
					[0.321]
Past involvement in artistic tasks					-0.060
					[0.125]
Major: stem vs. social/humanities					0.195
					[0.324]
Right-handed					-0.014
					[0.576]
Siblings					-0.185
					[0.135]
Birth-order					-0.009
					[0.171]
Taxonomy		0.043***		0.033*	
		[0.016]		[0.018]	
Math task				-0.491	
				[0.429]	
Incentives*count			-0.002		
			[0.003]		
Constant	3.227***	3.030***	3.100***	3.495***	3.208***
	[0.601]	[0.647]	[0.619]	[0.759]	[1.065]
Observations	84	82	84	82	81

Tobit regression
Standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

When considering closed creativity, the main engine for creativity is incentives. Table 2 shows that financial incentives matter *per se* ($p = 0.051$); neither risk-aversion nor ambiguity-aversion nor any interaction between risk, ambiguity and incentives is significant. Participants putting more effort in the task (using a higher number of words or operation) are the people who receive a significantly higher creativity score.[22] Column 2 shows that results do not change if we also control for the taxonomy score: furthermore, the taxonomy score is significant, suggesting that selecting more original meanings or more sophisticated operations - according to an objective classification such as the taxonomy we provided to the second group of judges - leads to a higher creativity score being assigned. Results hold also when including the insignificant interaction between count and incentives, as shown in column 3, when distinguishing between the math and the verbal tasks (column 4), and when considering demographic and personal features, as shown in column 5.

The regressions in Table 3 examine the role of incentives, effort, risk and ambiguity aversion, as well as interactions between these attitudes and financial incentives. At first blush, incentives appear to be ineffective in shaping open creativity. Again, participants exerting more effort in the task (using a higher number of words) generally receive a significantly higher creativity score, although column 2 shows that this effect disappears when controlling for the interaction between count and incentives. Furthermore, ambiguity (but not risk, except for a tiny effect in column 3) aversion seems associated with a decrease in the creativity score, suggesting that being less comfortable with uncertainty affects one's talent in a task involving open creativity. As proposed by our model, this uncertainty is likely to derive from poor definition of tasks and goals.

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[22] Since the creativity score is correlated with effort and taxonomy score, it seems that, on some level, judges' creativity evaluations reflect these objective measurements. But of course the correlation is not perfect; we suspect that there is some residual that matters in a creativity evaluation and cannot be readily captured by objective measures. Perhaps it is this residual that is enhanced by monetary incentives.

Table 3. Open creativity: Determinants of creativity score

Creativity score	(1)	(2)	(3)
Incentives	0.223	0.414	0.085
	[0.579]	[0.859]	[0.555]
Count	0.004**	0.004	0.004**
	[0.002]	[0.003]	[0.002]
Risk aversion	0.007	0.008	0.013*
	[0.007]	[0.008]	[0.007]
Ambiguity aversion	-0.015**	-0.016**	-0.019***
	[0.007]	[0.007]	[0.007]
Incentives*risk aversion	-0.007	-0.007	-0.015
	[0.010]	[0.010]	[0.009]
Incentives*ambiguity aversion	0.015	0.016*	0.023**
	[0.009]	[0.009]	[0.009]
Experimental creative style			0.732***
			[0.241]
Sensation seeking			-0.066
			[0.187]
Male			0.505**
			[0.254]
Past involvement in artistic tasks			0.175*
			[0.092]
Major: stem vs. social/humanities			0.460*
			[0.245]
Right-handed			0.234
			[0.408]
Siblings			-0.124
			[0.075]
Birth-order			0.284*
			[0.146]
Incentives*count		-0.001	
		[0.003]	
Constant	4.186***	4.080***	2.596***
	[0.464]	[0.583]	[0.721]
Observations	111	111	102

Tobit regression.
Standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Furthermore, Table 3 suggests that the relationship between creativity and incentives is mediated by ambiguity attitude. Ambiguity plays a twofold role. First, ambiguity interacts with financial incentives. Although financial incentives do not typically succeed in stimulating open creativity, we find that ambiguity-averse people are more sensitive to financial incentives. This classification is based on work by Nielsen et al. (2008), which introduces operational definitions of Galenson (2004)'s creative methods: conceptual creative people have definite goals and methods, whereas experimentally creative people do not have clearly established methods, use trial and error, and do not have specific goals. Consistent with this, our data suggest that open creativity is a form of experimental creativity: Column 3 shows that the more one has an experimental creative style, the higher the score for open creativity. We considered the fit of our measures of creativity with previous measures of creative style and personality, finding that open creativity overlaps some with Galenson (2004)'s definition of experimental creativity.

An additional result pertains to the within-subject difference between investment in the ambiguity lottery and in the risky lottery. Participants with a non-negative difference have a significantly higher open-creativity score than those with a negative difference (5.30 versus 4.82, $Z = -1.980$, $p = 0.047$, Wilcoxon rank-sum test using individual averages). This confirms the role of ambiguity attitude with respect to risk attitude.

In general, uncertainty about probability is a definition of ambiguity (Ellsberg, 1961): ambiguity-averse subjects might be less attracted to this type of creative task, but incentives might stimulate creativity for people who like to try new experiences ('experimental cognitive style'). In a similar vein, in a study focused on innovation contests, Boudreau et al. (2011) emphasize that, when designing incentives to innovation, uncertainty matters: the uncertainty they talk about is "the sense of uncertainty in the best approach to solving a problem and, consequently, who will turn to be the winner" (p. 845): the substantial remaining uncertainty about how to approach and solve a problem is the same subjects faced in our open task, when ambiguity attitude is shown to play a role.

5.4. Personality features and previous measures of creativity

We now focus on the role of demographic features and personal attitudes like cognitive style and sensation-seeking mind-set. We report supplemental regression tables for open and closed creativity in Appendix B.

Regarding closed creativity, neither creative style nor preferences for sensation-seeking nor involvement in artistic tasks plays a role. All in all, closed creativity appears to respond to financial incentives, but little else. Turning to open creativity, a few significant effects do emerge. First, the more a subject's creative style can be described as experimental rather than conceptual, the higher the creativity score in open tasks. Second, a marginally-significant gender effect emerges: males reach higher creative scores. Third, students majoring in the hard sciences are marginally more creative ($p = 0.052$).[23] Fourth, people with larger past involvement in creative endeavors (and people with more elder brothers) are more creative.

6. Discussion

Our results seem clear. In an individual framework, creativity is the same across all conditions except that it is markedly higher when there is a closed task and extrinsic incentives are provided. In this section, we discuss our results and relate them to previous work.

First, contrary to the predictions of much of the relevant literature in psychology, we see no evidence at all that providing financial incentives has a harmful effect on creativity, whether this is with closed or open tasks. This is good news in that, if true, providing financial rewards for creative performance will only be costly to the extent of the cost for the rewards. One might

[23] This could reflect the fact that 51.42 percent of subjects majoring in hard sciences choose the math task - for which they are likely to have more expertise – with respect to other subjects who choose the math task only in 25 percent of the cases (Wilcoxon rank-sum test with Z=-2.596, $p = 0.005$, one-tailed test).

argue that there is little or no intrinsic motivation in the first place, but this belies the mental effort most people put into the task when there was a flat payment and the work *per se* clearly did not benefit the researchers.[24,25]

According to Baer et al. (2003), the inconsistent relationship between rewards and creativity could result from the interaction between intrinsic and extrinsic motivations: creativity is enhanced by intrinsic motivations that are boosted by the presence of extrinsic rewards. A relevant dimension is that of cognitive style, either innovative or adaptive: highly-motivated people reach greater achievements, are more open to new experiences, and exhibit higher productivity in a variety of aspects of life (Heckman, 2007), intrinsic motivational qualities are likely to be stronger for those with an innovative style than for those with an adaptive style; the latter tend to perceive their jobs as being instrumental for obtaining extrinsic rewards.

This fits well with our results on individual creativity, as providing financial incentives has no beneficial effect in the more innovative open task, but does have an effect in the more adaptive closed task. Perhaps when employers wish to stimulate employees' creativity in organizations, monetary incentives should be offered according to the type of job. Another possible explanation grounds on the "short-term" structure of our incentive mechanism: Ederer and Manso (2013) find that long-term (vs. short-term) reward is able to motivate what they call "exploration", that presents similarities with our open creativity (whereas "exploitation" resembles closed creativity).

[24] In Appendix B, we present some examples of the creative responses made by the participants.

[25] Of course, it may also be possible to "crowd-in" intrinsic motivation. For example, Charness and Gneezy (2009) found strong effects from paying students to go to the gym multiple times and exercise. The main driver of this result was that people who had not previously been regular gym attendees continued to go to the gym after the payment period had ended.

We use subjective measurement (participants and external judges' evaluation) together with objective measurement. When judges are free to evaluate the degree of creativity of the answers with no indication of which criteria to follow, they appear to effectively share certain objective principles, but also focus on something that is idiosyncratic and therefore difficult to capture. Interestingly, our findings suggest it is the latter component that is more reactive to financial incentives.

Implications for innovation

A natural consideration for economists is the implication of our findings for innovation.[26] Patents have been used to prize innovators through the creation of (temporary) market power, yet there is a debate focused on the tradeoff between the gains generated by innovation - with the consequent need to provide incentives for stimulating R&D investment - and the costs of patent monopoly power (Gilbert and Shapiro, 1990). Following Kremer and Glennerster (2004)'s taxonomy of government interventions, the patent system is the more familiar "pull" program; these pay off only if an innovation is developed, whereas "push" programs subsidize the search for a socially-desirable innovation - such as a vaccine - whether or not the search is successful. Kremer and Glennerster advocate a monetary prize large enough to get the attention of the pharmaceutical companies and have them investing in the discovery of a new effective vaccine.

For what concerns the internal organization of a firm (such as the way that research activities are financed, the allocation of control over the R&D process, the specific share of property rights on innovations, and the structure of the monetary compensations to the inventors and to the managers responsible for corporate R&D) has been shown to contribute to shaping the frequency and size of innovation (e.g. Aghion and Tirole, 1994; Lerner and Wulf, 2007).

[26] Our results also offer implications for incentivizing artistic and musical creativity, topics of interest to economists.

We find that providing incentives can indeed have favorable effects for innovation when the goal is already delineated, as is often the case with incremental innovations. On the other hand, drastic innovations are typically less defined *ex ante*. In a similar vein, Hellmann and Thiele (2011) provide a theoretical model that shows that incentive contracts are feasible for those tasks that are well understood and measurable *ex ante*. To the extent that drastic innovations map onto what we have termed an open task (and people are not too ambiguity-averse), direct incentives seem unnecessary. Instead, firms and governments may wish to simply support or subsidize basic research, which is executed without any specific applications or products in mind.[27] Since innovation involves the exploration of untested approaches that are likely to fail, incentive schemes that punish failures with low rewards and termination may have adverse effects on innovation: as shown by Manso (2011), the optimal incentive scheme that motivates innovation should exhibit substantial tolerance for early failure and reward for long-term success.

7. Conclusion

Creativity is a main driver of the world's economy. Without creativity in areas such as science, technology, and the arts, our lives would be considerably poorer economically and aesthetically. From an economist's standpoint, one critical question is whether it is possible to incentivize creativity. We investigate whether incentives for performance can lead to higher levels of creativity at the individual level. To the best of our knowledge, we are the first to explore theoretically and experimentally how the effect of financial incentives on creativity can vary across types of creative tasks.

[27] Basic research lays the foundation for advancements in knowledge that lead to applied gains later on, occasionally as a result of unexpected discoveries.

We consider individual creativity in a laboratory environment. When a task is *closed*, i.e. delineated with specific *ex-ante* goals, we find evidence that in fact it is possible to successfully induce a higher degree of creativity with financial incentives. This result is applicable to a wide range of economic environments, particularly when a clear need has been identified. However, we find no evidence that paying for performance induces creativity that is relatively unconstrained and non-goal-oriented (except with a high degree of ambiguity aversion). In this case, performance incentives appear to be ineffective. Perhaps the best that can be done to achieve creativity in these realms is to create a research environment where funds are available as needed for talented researchers. This seems preferable to having competitions for research grants, as this latter approach seems much more conducive to incremental advances.

We have scratched the surface on the relationship between incentives and creativity, and there is more work to be done. For example, how do people select into creative versus non-creative activities? This cross-person variation is likely to be an important part of the creativity production function.[28] Nevertheless, we at least offer some novel and insightful results. We provide clean theoretical predictions and experimental evidence concerning the impact of financial rewards on two forms of creativity, which certainly points to the need for further research on this important issue.

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[28] We thank John List for this comment.

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Appendix A

Taxonomy – verbal closed task

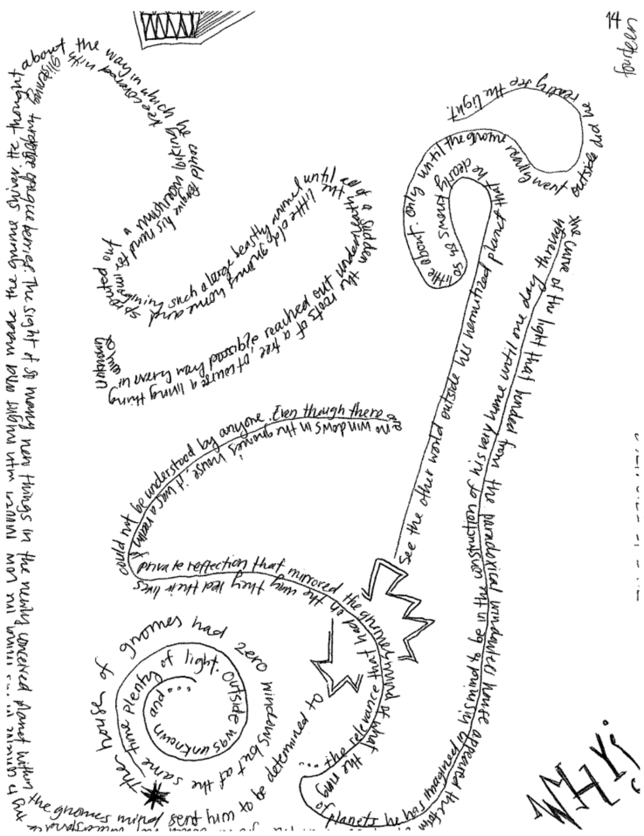
Word / Meaning	Score	Word / Meaning	Score
House		**cow**	
1. residence building	1	1. female bovine	1
2. verb: keep in a dwelling	2	2. figurative: unpleasant/fat woman	2
3. verb: provide a storage place	3	3. figurative: person who eats a lot	3
4. family/household	4	4. others	10
5. shelter	5		
6. legislative body	6	**tree**	
7. members of a college	7	**meaning**	
8. convent, abbey, church	8	1. plant	1
9. others	10	2. diagram	2
		3. tree-like shrub	3
zero		4. tree-like stand	4
1. number	1	5. others	10
2. figurative: starting point, absence	2		
3. figurative: unimportant person	3	**planet**	
4. verb: change to zero	4	**meaning**	
5. others	10	1. Mars, Venus…	1
		2. others	10
forgive		**ring**	
1. pardon/stop resenting	1	1. jewelry worn on finger	1
2. cancel a debt	2	2. circular band	2
3. others	10	3. sund of a bell	3
		4. circular shape	4
Curve		5. verb: sound of a bell/telephone	5
1. line or form that bends	1	6. verb: draw a circle around	6
2. bend in a road	2	7. circle of people/objects	7
3. verb: bend, not be straight	3	8. arena for circus/boxing	8
4. others	10	9. cooking hob	9
		10. others	10
Relevance		**send**	
1. effect, connection	1	1. cause to go/deliver	1
2. others	10	2. emit	2
		3. informal: delight	3
		4. others	10

Taxonomy – math closed task

Operations	**School level**	**Score**
+ , - , * , : , fractions	Elementary	1
exp, log, roots, equations, inequalities	Secondary (Middle and High)	3
integral, factorial, matrixes, trigonometrics, limits, derivatives	University	6
Others		10

Appendix B

B1: Example of an answer to the closed task (verbal)



B2: Example of an answer to the closed task (math)

$\boxed{7}$

$$\Big[27 - \sum_{i=2}^{5} \int_0^{\pi} i \sin(ix)\,dx \div \sqrt[3]{27} - \prod_{i=2} (3i) + \frac{25}{5^2} \cdot \frac{7}{2}$$

$$+ \int_0^{\pi}\int_0^{i}\int_0^{3} x^2\,dx \cdot \frac{1}{i\pi} - (8^2)^{1/3} + \cos(\sin(\cos(\tfrac{\pi}{2}))) -$$

$$i^{2} \cdot \frac{1}{i^2} - \log\left[\left(\lim_{x\to\infty} \frac{x^3 - x^2 - 1}{x^3 + x^2}\right) \Big/ \left(-\frac{2}{7} \cdot \frac{14}{3} \cdot \frac{6}{4}\right)\right] +$$

$$\frac{\partial}{\partial x} f\left(x^7/7 - x^6/6\right)\Big|_0^1 \cdot \sum_{i=1}^{\infty} \int_0^{\infty}\int_0^{\theta}\int_1^{\frac{\phi - x^2}{2}} \rho^2 \sin\phi\, e^{\phi - 1}\, d\rho\, d\phi\, d\theta -$$

$$\lim_{t\to\infty} \int_0^{t} e^{\left(x^2 - \ln x^e / e^{i \cdot 2} + \frac{\partial}{\partial\phi} f(x\phi)\right)} dt \cdot \frac{1}{t} + 10 \Big]^{-1/2} \cdot 2^3 +$$

$$\Big[\int_0^{\pi/2} \sin\theta\, d\theta + 5/2 + \frac{17}{6} \cdot \frac{18}{51} + 0.5 \Big]^2 - e^{\ln 4}$$

$$- \sqrt{\sqrt{\sqrt{i^6}}} \cdot \frac{6^{-2}}{6^2} + e^{\infty^{1/2}} = 6 \checkmark$$

C3: Example of an answer to the open task

(1) Question 1

If I had the talent to invent things by just thinking of them, I would invent a certain kind of peanut butter jar that would allow you to get more peanut butter out of the jar and not wasting any. The jar would have a twisty bottom (if you think of the bottom of a deodorant, it's basically the same concept). When you twist the bottom of the jar, the peanut butter gets pushed up to the top, making it easier to reach with a knife or spoon. I think we can all agree that when we throw away a peanut butter jar, there's always some left in it, but with the twisty bottom, you get more out of the jar than you did before and waste less. Plus, the last bit of peanut butter in the jar is always a struggle to get out — but wouldn't be with the twisty bottom

The same concept can be used for mayonaisse :)