Creative Production and Exchange of Ideas[*]

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Abstract

This paper explores how exposure to the ideas of others is embraced in creative-process technology. We report evidence from a two-stage real-effort lab experiment, in which subjects perform creative idea-generation tasks. In the first stage, we control whether the output of other players is observed; this design allows us to quantify the effect of new ideas on creative productivity. In the second stage, we make ideas costly and elicit the subjects' willingness to pay for them. We characterize investment behaviour in this creative environment by comparing expected monetary benefits from increased productivity to the cost of exposure. Our results show that observing output of others boosts productivity in creative tasks, but only when it discloses previously unknown items and the output of low creative-ability players is not found to be beneficial. When ideas become costly, subjects do not act in a profit-maximizing way. We find that they pursue lower costs and systematically overinvest in output of less creative players. This effect is more pronounced for females, risk-averse, more self-confident subjects and those of lower creative ability. As ideas of less creative participants are rarely original, this behaviour does not lead to the highest possible level of creative production in aggregate.

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1 Introduction

This paper explores experimentally the relationship between creative productivity and exposure to the ideas of others. The understanding that interactions lead to higher productivity has been widely supported by organizations[1]. The belief that being in touch with more people is beneficial for job performance shapes a new corporate trend. New tools for professional communication emerge and flourish (e.g., webinars, ideas.repec.org, LinkedIn). Firms actively use secondments, regular staff catch-ups, open plan office design and common spaces to foster interaction and exchange of ideas[2].

Modern network literature also lists exchange of ideas among the plausible explanations of higher productivity (Ductor *et.al.*, 2013). Network analysis of creative professionals in different fields suggest that more productive individuals are at the same time more connected and central in their networks (Goyal *et.al.*, 2006 describe the network of academic authors, and Burt, 2004 and Cross et.al., 2008 the networks of managers). However, this evidence comes from exogenously formed networks and does not guarantee that connections cause productivity (Manski, 1993; Moffit, 2001). If more productive individuals are also more proactive in reaching people, we would observe the same network patterns.

Understanding as to whether access to new ideas leads to higher creative productivity is insightful. An answer to this question may serve as an argument for or against teamwork, promoting interactions at the workplace or making privileged information publicly available[3]. Furthermore, as interactions involve substantial costs (in terms of money or time) in many cases, examining whether people over- or underpay for them can advocate or criticize different forms of policies intended to encourage exchange of ideas. We use the tools of Production Theory and Experimental Economics to address these questions in this paper.

For the purpose of this study we narrow the definition of interaction to its principal attribute - exposure to new ideas - and explore how it is embodied in the creative-process technology. We view idea generation as a production process and exposure to new ideas as a production factor. Using the evidence from a two-phase real effort experiment, we quantify the effect of exposure to ideas on productivity and analyze individuals' willingness to pay for ideas.

We set up a simple creative environment in the lab, in which subjects perform

[1] "A key purpose of the workplace is for sharing ideas including enhancing your product and service offerings, this won't happen by shutting people away," states Matt Oakley, Chairman of the Research Committee of the British Council for Offices.

[2] In addition to exchange of ideas, workplace interactions have many attributes, which are not considered here. Examples include an opportunity to get helpful feedback, find potential collaborators or simply the motivational impact.

[3] The US Patent and Trademark Office publishes every patent application "promptly after the expiration of a period of eighteen months from the earliest filing date for which a benefit is sought under title 35, United States Code" (USPTO, Patent Laws, Regulations, Policies& Procedures).

the Torrance's idea generation task (Torrance, 1974). In different treatments we vary (i) whether or not players observe output of other subjects, and (ii) whether participants are showed the output of a randomly assigned peer or given an opportunity to acquire the output of a peer they choose. We measure creative output as a number of conceptually distinct ideas generated and intensity of the treatment as a number of new ideas observed.

In Phase I our pool of experimental subjects is randomly split into two groups: Treatment and Control. All subjects face the Torrance's idea generation task. In the course of the experiment, the Treatment group is exposed to new ideas, while the Control group is not. By comparing the creative output of these two groups we quantify the effect of exposure to new ideas on productivity. In Phase II we make exposure to ideas costly. Following our hypothesis that exposure to new ideas increases creative productivity, we interpret a decision to acquire ideas as an investment decision. Subjects are given a menu of randomly chosen players, whose ideas can be observed. Our participants are free to pick none, one or more subjects from this menu. Each available player is characterized by the number of ideas she has and the connection price, where the price is an increasing function of a subject's output. We explore the role of own creative ability and some behavioural and demographic characteristics on investment behaviour.

We find that being exposed to new ideas leads to a substantial productivity increase, as our Treatment group produced 20% more original ideas than our Control group. But not all ideas are helpful: output of low creative-ability players is not beneficial for creative productivity. This finding is consistent with multiple creative stimuli mechanism, where a new idea is born as a combination of several existing ones (Nijstad and Stroebe, 2006). If a subject does not observe a new concept, no new combination is produced.

When ideas become costly, subjects do not act in a profit-maximizing way. They systematically overestimate benefits from connections to low creative-ability players and underestimate potential benefits from the ideas of high creative ability participants. When seeking for lower costs, subjects choose to buy ideas from overly low creative-ability players, which are unlikely to help in generating creative output. This effect is more pronounced for females, subjects with a higher degree of risk aversion or self-confidence and those of lower creative ability. This evidence warns that despite the high benefits that exchange of ideas have for creative productivity, endogenously formed interaction patterns do not ensure the highest returns. When costs of interaction are assumed by the subjects, the most creative players are rarely reached and potential benefits from these interactions are never released. In this light, any external impulse to exchange ideas would be beneficial and desirable for the society.

This study contributes to the experimental literature on creativity, which is mainly dedicated to exploring the effectiveness of financial incentives to stimulate creative performance (e.g. Eisenberg and Rhoades, 2001; Kachelmeier *et.al.*, 2008; Charness and Grieco, 2012; Bradler *et.al.*, 2013). Departing from sociological work on group brainstorming (Paulus and Yang, 2000; Dugosh *et. al.*, 2000; Nijstad *et. al.*, 2002), we carefully design an experiment to explore the creative-process technology in economic context. We quantify the effect of exposure to new ideas, explore the determinants of investment behaviour and characterize endogenously formed connections in a simple creative environment. To the best of our knowledge, this paper is the first attempt to consider the technology of creative process from the point of view of production theory and to evaluate the efficiency of investment decisions in a real-effort creative task.

The reminder of the paper is organised as follows. Section 2 describes the most common ways to measure creativity and the creative environment used in the experiment. Section 3 describes the experimental design. The estimation strategy is described in Section 4, followed by Section 5 reporting our results. Finally, Section 6 concludes by listing possible applications of our findings and outlines guidelines for further research.

2 Creative Environment

2.1 Background

While it is widely accepted that creative process constitutes a basis for innovation, there is no commonly established way of defining what creativity is. Meusburger (2009) reckons that over a hundred different analyses can be found in the literature. Some authors argue creativity is a mind skill, while others consider it a process equipping us to make a new idea. The most habitual way of describing creativity is the production of ideas, solutions or products that are novel (i.e., original) and appropriate (i.e. useful) (Amabile, 1996; Shalley and Perry-Smith, 2001; Mumford, 2003; Byron and Khazanchi, 2012). Departing from this generally accepted understanding of the creative process, this paper considers creative productivity from the point of view of Production Theory. Fusing productivity (output per unit of input) and creativity (production of new) definitions, we shall consider creative productivity to be a variety of new outputs produced with homogeneous inputs.

The literature describes two broad approaches to creativity measurement in the lab. The first approach relies on expert assessment of the *quality* of creative output, in other words, how interesting, original or rare a given idea is. This approach is usually used in non-quantifiable creative tasks. Examples of these tasks include, but are not limited to, thinking of the title for a story (Eisenberg and Rhoades, 2001), developing rebus-puzzles (Kachelmeier *et.al.*, 2008), finding a way to apply mathematical operations to achieve a given result or composing a story (Charness and Grieco, 2012). The second approach is based on a standard test of creative ability (e.g. The Torrance's Test of Creative Thinking) as in Bradler *et.al.* (2013). This approach allows both the *quantity* and *quality* sides of creativity phenomenon - how many ideas are suggested and how original they are – to be taken into account.

Following our definition of creative productivity, in our idea-generation task we propose to measure creative output as the number of conceptually different ideas generated by an individual. This measurement of creative productivity does not account for quality or objective originality of ideas once they pass the minimum requirement of being distinct from each other. Despite any possible variation in the quality of creative output defined in this way, we believe that in a properly incentivized idea-generation task, the number of distinct ideas provides a reliable measurements of an individual's overall creativity. Our decision to exclude the quality component from our measurement is motivated by the following considerations. First, quantity and quality of ideas in idea-generation tasks are shown to be positively correlated (Stroebe and Diehl, 1994). Ideas generated by more productive participants, on average, are also more elaborated and original according to the experts. Second, quantity incentives induce higher quality (Kachelmeier *et.al.*, 2008). Incentive schemes based on the quantity of creative output result in higher average quality than incentive schemes contingent on both quantity and quality. Third, scoring procedures relying on expert opinion are time- and effort-demanding, which makes them less suitable for conducting in the lab. Furthermore, expert assessment can produce noisy results and may seem to lack in transparency to the participants.

Finally, quantity incentives are straight forward to conduct in the lab. Such incentives are easy to explain as the connection between payment and observable output are very transparent. Unlike in the case of quality, targeting quantity does not lead to any perverse incentives when subjects differ in their expectations regarding expert opinion. Output measurement takes little time, reducing the waiting time between the end of experiment and payment to participants.

2.2 Experimental tasks

Our experiment is based on the Torrance's Test of Creative Thinking (Torrance, 1974). The Torrance's Test of Creative Thinking (TTCT) is a widely used in Psychology to test creativity and other problem-solving skills, and the validity of which has been confirmed in a large number of studies (Kim, 2006). Originally, performance in TTCT tasks is scored on four scales: (i) *fluency*, or total number of items produced, (ii) *flexibility*, or the number of different categories of relevant responses, (iii) *originality*, or statistical rarity of the responses and (iv) *elaboration*, or the amount of detail. In our experiment, the scoring procedure is modified to depend only on the number of valid answers.

We use two tasks from TTCT: the graphic task (task A in our design) and the unusual uses or verbal task (task B). Both tasks are not time consuming and do not require any particular skill or background, which makes them appropriate for the lab. These tasks capture a central element of applied business innovations: the fact that most successful innovations present a clever application of an existing idea or process in a new context (Bradler *et.al.*, 2013). The experimental tasks are described in detail below.

2.2.1 Task A (Graphic Task)

Participants are given a sheet of paper that contains the same repetitive workpiece (a geometric form). The task is to sketch as many *conceptually different* objects as possible, which would incorporate given geometric elements.

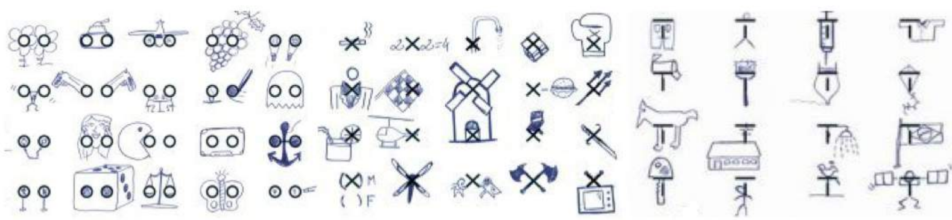


Figure 1. Examples of creative exercise, task A

Figure 1 shows several valid examples of outputs corresponding to the different geometrical forms used in the experiment: circles, crosses and Ts. For example, two circles can be used to sketch two flowers, a car or a tyre. Creative output is measured as the total number of distinct drawings produced within a prescribed time.

2.2.2 Task B (Verbal Task)

Participants are shown a picture of a commonly known object and asked to list as many *conceptually different* alternative uses for that item as they can. Creative output is measured as a total number of the different alternative uses for the object suggested. Common use, if listed, was not included in the creative output measure.

Table 1. Examples of creative exercise, task B

Pillow	Brick	Pen	Newspaper
			
- a Teddy-bear - to fake pregnancy	- hold the door - fake gold ingot	- hair-pin - Martini straw	- fly-swat - PC mouse carpet

Table 1 contains several valid alternative uses for the objects used in the experiment: pillow, brick, pen and newspaper.

3 Experimental design

3.1 General procedures

The experiment was conducted in 15 sessions at the LaTeX laboratory at the University of Alicante. Each session was based on one of the tasks (Task A or Task B) with each subject participating only in one session. Our sample was based on 181 participants: 52 subjects participated in the Task A[4] sessions and 129 in the task B[5] sessions. The subjects were randomly selected from the laboratory's pool of undergraduate students willing to participate in the experiments and then randomly assigned to the Treatment and Control sessions corresponding to each task.

Treatment sessions consisted of two phases: Phase 1 (Creative Production) followed by Phase 2 (Investment). Phase 1 was designed to test experimentally whether observing creative output of others helps an individual to come up with more ideas. Phase 2 was aimed at analyzing investment behaviour when ideas are costly.

In the Treatment sessions, the size of final payment was determined at the end of the experiment by the results of a randomly selected phase. In the Control sessions, participants performed only the first, the Creative Production phase, and were paid accordingly. The average payment received in the experiment was €9.5 per hour[6].

At the beginning of each session, a printed copy of the instructions was handed out to every participant and read aloud[7]. Upon completing the experimental tasks all participants were asked to complete a brief questionnaire on their basic socioeconomic and demographic background. Table 2 resumes the general structure of the experiment.

Table 2. Timeline of the experiment

Time	Treatment Group		Control Group
	Task A	Task B	Tasks A and B
stage 1: 00:00-06:00	TTCT	TTCT	TTCT
	Access to ideas of others:		
	two relevant ideas	other player's output	∅
stage 2: 06:00-10:00	TTCT	TTCT	TTCT

Each phase lasted exactly 10 minutes, during which time subjects performed one of the creative tasks. A phase comprised two stages: stage 1 lasted 6 minutes and stage 2, 4 minutes. Stage 1 procedures and conditions were identical across all Treatment and Control sessions: participants had to generate as many different ideas as possible

[4]30 in the Treatment group (3 sessions) and 22 in the Control group (2 sessions)
[5]60 in the Treatment group (4 sessions) and 69 in the Control group (6 sessions)
[6]Treatment sessions: 13.6 EUR, Control sessions: 6.7 EUR on average
[7]Full instructions for the experiment can be found in the Appendix.

in the framework of the creative task. In stage 2 subjects in the Treatment sessions had access to the ideas of others, while subjects in the Control sessions did not[8]. Our design is absolutely identical for the Treatment and Control session in all respects except for the fact that subjects in Treatment group are exposed to new ideas while subjects in the Control group are not. Thus, any difference in creative output between Control and Treatment groups can only be explained by exposure to the ideas of others.

Despite the similar general structure, Tasks A and B bear significant differences with respect to access to the ideas of others. The ideas shown to the participants in Task A came from an 'ideas bank', which is an exogenously formed pool of ideas. Unlike Task B, Task A ensures that participants observe new ideas in Stage 2. In Task B design ideas come from another subject in the lab, e.g. from an endogenously formed pool of ideas. There is no guarantee that these ideas do not coincide with the ones that the recipient has already thought of.

Task A design allows the pure effect of exposure to ideas to be studied. Task B is more restricted in the sense that the number of new ideas available to each subject is then only quasi-random. Despite the random matching, the number of new ideas depends on the recipient's creative ability, as more creative participants are less likely to receive an item they have not thought of. This, more realistic in some sense, setting allows us to explore investment behaviour more deeply. Sections 3.2 and 3.3 describe the experimental procedures corresponding to each task in detail.

3.2 Task A (Graphic task)

3.2.1 Creative production (Phase I)

After the instructions have been read, the subjects receive a sheet of paper with a repetitive geometric form similar to the one depicted in Figure 1. Participants are given 10 minutes to sketch as many different objects incorporating this form as possible.

The phase is split into two stages: Stage 1 (first 6 minutes) followed by Stage 2 (last 4 minutes). To distinguish between output produced during the two stages, subjects are asked to change the colour of the pen they were using while sketching. Control group participants are not given any additional instruction between stages. Treatment group participants are interrupted twice once the first stage is over. Each subject receives two envelopes with one relevant drawing each. The first envelope is received at the beginning of the 7th minute of the task and the second envelope at the beginning of the 9th minute.

The drawings shown to participants are based on the same geometric form that participants have in their task. All examples are taken from an 'ideas bank' and are

[8] Six minutes were enough to state all the ideas that the subjects had. Only two participants reported that they still had not mentioned ideas when the second stage started.

the set of the most uncommon drawings produced in a non-paid preliminary stage by a team of 9 graduate students. To make sure two new drawings are shown, an example is changed in case a subject has already sketched a similar object.

Subjects are encouraged to develop their own ideas and not to copy examples by considering only distinct (from each other and from examples provided) drawings for payment. Control group participants are paid €0.25 per drawing and the Treatment group €0.5 if this phase is chosen for payment.

3.2.2 Investment (Phase II)

In Phase 2 acquisition of relevant examples becomes costly. Only the Treatment group is subject to this part since these subjects, in contrast to the Control group, have experienced the benefits of observing new ideas and possess more information to make informed decisions.

The experimental procedures have the same structure as Phase 1 with one exception, that the envelopes are now *sold* to the subjects willing to pay the price. Prices range from €0.5 to €3 per example and are randomly assigned and privately communicated to the subjects.

In case this phase is chosen to be paid, the participants receive €0.5 for each conceptually different drawing minus the total investment cost (if occurred).

3.3 Task B (Verbal task)

3.3.1 Creative production (Phase I)

Similarly to Task A, in Task B some participants are exposed to the ideas of others, while the others are not. All Task B sessions are computerized[9]. After reading the instructions, the participants see on their screens a well-known object and are given 10 minutes to type as many unusual uses for this object as they can.

Figure 2a. Task B, Stage 1

[9]The experiment was programmed and conducted using z-Tree software (Fischbacher, 2007).

As in Task A, Phase 1 consists of two consecutive stages: Stage 1 (6 minutes) and Stage 2 (4 minutes). Figure 2(a) shows the Stage 1 user interface. Unusual uses suggested by a subject are numerated and shown on the screen together with total number of items and the earnings they would get so far.

Figure 2b. Task B, Stage 2

Figure 2(b) shows the Stage 2 user interface. At minute 6, each subject in the Treatment group is randomly matched to another participant. All the items suggested by her partner during Stage 1 appear on the screen. The matching is not symmetric, e.g. it is not necessarily the case that two subjects observe the ideas of each other. The Control group participants are not shown any new information and just have 4 additional minutes to perform the same task.

The payment scheme is exactly the same as for Task A: the Control group participants receive €0.25 for each conceptually different item; The Treatment group participants are paid €0.5 for each unique item if this phase is chosen to be paid.

It is not possible to ensure in the computerized that all the ideas observed by the participants are new to them due to technological restrictions. Several people often come up with several similar ideas, particularly at the very beginning of the phase. Thus, a part of output shown to the subjects sometimes duplicates their own output, in other words, not all ideas are new to the subjects.

3.3.2 Investment (Phase II)

As in Task A, Phase 2 introduces the costs of obtaining access to new ideas. However, unlike in Task A, subjects can choose their partner. When participants reach minute 6, they are randomly split into groups, each consisting of five people. Each group member has an opportunity to buy access to the Stage 1 output of her group members.

Figure 3 shows the Stage 2 user interface. Each subject is shown a table with a menu of possible contacts available to her. Each potential contact is characterized by a pseudonym, number of items produced in Stage 1 and contact price. To make contacting more creative individuals more expensive, the price is proportional to the partner's output in Stage 1 (equal to Stage 1 production divided by 10). In our sessions, prices ranged from €0.5 to €2.6 per connection.

Figure 3. Task 2, Phase II

The subjects have to select the corresponding line and press the button "Contact" to see the output of a group member. The participants are free to make one, multiple or no contacts at all. The decision to acquire the output of others can be made at any point in time until the end of Phase 2. In the case that the stage is chosen for payment, the participants are paid €0.5 for each unique item minus the total cost of investment in contacts they have made.

3.3.3 Risk and self-assessment

Self-assessment and risk attitudes are elicited from incentivized behaviour and all the other characteristics are taken from the questionnaire and are self-reported.

In Task B, all the participants assess their own creative ability with respect to the performance of others. Between Stage 1 and Stage 2 of Phase 1, individuals are asked to guess how many participants in their session have come up with more items than themselves. Quadratic scoring rule is used as an incentive scheme: the participants who have guessed correctly receive €1.5, and the less precise the guess is, the less money is paid.

Risk attitudes are elicited with the help of the Hey and Orme (1994) procedure in 24 rounds once the main experiment is over. In addition to other experimental earnings, the subjects are paid the outcome of one of 24 rounds selected at random. See Appendix for procedures.

4 Creative Productivity

This section outlines our estimation strategy to quantify the effect of new ideas on creative productivity in our experiment. Furthermore, departing from these results, we develop a simple econometric model that allows us to analyze the subjects' decisions regarding acquiring ideas of other players. We also discuss these investment decisions in the context of networks, where each connection is represented by a directed link between these two players.

To draw conclusions on the importance of new ideas we shall compare average outputs produced by treatment and control groups during the last four minutes of each stage. Under the design described in Section 3, during the first six minutes of the creative task there was no possibility to access the ideas of others and all participants had no other resources than their own creative ability. During the last four minutes, however, the treatment group observed several ideas belonging to others. In contrast to the control group, these participants received additional information, which might constitute an important input for creative production.

Under the presumption that any single idea generated by an individual represents a combination of different pieces of information available to her, only new information might stimulate generation of new ideas. Learning an idea, which is not currently in the individual's stock, adds a new element to her information set. This permits creation of new (unavailable before) combinations of information, which in turn might convert to new ideas. Observing items that are already contained in the individual's stock of ideas will not amplify her information set and cannot stimulate generation of new ideas. In what follows we call these new, potentially beneficial items *'Relevant'* ideas for a given individual. Note that Relevance here is a relative concept, as the same idea may be relevant for one individual and at the same time irrelevant for another.

4.1 New ideas and Creative Production

Let $N = \{1, 2, ..., n\}$ be the set of creative producers, where i is a member of this set. Let producer i be endowed with creative ability $c_i \in [0, \infty)$. This creative ability reflects an average speed of idea generation when i has no access to any inputs. Denote as y_i^{S2} the number of creative items i has produced during the last four minutes (stage 2) of a phase. Also denote g_i the number of *relevant* items i observes before stage 2.

For further analysis we model i's production during the last four minutes of the task as a linear function of her creative ability c_i[10]. If i belongs to the treatment group in addition to own creative ability, her production also depends on the number of relevant items available to her g_i. To estimate the relationship between the number of relevant items observed by i and the number of creative items she produces, we use the following functional specification:

$$y_i^{S2} = \alpha_0 + \alpha_1 c_i + d_i \times (\beta_0 + \beta_1 g_i) + u_i, \tag{1}$$

where d_i is a dummy equal to 1 for all i that belong to the Treatment group and equal to 0 for i in the Control group, $u_i \sim N(0, \sigma_u)$ is an error term, α_0, α_1, β_0 and β_1 are the parameters to be estimated.

Even though true creative ability c_i is not observed, we can use the number of items produced by i during the first six minutes of the task, y_i^{S1}, as a reliable proxy.

[10]We tested for potential non-linear effects and the results indicate that a linear model fits the data better.

At this stage there is no other factor influencing productivity, meaning that the final output must be highly correlated with individual's creative ability.

As explained at the beginning of this Section, the number of relevant items, g_i, is individual-specific. In what follows we explain our approach to its assessment.

Verbal task

As described in the experimental design, at the beginning of Stage 2 individual i is randomly matched to individual j. As the result of this interaction i observes y_j^{S1} items - all j's output generated during the first six minutes of the task (Stage 1). However, it is not necessarily true that all y_j^{S1} items are relevant to i: $g_i \leq y_j^{S1}$.

Under random matching and assumption of finite set of all possible ideas, it must be true that the number of ideas relevant for i is positively related to the size of j's set of ideas, while negatively related to the size of own idea set. In other words, the probability that a randomly chosen j's idea is relevant to i increases with the number of ideas j has and decreases with the number of ideas i has. To take into account these considerations we shall approximate the number of relevant ideas i receives from interaction with j with the function increasing in y_j^{S1} and decreasing in y_i^{S1}.

$$g_i^j = \frac{y_j^{S1}}{y_j^{S1} + y_i^{S1}} * y_j^{S1} \tag{2}$$

We choose to use (2) to assess the number of relevant ideas i gets from interaction with j due to its simplicity and intuitivity[11].

Graphic task

The design of the graphic task is such that the examples are taken from the 'ideas bank'. It assures two relevant examples for each treatment group participant, in this case g_i is exogenously set and does not depend on an individual's or partner's creative ability: $g_i = g = 2$ for any i.

In the described setting, the number of relevant ideas player i observes - g_i is the only variable input for the production of ideas. An individual's ability to create c_i constitutes an individual-specific production technology. The identification of (1) is possible due to [twice] random assignment: (i) random assignment of the participants to the treatment or control group and (ii) random matching between individuals in the verbal task. Since the creative abilities of the matching partners are uncorrelated, the true causal relationship can be estimated.

If we find the estimate $\hat{\beta}_1$ to be positive, we would interpret it as a positive effect of observing relevant ideas on own creative productivity. In turn, it would mean that there are non-zero benefits of exposure to the ideas of others on aggregate output. We expect the constant treatment effect $\hat{\beta}_0$ to be equal to zero if only relevant ideas are useful for creative production. The opposite would mean that a constant treatment effect exists independent of the number of relevant ideas the players observe.

[11] (i) The probability of relevance approaches 1 as y_j^{S1} goes to infinity or $y_i^{S1} = 0$; (ii) it is equal to zero when $y_j^{S1} = 0$ or y_i^{S1} approaches infinity.

4.2 Investment decisions

4.2.1 Yes/no decision

Once the impact of new ideas on creative productivity is estimated, we can draw an inference about the increase in potential productivity that a new idea brings. For any pair of producers i and j, we will be able to assess a number of additional items i should expect to produce if she observes j's items.

Denote λ_i^j the expected number of new ideas i produces when she observes j's output. We can assess the expected value this connection brings to i as:

$$E(\lambda_i^j) = \hat{\beta}_0 + \hat{\beta}_1 g_i^j$$

where $\hat{\beta}_0$ and $\hat{\beta}_1$ are the OLS[12] estimates of equation (1) and g_i^j is given by (2).

Conceptually, λ_i^j represents i's *opportunity cost of investment* in j's ideas. If i is a payoff-maximizer, λ_i^j would represent the maximum price she is willing to pay to observe the output of j.

Let P_i^j denote the price i must pay to access the ideas of j. The net benefit i receives from connection to j, π_i^j, is given by the difference between expected output increase and the price:

$$\pi_i^j = \hat{\beta}_0 + \hat{\beta}_1 g_i^j - P_i^j$$

Let x_i be a binary variable representing i's investment decision: $x_i = 1$ when i decides to acquire someone's ideas in the second stage and $x_i = 0$ otherwise. An investment is beneficial only when it brings positive net profits. We estimate the following equation to infer if on average the investment decisions in our experiment are beneficial to the producers (rather than loss-making):

$$x_i = \gamma_0 + \gamma_1 \lambda_i^j + \gamma_2 P_i^j + v_i, \tag{3}$$

where $v_i \sim N(0, \sigma_v)$ is an error term, γ_0, γ_1 and γ_2 are the parameters to be estimated.

If producers make beneficial investments, the costs and benefits of the connections have the same weight for the investment decisions and we should observe $\hat{\gamma}_1 = -\hat{\gamma}_2$. If, instead, $\hat{\gamma}_1 > -\hat{\gamma}_2$, data would indicate that expected benefits, on average, outweigh price effect in the investment decision process, and the producers are willing to carry out loss-making investments. Regarding the constant term, we should find $\hat{\gamma}_0 = 0$ if investment decisions are not systematically influenced by factors other than costs and benefits of connections. Instead, for example, if subjects derive some utility from interactions, we may observe our constant term being positive[13].

[12] Estimating (1) with Tobit gives identical to OLS results. Although theoretically bounded below zero, in practice the dependent variable is equal to zero in less than 1% of the cases.

[13] Note that if the constant is zero, the degree of risk aversion should not influence investment decisions. Any utility function concave in monetary outcomes is maximized when expected net benefits from investment are maximized.

4.2.2 Partner selection

When, as in our verbal task, a producer has more than one investment possibility, the fact that an investment is not loss-making does not necessarily imply it is a net-benefit maximizing decision.

Imagine producer i can choose between two potential connections (partners): producer j (with y_j^{S1} items) and producer k (with y_k^{S1} items). According to our design, the price associated to each of these connection is proportional to the number of items a partner has:

$$P^j = \alpha y_j^{S1},\ P^k = \alpha y_k^{S1}$$

where $\alpha \in (0,1)$ is an exogenously set positive coefficient.

If $y_j^{S1} \neq y_k^{S1}$, one of the producers will be expected to bring higher net benefits to i. A profit-maximizing producer i would choose to acquire output of j if the connection to j results in higher expected profits compared to k:

$$\hat{\beta}_1(g_i^j - g_i^k) > P^j - P^k \text{ and}$$

$$\hat{\beta}_0 + \hat{\beta}_1 g_i^j - P^j > 0$$

Having the estimate $\hat{\beta}_1$ from (1) is sufficient for determining a partner (group member) connection that maximizes i's expected benefits (or minimizes her losses). In what follows we refer to such profit-maximizing connection as *i's best partner*.

We use the Heckman Selection Model (Heckman, 1979) to characterize the partner selection in our experiment. The Heckman two-step procedure allows us to correct for selection bias, which can occur since we only observe the partners of subjects who decided to form connections. If the decision to form connections is not random, a simple OLS analysis of the partner selection would be misleading.

As explained earlier in this Section, i should form a connection only if she expects to receive positive net benefits from it. Since the best partner brings the highest expected profits, a profit-maximizing i will always chose her best partner among other available connections. Producers who expect to make losses from connection to their best partner should decide not to invest at all. This leads to the selection rule based on the best partner's profitability:

$$x_i = \begin{cases} 1 \text{ if } \hat{\beta}_0 + \hat{\beta}_1 g_i^{BP} - P_i^{BP} \geqslant 0 \\ 0 \text{ if } \hat{\beta}_0 + \hat{\beta}_1 g_i^{BP} - P_i^{BP} < 0 \end{cases} \tag{4}$$

where g_i^{BP} and P_i^{BP} are the number of relevant items and the connection price for i's best partner correspondingly.

When investment occurs ($x_i = 1$) we observe partner's creative output y_j^{S1} and can assess the number of relevant ideas i observes g_i^j. We use the following model to check whether producers indeed chose their best partners:

$$g_i^j = \delta_0 + \delta_1 g_i^{BP} + \theta X_i + w_i \tag{5}$$

where g_i^{BP} is the number of relevant ideas i's best partner has, $X_i = (X^1, ..., X^n)$ is a vector of i's individual characteristics, $w_i \sim N(0, \sigma_w)$ is an error term, δ_0, δ_1 and $\theta = (\theta^1, .., \theta^n)$ are the parameters to be estimated. δ_1 indicates the degree of similarity between best and chosen partner. $\theta = (\theta^1, .., \theta^n)$ is a vector of parameters that characterize the importance of individual characteristics for the partner choice. If the participants make profit-maximizing partner choice we should observe connection to the best partner ($\hat{\delta}_1 = 1$ and $\hat{\delta}_0 = 0$) and no effect of individual characteristics on the choice ($\hat{\theta} = 0$).

By examining vector $\hat{\theta}$ we will be able to highlight individual-specific factors that matter for connection choice. Our vector X_i is composed by behavioural (risk attitude, overconfidence) and demographic characteristics (gender, GPA, etc.) measured in the experiment or taken from questionnaire responses.

5 Results

In this section we report our estimation results. First, we report our average treatment effects in Phase I and conclude regarding the importance of new ideas for creative productivity. Second, we use these estimations to analyze the investment decisions of our participants in Phase II.

Participants were randomly assigned to a Treatment or a Control session. As expected, all observable demographic characteristics are similar across treatments: around 50% of the participants are females, the average age is 22.5 years old and the average GPA is around 66% in all groups. Average levels of creative ability measured as a total number of distinct items produced in Stage 1 are also similar across groups and sessions. There are significant differences in creative output between the tasks: participants produced 10.5 items on average in the graphic task, while the average production was lower, 9.4 items, in verbal task. We control for this difference in our estimations. The absence of significant differences ex-ante between control and treatment groups should imply that any differences in the output produced during the last 4 minutes is due to the unique variable attribute of the experimental design, exposure to the ideas of others.

5.1 Phase 1 - Creative Production

In both experimental tasks our design provides identical conditions for the Control and Treatment group participants during the first six minutes of the task. We use creative output produced at this stage, y_i^{S1} as a proxy for i's creative ability. In the second stage (last 4 minutes) there is just one difference between the treatments: the Control group participants do not have any access ideas of others, while the Treatment group participants do. If observing creative output helps to generate more ideas, we should find higher levels of output y_i^{S2} in treatment with access to the ideas of others.

Figure 4 shows our aggregate results graphically for each of the two experimental tasks.

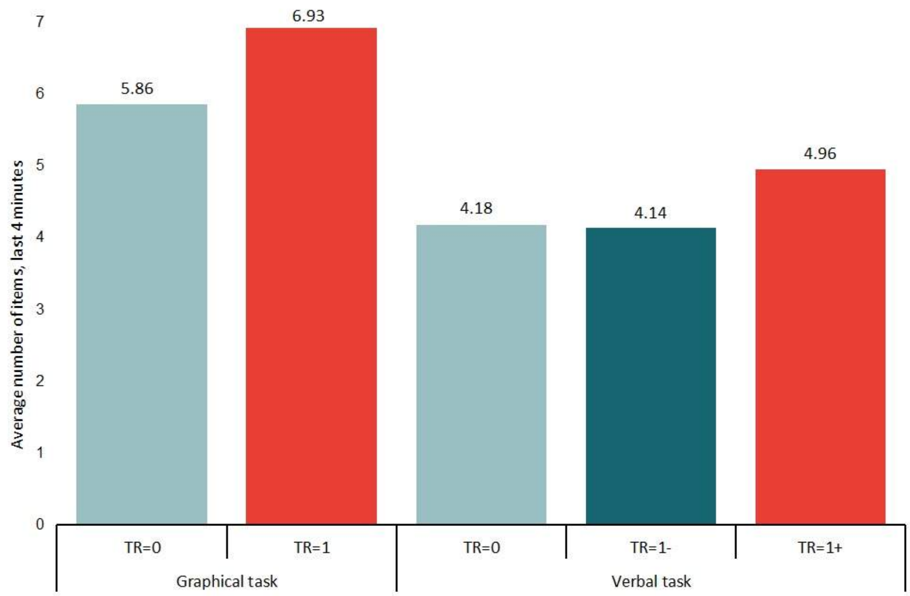


Figure 4. Treatment effects

On average, the treatment group (TR=1) produced more creative items during the second stage of the task than the control group (TR=0). In the graphic sessions the participants who observed two related pictures produced 1.07 items more than the control group participants (one-sided t-test, p-value 0.06). In relative terms, this result translates to a 20% increase in creative productivity.

Regarding the verbal sessions, a simple comparison between treatments might be misleading. The experimental design of the verbal sessions does not ensure a certain number of new items and being assigned to the treatment group does not necessarily imply exposure to new ideas. With the aim of a simple comparison, we divide treatment group participants in two groups. The first group (TR=1-) includes those participants whose randomly selected connection is less creative than a median participant, in other words, the number of ideas that these participants observe is less than the median number of items produced in the first stage of the task. The second group (TR=1+) comprises the individuals who observed output of upper-50% creative individuals.

If the ideas that are not new to a subject do not help to generate more creative items, we should expect to find higher production levels for the connections to high-creative ability players (as in TR=1+) compared to connections to low-ability players (TR=1-) or no connections at all (TR=0). Indeed, as Figure 4 shows, those connected to lower-than-median participants did not produce more than control group participants. Observing ideas of more creative than median participants (TR=1+) resulted on average in 0.78 extra items produced during the last four minutes of the creative task (one-sided t-test, p-value 0.07). This difference implies a 19% increase in creative productivity for those who observed more items. These findings are in line with our hypothesis on the uselessness of repetitive ideas. Only those who had access to a greater number of ideas were more likely to observe new ones and as a result could produce more of their own output.

Although these aggregate results are intuitive and easy to interpret, it should be noted that the creative output depends not only on the ideas of others, but also on the participants' own creative ability. Controlling for it may help us to obtain cleaner and more precise results especially if (as we assume in Section 4) the number of extra items produced is a function of the number of new ideas observed. More creative individuals are less likely to be connected to someone who could ensure many new ideas and their impact could be underestimated in aggregate comparison. We estimate average treatment effects controlling for creative ability to take this consideration into account. In what follows we summarize the results of our OLS estimation.

Table 3 contains the results of OLS estimation of creative production function given by (1):

$$y_i^{S2} = \alpha_0 + \alpha_1 y_i^{S1} + d_i \times (\beta_0 + \beta_1 g_i) + u_i,$$

The first column reports the estimation results based on the data from Task 1, the second column only on data from Task 2, and the third column relies on pooled data from both tasks. For a pooled estimation, we control for potential differences between the tasks by introducing a dummy for task 1 (graphic task), GR.

$$\begin{aligned} y_i^{P2} &= \alpha_0 + \alpha_1 y_i^{S1} + d_i \times (\beta_0 + \beta_1 g_i) + \\ &\quad GR_i + GR_i \times \alpha_2 y_i^{S1} + d_i \times GR_i \times \beta_1 g_i + u_i \end{aligned} \tag{6}$$

This equation does not contain the intersection term between GR and treatment dummy as it is perfectly correlated with $g_i \times GR_i \times g_i$ when g_i is constant across individuals as was the case.

Table 3: Average Treatment Effects

Dependent variable - number of items produced during the last 4 minutes

	Graphical	Verbal	Pooled
Creative ability (proxy)	0.446***	0.378***	0.378***
	(0.10)	(0.049)	(0.052)
Creative ability × task A dummy			0.678
			(0.104)
Treatment dummy		-1.049	-1.049
		(0.692)	(0.74)
Relevant items observed (expected)	0.596**	0.356***	0.356***
	(0.298)	(0.128)	(0.137)
Relevant items × task A dummy			0.765**
			(0.376)
Constant	1.056	0.613	0.613
	(1.164)	(0.489)	(0.523)
Constant × task A dummy			0.444
			(1.171)

Standard errors in parentheses: * significant at 10%, ** at 5%, *** at 1%

As Table 3 shows, own creative ability is strongly correlated with creative output in Phase 2. On average, an additional creative item produced in the first stage translates to an increase in Phase 2 production by 0.378-0.446 items. The constant is not statistically significant, which means that if access to the ideas of others is absent, Stage 2 production is proportional to Stage 1 output. This supports validity of using Stage 1 output as a proxy for creative ability.

According to our estimation results, exposure to the ideas of others has a strong positive effect on future creative production in both creative tasks. On average, observing one relevant example leads to an increase in creative output of 0.6 items or 10% in case of Task 1 (graphic) and by 0.35 items or 8.5% for Task 2 (verbal). In aggregate terms, the estimated increase in creative production is 1.1 items (or 20%) in Task A and 5.1 relevant items (or 43%) in Task B. The latter numbers are calculated for average ability individuals.

These results provide strong evidence in favour of the positive effects the exposure to the ideas of others has on creative production. The next section investigates whether the individuals demonstrate awareness of these potential benefits by making beneficial investment decisions when given the opportunity to *acquire* access to the output of others.

5.2 Phase 2 - Investment

5.2.1 Decision to invest

This Section analyses the investment decisions of the subjects. Following the discussion of Section 4, we shall compare expected benefits from investment in acquisition of ideas to the cost of that investment to conclude whether an investment decision is beneficial. The benefits are defined as the monetary equivalent of the expected increase in creative output due to new ideas (*opportunity costs of investment*) and the costs of an investment are given exogenously.

For verbal sessions, there is more than one potential partner and each of them differs in terms of connection costs as well as in terms of expected new items. We observe investment decisions, but do not possess the information on the exact decision-making process. Note that higher creative ability of a partner implies higher expected benefits, but higher connection costs at the same time. The group member with maximum creative ability is not guaranteed to be the best choice of everyone, as there could be another group member connection which is predicted to result in higher net benefits.

For simplicity of analysis, we here analyze investment decision from the point of view of *'the best partner rule'*. The best partner is a connection that brings the highest expected net benefit. A profit-maximizing investor should invest (in the connection to her best partner) when this expected net benefit is positive and not to invest when negative.

To calculate an ex-ante opportunity costs for each subject, we first calculate the expected benefits of all connections available to her using the estimates reported in Table 4. We, then compare each expected benefit to the cost of connection specified by the experimental design. In this way we identify the best partner for each subject in our sample. The opportunity costs of investment are the expected benefits associated to the connection to the best partner, the costs are the costs of connection to her.

We use (3) to assess to what extend the participants' actual investment decisions are beneficial:

$$x_i = \gamma_0 + \gamma_1 \lambda_i^j + \gamma_2 P_i^j + v_i$$

where x_i is equal to 1 when i decides to invest and to 0 otherwise, λ_i^j represents the opportunity costs of investment (in task A) or connecting to the best partner (in task B), P_i^j is the investment cost. Equality of γ_1 and -γ_2 would be an evidence of balanced, profit-maximizing investment decision. The results of are presented in Table 4.

Table 4: Marginal effects for investment decisions, probit

Dependent variable - decision to invest at least once

	(1)		(2)	
	Probit regr.	Marginal Effects	Probit regr.	Marginal Effects
Opportunity costs	0.414	0.160	0.451	0.174
(estimated)	(0.356)	(0.137)	(0.360)	(0.138)
Price of contact	-0.537**	-0.207**	-0.549**	-0.212**
	(0.23)	(0.087)	(0.233)	(0.089)
Creative ability			0.022	0.008
			(0.032)	(0.012)

Standard errors in parentheses: * significant at 10%, ** at 5%, *** at 1%

The first column reports probit estimates of (3) suggesting that higher opportunity costs are associated with a higher probability of investing, and higher connection prices, with lower probability of investment. Only the contact price coefficient is significantly different from zero, but the hypothesis regarding the equality of the effects and efficiency of investment decisions is not rejected. The second column of Table 4 explores to what extend creative ability determines investment decision. If more productive individuals choose to get more exposure to ideas, we should observe a positive relationship between creative ability and investment dummy. But as the estimation results suggest, creative ability has no impact either on the decision to invest or on the coefficients of opportunity costs and price. This evidence is in contrast with the hypothesis that higher productivity leads to more interactions.

The next section investigates what other factors other than cost-benefit weighting influence investment decisions in our creative environment.

5.2.2 Choice of a partner

Verbal session design is based on a rich environment, which allows us to analyze investment decisions more deeply. Each single investment decision can be partitioned into two sub-decisions: (i) invest or not to invest, and if yes, (ii) whom to choose as a partner. The estimates in Table 4 demonstrate that participants' investment decisions are consistent with the behaviour of a profit-maximizing individual and the potential benefits are on average well calibrated. This section analyses the second part of the investment decision.

As we illustrate in Section 4, a profit-maximizing investor should follow the best partner rule. This rule states that if the maximum attainable net benefit is positive, the subject should invest in connection to the individual who is associated to this highest benefit. If, in the opposite case, the highest attainable net benefit is negative, the subject is better off not investing at all and should not form any connections.

In what follows, we analyze the relationship between the expected number of relevant items that the best and actually chosen partners have. We do not observe partners for the participants who decided not to invest at all. To control for the link-forming decision, we use the Heckman two-step procedure, where in the first step individuals asses the profitability of investing in a connection to their best partner available, and the second step is actual partner choice. The selection equation is given by (4) and the partner choice by (5). The first-step estimates (selection equation) are reported in Table 4 and are in line with profit-maximizing investment decisions. Table 5 reports the estimates of six different specifications for second step, partner selection.

The first column of Table 5 shows our basic specification: our dependent variable is the expected number of relevant items a subject's partner has and our independent variable is the expected number of items the subject's best partner has. The estimation results show the absence of any significant relationship between the two. On average, the selected partner's profile does not coincide with the choice that maximizes expected net benefits.

Choice of the partner is not a simple decision to be made ex-ante. Before the partner's output is revealed to a participant, in other words, before the decision is made, the number of relevant items remains uncertain. This in turn introduces uncertainty in future benefits and makes investment decision risky. Thus, investment decisions in our environment, as any other decision under risk or uncertainty, might be affected by subjects' risk attitudes or/and other individual characteristics. Columns 2-6 of Table 5 report the estimates of five alternative model specifications. In addition to the best partner items, these specifications include various individual characteristics that may have an effect on the partner's profile. These characteristics include: risk attitudes, creative ability, self-assessment of own creative ability, gender, age, GPA and other demographic variables.

Table 5: Heckman maximum likelihood estimations

Dependent variable - Expected number of relevant items

Opportunity costs	0.521	1.081***	1.071***	1.134***	1.127***	1.165***
	(0.39)	(0.39)	(0.39)	(0.38)	(0.38)	(0.37)
Price of connection	-0.528**	-0.754**	-0.766**	-0.760**	-0.759**	-0.749**
	(0.21)	(0.35)	(0.36)	(0.33)	(0.33)	(0.33)
New items (best partner)	0.104	-0.096	-0.12	-0.059	-0.023	-0.137
	(0.12)	(0.14)	(0.14)	(0.12)	(0.12)	(0.15)
Risk parameter		4.917*	5.134**	7.019***	7.308***	8.993***
		(2.53)	(2.44)	(2.29)	(2.18)	(2.43)
Perceived ranking			-5.949*	-6.063*	-5.382*	-7.723**
			(3.45)	(3.15)	(3.02)	(3.67)
Creative ability				0.468**	0.526***	0.568***
				(0.19)	(0.18)	(0.19)
Female					-1.828*	-2.409**
					(1.05)	(1.11)
GPA						0.127
						(0.09)
2D:4D ratio						-16.69
						(20.31)
Left-handed						-1.70
						(1.95)
CRT						0.356
						(0.91)

Standard errors in parentheses: * significant at 10%, ** at 5%, *** at 1%

The choice of partner is to a great extend explained by an individual's risk attitudes[14], gender, creative ability and self-confidence[15]. More risk-neutral subjects usually aim for more creative partners and a 0.1 change in risk parameter toward risk-neutrality imply from 5 to 9 more expected new items depending on specification. The individuals with higher creative ability also opt for connections with a higher expected number of new items and an additional point of creativity is associated with approximately 0.5 additional new items. The subjects with higher self-assessed position in creative ranking, in contrast, aim for less creative partners, where a 10% increase in self-perceived ranking lowers the expected number of related items by 0.6-0.8. Furthermore, females chose lower quality partners; their partners are expected to ensure 1.8-2.4 new items less than those chosen by males. However, this result is just marginally significant. Although controlling for other variables such

[14]See Appendix for elicitation and estimation. Risk parameter is equal to 1 for risk-neutral individuals and 0 for completely risk-averse.

[15]Self-reported percentile according to creative ability.

as being left-handed, 2D:4D ratio or GPA and the results of cognitive reflection test adds explicative power to the estimation, these variables do not have a significant effect on the partner chosen.

5.3 Networks

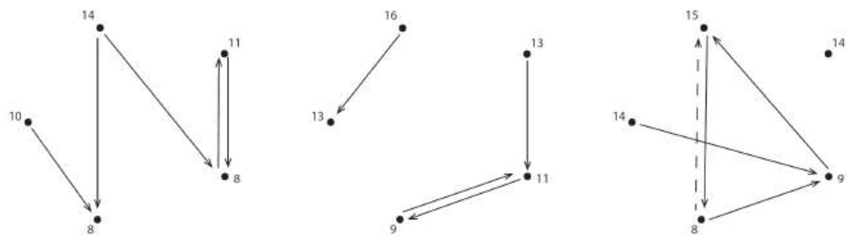
This section considers the investment behaviour in the context of networks. Figure 5 depicts all the networks formed in the verbal sessions of the experiment (solid lines). Each node represents an individual, the number next to the node corresponds to their creative ability (e.g. the number of items generated during the first 6 minutes of the creative task) and each arrow between two nodes corresponds to the connections formed by an initiating node to the node of destination. Each network consists of five nodes located in descending order of creative ability from top to the bottom: the node corresponding to the maximum creative ability in a given group is always shown on the top, and the minimum at the bottom.

In total, 31 links were formed in 4 sessions. 28 out of 60 participants have decided to form connections: 3 individuals have formed two links, and the remaining 25 one link each. From the other side, 23 individuals were contacted in total, among them 16 were contacted once, 6 were contacted twice and one participant was contacted three times.

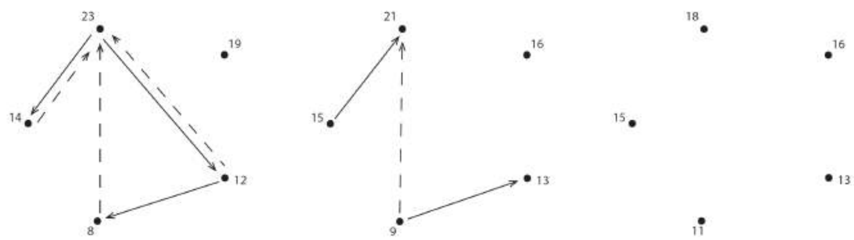
Following our discussion in Section 4,all profit-maximizing links should connect a subject with her best partner. Optimal connections were derived as the connections that give maximum nonnegative expected profit to the participants. If neither of the available partners gives positive profits, no connections should be formed, and if several of them are expected to bring positive profit, the one corresponding to maximum profit should be optimally chosen. Figure 6 depicts the best partner connections with dashed lines. If there are no dashed lines in the graph, no links should be formed. Only one link was made according to the best partner rule (Session 3, from 10 to 18) and a further 30 should not have been formed according to the optimal decision rule.

Moreover, although for the majority of participants their predicted best partners are of higher than own creative ability; only 11 out of 31 links were made to the people of higher creative ability. The participants of maximum creative ability in the group would be an exception, as the only choice available to them is to connect to someone with a lower creative ability than their own. 8 out of 20 links to nodes of lower than own creative ability are formed by maximum ability individuals. However, neither of these links is made to a second-best node, but to substantially lower nodes instead.

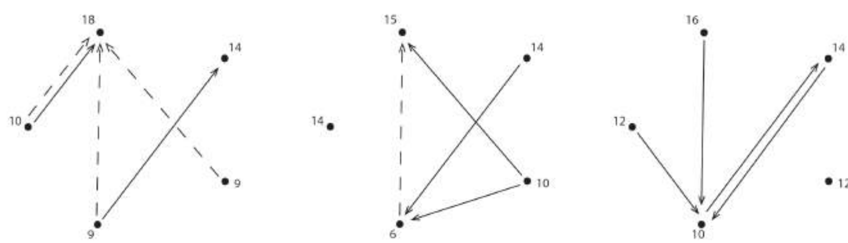
Session 1



Session 2



Session 3



Session 4

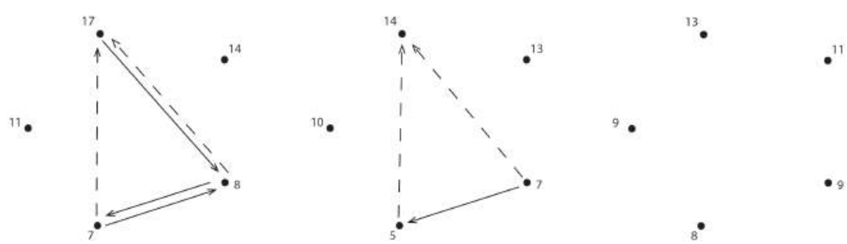
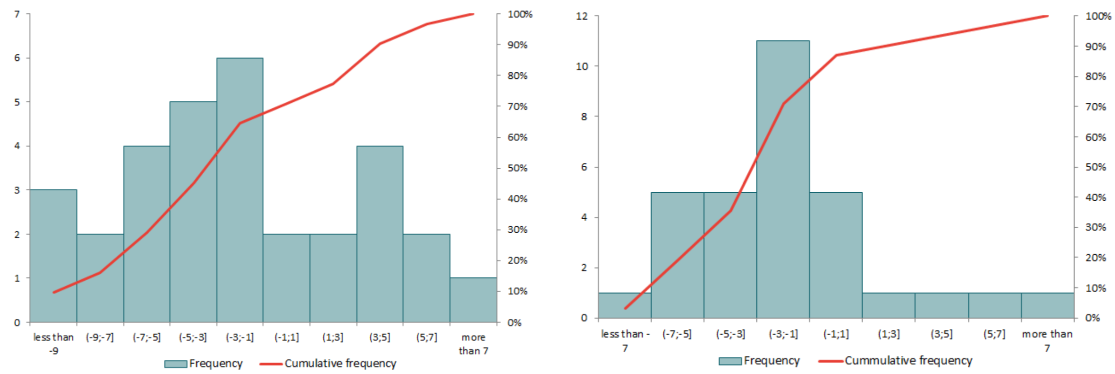


Figure 6. Real and profit-maximizing networks.

As our Figure 6 shows, actual connection behaviour in the experiment is at odds with the profit-maximizing strategy. As a rule, the links formed to lower than optimal creative ability individuals result in losses in actual or potential profits from forming links. The explanation to this phenomena is that, as discussed earlier, the connection behaviour is determined by risk attitudes, own creative ability and other individual characteristics, and does not reflect the best possible connection that could have been made in a given network.



(a) Own - partner's creative ability (b) Group's median - partner's creative ability

Figure 8: Connections formed, distributions

Figure 8 characterizes the links formed in the experiment. Figure 8 (a) shows the distribution of differences between own creative ability and the creative ability of the chosen partner. Figure 8 (b) shows the distribution of differences between median creative ability in the participant's group and the partners' creative ability. More than 70% of all connections are formed to a participant of lower than own creative ability and more than 85% of the links were formed to a subject of lower than observed median creative ability. These connections can be interpreted as unproductive: they are unlikely to bring new ideas but are still costly to participants as Figure 4 shows. Only 2 out of 12 networks formed are optimal and only out of 10 non-optimal are predicted to result in positive net benefits[16]. Two thirds of the networks would lead to net losses according to our estimations presented in Table 3.

6 Conclusions

Our experiment relies on a simple creative environment aimed at mimicking communication between creative professional and excluding any communication channel distinct from observing ideas of other. There are therefore no discussions and no feedback. In this sense, the experimental environment is close in spirit to on-line communities with restricted opportunities to discuss or create noisy feedback, where observing what others are doing is the main activity one can undertake. In a broader view, we can view the experimental results as a lower bound of potential benefits from creative communication.

Regarding the productivity-linkage relationship, our results suggest that more connections do make the individual more productive but not that more productive individuals form more connections. Moreover, not all the formed connections are chosen optimally: there are too many unproductive links, which in expected terms lead to profit losses. Even though participants decide whether to form connections

[16]Net benefits for a network are calculated as a total predicted additional output due to connections minus total cost of these connections.

by weighting costs against benefits, they choose partners of too low creative ability. In other words, many participants rely more on own ability and tend to overestimate their interpretative power (a technology of turning ideas received into new output) or their uniqueness (a likelihood of having overlapping sets of ideas with their partners). Exploring the role of behavioural characteristics in the partners' choice, we find that some of them help to explain this behaviour. For example, higher perceived ranking in creative ability is associated with less than optimal creative partners. Females are also more likely to choose partners of too low ability. Higher creative ability and risk-averse individuals, instead, are shown to form links closer to optimal. The overconfidence effect could be explained by a desire for superiority, creative ability effect, as possible higher self-awareness due to a deeper experience and risk aversion effect as a desire to avoid higher costs. However, these are only possibilities, we are not aware of any theory that would embrace all these findings.

Defined as a sum of all participants' payoffs (Bala and Goyal, 2000), the efficiency of a network with heterogeneous agents is determined by its structure (Galeotti *et.al.*, 2006). Previous experiments conducted to deal with equilibrium network structure and the process of network formation (see for example Callander and Plott, 2005; Berninghaus *et.al.*, 2006; Charness *et.al.*, 2007; Corbae and Duffy, 2008; Goeree *et.al.*, 2009) impose the agents' heterogeneity in costs of forming a link. In this spirit, this paper also deals with structure and efficiency of a network with heterogeneous agents. However, in this real-effort creative environment the costs are determined endogenously and payoffs depend on own effort, ability, investment decisions and uncertain quality of the connections. The experimental results suggest that whilst some connections are beneficial, the resulting networks are inefficient.

This justifies a need for intervention (in monetary or non-monetary form) to induce a 'better' network structure in creative environments according to the intervener's purpose: social welfare, creative output generated or any other output of interest. This kind of analysis may be useful for evaluating investment in establishing costly contacts between creative professionals. The costs here are not limited to monetary costs only, but may also include time spent on certain activities.

The policy implications of the paper's findings for fostering innovation and creativity at the workplace include directing money flows to more risk neutral organisms rather than individuals, central planning of the collaborative activities and providing sufficient funds to R&D entities that would not restrict them in terms of quality of resources. For the outcomes to be positive, all these measures should be carefully evaluated against potential negative impacts they may have on the output produced.

Possible extensions of the study may include analyzing investment behaviour in environments with other real-effort tasks where the individual is responsible for investment and production at the same time, such as decisions regarding becoming an entrepreneur or getting additional education. Another interesting question for future research is the nature of the behavioural effects we observe at an investment stage, by understanding why risk aversion or perceived position matters for connecting behaviour would be important for designing policies that overcome these inefficiencies.

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7 Appendix

7.1 Instructions: task A

The purpose of this experiment is to study the behavior on decision making. Do not think that any particular behavior is expected from you. However, be aware that your decisions will affect the money you can earn during the experiment. These instructions will explain you the rules of the experiment. Instructions are identical for all participants. The anonymity of the participants and their decisions is also guaranteed. Please, it is important that you do not talk to nor disturb other participants. If you need help, raise your hand and wait in silence. Someone will come to you as soon as possible. This experiment consists of two Stages (and each stage consists of 3 phases). Your total earnings in the experiment will be determined at the end of it, as a sum of three phases of a randomly chosen stage.

Stage 1

Phase 1

All the task of this phase have to be done with BLUE color pen, which you already have on your table. Phase 1 begins once we finish reading instructions and will last 6 minutes.

In this phase you will get a sheet of paper containing cells with geometric forms, some of them you will complete to get a drawing of a concrete object (precise, definite). Each drawing has to stay inside of a cell. A drawing can be very schematic, the quality of the drawing doesn't have any importance, but it has to be clear which object are you referring to. You are free to rotate the form and skip some cells.

Figure 1

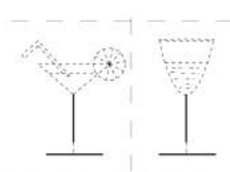

Figure 2

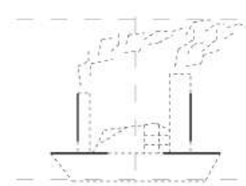

Figure 3

Your earnings in this phase will be determined as follows. For each unique drawing you will receive 50 cents. So, to earn more money, you task is to make as much as possible different drawings.

Figure 1 contains an example of the sheet. In this example each drawing should contain just one of the T-inverses. Figure 2 shows two examples of drawings with this form. Given that both use T-inverse as a base for the glass, these two drawings cannot be considered as different. In this case the participant will receive just 50 cents as for one drawing. Figure 3 gives an example of a drawing using two geometric forms. This drawing intersects the boundary of the cell, which is prohibited by the rules. In this case the participant will receive 0 cents for the drawing of a boat.

Summarizing, the total amount of money you can get in this phase depends on the number of conceptually unique drawings that you do.

Phase 2

All the task of this phase have to be done with BLACK color pen, which you already have on your table. Phase 2 starts after reading the instructions and will last 2 minutes. In this phase we will give you an example of a drawing which you haven't done in the previous phase and which uses given geometric form. This example is just for you, it is important not to show it to any other participant and not to try to see the examples of others. To assure that you receive a NEW example, please, if the envelope contains the drawing that you already did, rise your hand and we will give you another drawing.

After receiving an example, in the same sheet of paper we gave you at the beginning of the experiment, your task is to continue drawing as much drawings as you can, that contain given geometric form.

The requirements are the same as in the previous phase: each drawing has to be inside of a cell, can be very schematic, the quality doesn't matter, but has to be understandable which object you are referring to. It's OK to skip some cells. It's not OK to draw the same example we gave you. Your earnings in this phase have the same structure as the previous one: for each unique drawing you can receive 50 cents. So, the total earnings in this phase depend just on the number of unique drawings you produce in these 2 minutes.

Stage 2

Phase 2 (see Stage 1 for Phase 1)

All the task of this phase have to be done with BLACK color pen, which you already have on your table. Phase 2 starts after reading the instructions and will last 2 minutes. In this phase you can BUY an example of a drawing which you haven't done in the previous phase and which uses given geometric form. This example would be just for you, it is important not to show it to any other participant and not to try to see the examples of others. To assure that you receive a NEW example, please, if the envelope contains the drawing that you already did, rise your hand and we will give you another drawing.

After this an example, in the same sheet of paper we gave you at the beginning of the experiment, your task is to continue drawing as much drawings as you can, that contain given geometric form.

The requirements are the same as in the previous phase: each drawing has to be inside of a cell, can be very schematic, the quality doesn't matter, but has to be understandable which object you are referring to. It's OK to skip some cells. It's not OK to draw the same example we gave you.

Your earnings in this phase have the following structure: for each unique drawing you can receive 50 cents minus the total investment cost (if occurred). So, the total earnings in this phase depend on the number of unique drawings you produce in these 2 minutes AND your investment decision.

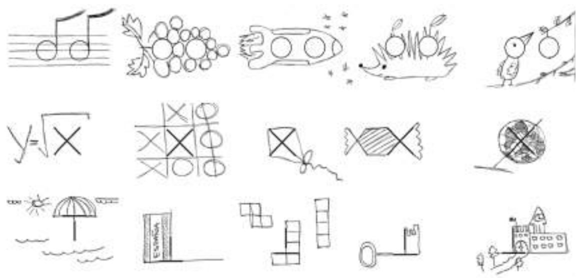

Figure 7: Examples suggested to the participants[17].

7.2 Instructions: task B

The purpose of this experiment is to study the behavior on decision making. Do not think that it is expected a special behavior from you. However, be aware that your decisions will affect the money you can earn during the experiment. These instructions will explain you the rules of the experiment. Instructions are identical for all participants. The anonymity of the participants and their decisions is also guaranteed. Please, it is important that you do not talk to nor disturb other participants. If you need help, raise your hand and wait in silence. Someone will come to you as soon as possible. This experiment consists of two Stages, and your total earnings in the experiment will be determined at the end of it, as a sum of earnings corresponding to you in a randomly chosen stage.

Stage 1

At the beginning of this Stage you will be shown a well-known and widely used object. Your task will be to find various ways to use this object different from the usual one. For example, the usual use of a book is to read it and one possible unusual use would be using it as a carpet for computer mouse.

This phase will last 10 minutes and for each unusual use conceptually different you will receive 50 cents. It is very important not to introduce similar uses, because

[17] Not part of instructions. The examples were suggested in the presented order for each geometric form. In case the individual already had the example proposed, the next by order was suggested and so on. Never more then one change was needed, one change was needed in 4 cases.

for each similar use you suggest we will substract 50 cents from your earnings. For example, if you have said that a book can be used to keep the door open, you will receive 50 cents for this idea, but if you add 'to keep the window open' 50 cents will be substracted and in total you would receive zero for these two uses because they are not conceptually different.

To summarize, to earn more money your task is to produce as many different unusual uses as possible.

How to use the computer in this task:

To let us know the uses you come up with, you will use the computer. To introduce a use you need to type it in the bottom part of the screen - as it is shown on the picture below - and press 'ENTER' button. Please, enter each new use in a new line. In this way, the will be numerated automatically. In the left top corner of the screen you will see the statistics on the total numbers of uses suggested and your earnings so far.

Figure 1

Important: in case you make entries with no sense, irrelevant or just enter empty lines, the computer will not recognize the error immediately and will increase your earnings. However, this will be checked upon termination of the experiment, and if such a behavior is detected, all the earnings in a corresponding phase will be cancelled.

After first 6 minutes of the task you will have a little break, and after it you will continue with the same task, the same object and the same rules. The screen will show you all ideas that a random person in this room came up with. Observing the ideas of others can help you to generate mor your own ideas, however, you should not copy the ideas of others or introduces similar, because in this case it will not be a different use anymore and 50 cents will be substracted from your earnings.

Stage 2

At the beginning of this Stage you will be shown ANOTHER well-known and widely used object. As in the previous stage, your task will be to find various ways to use this object distinct from the usual one.

As in the previous stage you should enter your ideas in the bottom part of the screen. The stage will last 10 minutes and for each conceptually different unusual use you will be paid 50 cents.

As in the previous stage, after first 6 minutes you will have a little break and after it you will need to continue with the same task, the same object and the same rules.

This time, you and 4 other people in this room chosen randomly will form a group, which composition will remain constant until the end of the session. In addition to your statistics you will see a table containing the number of ideas each member of your group has, like this:

Figure 2

To each one of you the 'contact price' will be assigned, which is proportional to the total number of unusual uses the member suggested. The greater is the output - the more expensive will be to contact a particular member. This price you also will see in the statistics table.

When you want, you can see the unusual uses suggested by a member of your group paying the price of contact. To do so, please, select corresponding line and press the button 'CONTACT'. The screen will show you all the ideas of the selected person in the middle. You can choose to contact one person only, multiple persons or not to make contacts at all. Total amount of money spent making contacts by you will be shown in the table of your statistics. To be able to contact someone, you have to have sufficient earnings, in case you don't - the error message will appear.

Important: in case you make entries with no sense, irrelevant or just enter empty lines, the computer will not recognize the error immediately and will increase your earnings. However, this will be checked upon termination of the experiment, and if such a behavior is detected, all the earnings in a corresponding phase will be cancelled.

7.3 Risk-elicitation

7.3.1 Instructions

In each of the 24 rounds of this phase, we present you two lotteries and you will have to choose the one you prefer. At the end of the experiment the server will determine randomly one out of the 24 rounds, and you will be paid the money that results from playing the lottery you selected.

In each round, there will appear two lotteries on your screen. You will have to choose one. Each lottery assigns different probabilities to win four prizes of 0, 5, 10 and 15 euros, respectively. Each prize is associated with one color. This association between prizes and colors will hold for all 24 rounds in this phase. The figure below shows an example of a lottery.

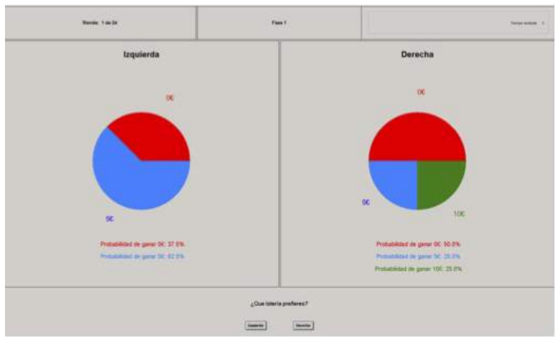

Figure 3

If you choose the lottery on the LEFT, you can earn 0 euros with a probability of 37.5% or 5 euros with a probability of 62.5%. If, on the contrary, you choose the lottery on the RIGHT, you can earn 0 with a probability of 50%, 5 euros with a probability of 25% and 10 euros with a probability of 25%.

In each round, you simply have to choose your favorite lottery clicking with the mouse on the corresponding button. It is important that you play all 24 lotteries as if it was the one determining your payoff. This is due to the fact that after the experiment the server will choose one out of the 24 rounds, and will play the lottery chosen by you in that round.

In summary, the money you earn depends on the round chosen randomly by the server and the result of the lottery chosen by you in that round.

7.3.2 Estimation

The risk aversion parameter is estimated for each individual separately by Maximum Likelihood estimation procedure. For this purpose, an Expected Utility specification is used:

$$EU_i = \sum_{m=1}^{4} [q_m \times u(w_m)], \text{where}$$

q_m and w_m are the probabilities and prizes in each lottery.

Denote the utility function

$$u(x) = x^{\rho}.$$

Based on latent preferences, and choosing a logistic CDF, the conditional log-Likelihood Function (l-LF) is

$$\ln L(\rho, c) = \sum_{l} \left[\ln \left(\frac{\exp(EU_L)}{\sum_{c'=L,R} \exp(EU_{c'})} \bigg|_{c_l=L} \right) + \ln \left(\frac{\exp(EU_R)}{\sum_{c'=L,R} \exp(EU_{c'})} \bigg|_{c_l=R} \right) \right]$$

The estimated ρ parameters vary substantially across individuals. The average estimate is 0.64 and the standard deviation is 0.33.

7.4 Self-assessment

7.4.1 Instructions

In *task B* all the participants assessed their own creative ability with respect to performance of others. Between stage 1 and stage 2 of phase I, the individuals were given feedback on their output and were asked to guess how many participants in their session have come up with more items than themselves. Figure 8 shows a screenshot of this task.

Figure 8: Overconfidence task

Quadratic scoring rule was used as an incentive scheme: the participants who have guesses correctly received 1.5 euros, and the less precise was the guess, the less money was paid.

7.4.2 Estimation

The self-confidence parameter used in estimations is calculated as the self-identified position normalized over number the participants in a session. For example, if a subject said that there are 4 participants with more items than herself, her self-confidence parameter would be 20 (her ranking in ascending order) over 24 (total number of participants in the session, resulting in 0.83.