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Brainstorming: an empirical analysis

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1 Introduction

Nowadays working in groups is a must-have soft skill in everyone's resume. How many times when starting a group session, have we heard the sentence "Ok everyone, let's start with a brainstorming"? It is likely hearing this phrase in different situations: at the university when performing a group assignment, at a work meeting, when discussing the holiday destination with a group of friends and so on.

Many important companies are notorious for their use of brainstorming: the most famous example is Google, where sharing ideas is a leitmotif, but there are also other important firms like IBM and its electronic brainstorming or IDEO, the company which designed the first Apple mouse. We do not have to go that far to find someone using brainstorming though: H-FARM in Treviso has become famous for its massive use of group activities.

The idea of brainstorming was developed in the late 50s, ever since a lot of researchers have spent their time trying to study whether the common assumption of group effectiveness is true and whether brainstorming indeed leads to a superior output in term of quality and quantity. There are several evidences supporting the assumption that sharing ideas is not always as effective as we believe, the outcome of group thinking is tightly related to the way we shape groups and the rules provided.

Even though the brainstorming technique is massively used, the real mechanism underlying the performance is neglected most of the times and this leads to undesired or unexpected outcomes. We brainstorm because we believe that sharing opinions and discussing with other people would trigger productivity, rocketing the number of ideas produced. The latter is a common bias that is usually defined as the *illusion of group productivity*: we believe that group's performance is higher than the individual one, moreover we perceive our own performance more effective when working in group because we are not able to distinguish our ideas from the others' ones (Paulus, Dzindolet, Poletes, & Camacho, 1993). It is unlikely finding someone questioning brainstorming because its positive effect is taken for granted most of the times, this is

indeed what we aimed to do in this thesis: assessing brainstorming and some aspects of the mechanism, always keeping a critical perspective.

After an introduction of brainstorming, we are going to discuss the concept supporting our thoughts with empirical data coming from two experiments that we ran at Ca' Foscari University of Venice. We are going to present data partially consistent with literature and we are going to discover that group effectiveness cannot always be taken for granted.

2 The story of brainstorming

2.1 The origin: from group activity to brainstorming

The word brainstorming is widely acknowledged, but not many people know its origin and how it was developed. The first one using this term was the advertising executive Alex Faickney Osborn between the end of the 50s and the 60s, he worked in the marketing company BBDO and was looking for a way to fix employees' inability in producing creative ideas.

The concept was developed in more than one book, but in *Applied Imagination* (1953) Mr. Osborn defined brainstorming as we know it today: the use of *brain* to storm *ideas*. He believed that a group activity designed in this precise way would have increased the number of ideas produced overwhelming the problem of inefficiency. Moreover, he was convinced that brainstorming would have turned his employees in *imagination machines* fostering BBDO's success (Lehrer, 2012).

Someone could argue that this concept was not a real innovation, this is partially true, in fact brainstorming can be included within the group activities, but it is somehow different because criticism is ruled out and no negative feedback can be given during the sharing process (Lehrer, 2012). This is not the only pillar of brainstorming, Osborn defined four core values in *Applied Imagination* (1953):

- **criticism is ruled out**, as already mentioned members are not admitted to criticize ideas, this would be a solution of the common apprehension of evaluation, feedback will be allowed in a later process of idea selection
- **freewheeling is welcome**, members are urged to unchain their minds coming up even with *wild* ideas
- **quantity is wanted**, one of the main problem in BBDO was the poor number of ideas, groups should strive to produce as many ideas as possible
- **combination and improvement are sought**, participants should pick up all possible hints in order to unleash creative ideas and everyone is welcome to add possible improvements, variations or combinations with other ideas

Brainstorming can be applied to a variety of problems in different sectors, from business to science, but also for every day's problems, the important thing is following Osborn's pillars. Group members have to feel comfortable during the meeting, each session should be more similar to a game with fair rivalry and for this reason even the dress code should be informal in order to ease interactions. In *Applied Imagination*, a team leader was quoted stating that, when he made his brainstorming team feeling like playing, he got the best results. The spirit of all sessions should point self-encouragement as much as mutual encouragement, people came up with more ideas when trying hard, but in a relaxed atmosphere, as they were at a picnic (Osborn, 1953). It would be useful recognizing a team leader in each session, he should be able to transfer the four pillars to group members and watch that everyone is respecting the rules. The leader must be sure that members are working as a whole and no small groups are created, otherwise the goal of brainstorming will fade away. Furthermore, he should list all conceived ideas and this list should be forwarded to all participants later on, because in the following days some new ideas could come up.

It is suggested to create groups with a number of members between five and ten, no prescription is given to gender composition, there can be all males, females or mixed. Hints are also given for the background of each participant, neophytes and veterans can be mixed, but it is recommended to avoid groups of people over-trained on the same task because creativity could be missed.

The problem should be narrow and not wide so participants can better focus and work on it, once everyone has reported all ideas, the selection process can start. There are two possible ways to run the second stage: ideas can be discussed by the same previous group or they can be assessed by a new group (which can include some members of the first stage) which has more knowledge about the feasibility of each idea. Both possibilities have benefits and difficulties, for instance people who participated at the first stage would suffer neglecting the second the stage, meanwhile people with more experience would be more effective in choosing the best ideas. Which method has to be pursued depends on the nature of the task or problem, regardless this decision it would be useful defining a checklist with the necessary characteristics of the desired solution.

2.2 Literature review

In the previous paragraph we have defined brainstorming and its characteristics according to his inventor, who was convinced that working in this way would have led to an improvement in ideas' quality and quantity. From the very beginning of its story, researchers have tested the efficiency of brainstorming with studies covering different aspects and the results were slightly different from the prevision.

Before entering the topic of brainstorming, we have to remember that it is a subclass of the wider set of group activities, therefore it takes advantage from benefits encompassed in the whole category, but it is also affected by its biases. A lot of discussion has been made on the real productivity and effectiveness of activities conducted with a collective mechanism and providing an answer is a very difficult task. The difficulty is given by the fact that the outcome of a group cannot just be computed as a sum of individual productivities, the interactions happening in groups always lead to unexpected outcomes, both positive and negative. There are several aspects which can affect the performance, we are presenting below the most relevant:

- *Social attitude*. Not all people are prone to group activities at the same degree, there are people passionate in working collective, but also other who prefer eschewing such setting. We can hypothesize that those who do not appreciate group activities could exhibit a poor commitment when involved in collective works and even affect in a negative fashion others' performance. On the other hand, advocates of group activities could increase their performance working in groups and could urge other people to strive the most.
- *Knowledge*. It cannot just be differentiated in high or low, but also in different fields. As people who already know the topic of the task could help the group, members with a minimum competency on the task could lower the group or decide to not contribute becoming *free-riders*.
- *Task*. We are going to present several studies focusing on the effect of task on group performance. It can be easily understood that striving to solve a difficult equation or maze is not the same thing of collaborating to pull a rope.

- *Social influence*. Groups are a matter of social relations, it is predictable that some members could influence other people and their performance. A lot of times influence is tightly related to the aforementioned "knowledge": having groups composed only by peers or including experts can affect in a remarkable way the productivity of groups and the performance of individual members. It is important highlighting that influence does not necessarily means "voluntary influence", instead most of the times it is totally unconscious. This particular behavior could be due to the collective context itself rather than to a specific person deliberately aiming to influence someone. The topic will be discussed later on in the paragraph.
- *Setting (Research Design)*. In all the following examples, but also in the experiments specifically held for this thesis, we are going to present data which seems to be really in contrast. Sometimes it could happen that experiments come out with different conclusions concerning the same variable, it would be a mistake considering all these studies in contrast: differences could simply arise from different settings and rules. The fashion in which groups are manipulated and allocated can have a crucial impact on the outcome.

Researchers have shown different insights concerning the effect of collective activities on performance, these differences are mainly due to different perspectives held in studying the same topic. An instance of these perspectives can be found in the concepts of *social loafing* and *social facilitation*. Supporters of the first paradigm assume that people exert less effort when performing the same task collectively rather than individually[1], for this reason we talk about loafing. It is slightly different the insight provided by advocates of social facilitation: this theory focuses on a comparison between the performance of individuals observed when working in groups or individually on the same task. More specifically, people perform better when working in groups rather than individually on simple tasks; on the other hand, performance is negative affected by collective activities when working on difficult tasks, this result was

[1] Jackson, J. M., & Williams, K. D. (1985). Social loafing on difficult tasks: Working collectively can improve performance. *Journal of Personality and Social Psychology*, *49*(4), 937.

bounded to the fact that working in groups increases drive therefore the likelihood that the most probable response will be observed[1]. Jackson and Williams (1985) compared the latter perspectives bestowing differences to the settings adopted in the experiments. For instance, subjects working in the group condition under the social facilitation paradigm, are supposed to perform similar but independent tasks, in the presence of co-actors and an experimenter. It is straightforward that this setting does not represent the common idea of group activities, moreover participants could perceive a competitive environment fostered by the pressure provided by both co-actors and the experimenter. The group setting adopted under the social loafing theory is more similar to the stereotype of group activities since participants are supposed to work as a whole on the same goal instead.

The two researchers stated that differences in performance have to be attributed to "drive", in particular: social facilitation groups are designed in order to experience a high level of drive leading to a better performance on simple task, whereas social loafing groups experience low drive therefore an opposite effect. In conclusion their hypothesis assumed that there is as common mechanism underlying the two paradigms, that is drive. The difference in the final outcome could be simply due to the opposite effect that the hypothesized variable has on the two settings. In order to support their statements, Jackson and Williams performed a new experiment comparing individual, co-working (group setting under social facilitation) and collective (group setting under social loafing paradigm) settings, working both on difficult and easy tasks.

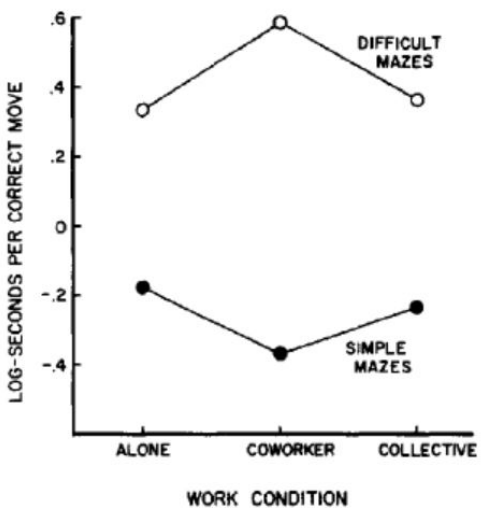


Table 1. Performance on difficult/simple tasks according to different settings[1]

In Table 1 it is reported the observed outcome of Jackson and Williams' experiments, as they were hypothesizing, those observed under co-working setting performed better on easy tasks rather than on difficult ones, meanwhile subjects working collectively benefited from their allocation on difficult tasks rather than on easy ones. This result seems to support the hypothesis previously mentioned, moreover Jackson and Williams explained the reason why drive is the cause of differences instead of competition as it could be forecasted. They identified three reasons because competition cannot be the driver of differences:

1. participants did not report feeling more competitive;
2. theorists of evaluation apprehension assume that competition is actually a component of social facilitation, therefore even if it is experienced it would produce social facilitation;
3. competition itself cannot explain the drop in performance of co-working setting observed in difficult tasks.

In this study it was reported an outcome not due to competition, later on we are presenting other studies in which competition held significance, but as we have stated before, a lot of differences rely on the research design.

The first research specifically conducted on brainstorming was held in 1958 at Yale University (Lehrer, 2012) comparing group and individual productivity, researchers found out that solo participants produced on average twice the ideas of groups, moreover ideas produced by individuals were deemed more feasible and effective. A lot of studies are focused on the comparison of the productivity between real (brainstorming) and *nominal* groups. The latter is a group technique in which members are supposed to spend part of their time working alone, the meeting is conducted in the following way (Potter, Gordon, & Hamer, 2004):

1. **Introduction and explanation**: participants are provided with the rules and goal of the meeting.
2. **Silent generation of ideas**: participants brainstorm the task individually writing down all their ideas in a sheet of paper.
3. **Sharing ideas**: participants now have the chance to report their ideas and share them with all other individuals, a facilitator has to list all ideas in a new sheet of paper. The goal of this step is making all members able to report their thoughts, therefore debate is not permitted.
4. **Group discussion**: participants can ask explanations from other members, everyone has to take part to the debate, the facilitator is in charge of supervising that all members are allowed to speak, new ideas and modifications are welcome.
5. **Voting and ranking**: all ideas conceived in step 4 and 5 are prioritized according to the original task, afterwards members are asked to vote and a ranking of solutions is provided.

The reason why this activity is defined nominal is simple: discussion does not start from the beginning of the meeting, but members have the chance to develop their own ideas that, in a following step, they will share and discuss. This technique was found more effective than brainstorming, people produced more solutions and even more creative (Diehl & Stroebe, 1991; Paulus et al., 1993).

Authors did not just stop their study stating that nominal groups outperform real groups (*productivity loss*), they also tried to discover the reason of this discrepancy since Osborn has declared for a long time that brainstorming encompasses superior performance. Stroebe and Diehl (1994) defined two main causes of productivity loss in interacting groups: *motivation losses* and *coordination losses*, both categories can be further split in two subcategories that we are going to present below.

Motivation losses suggests that some aspects of brainstorming decrease work motivation of groups leading to a performance that is lower than the individual one; Stroebe and Diehl defined two "motivations": *free riding* and *production matching*. The first one could happen for many reasons, for instance when individuals are not interested in the task or they feel their contribution as less important. These

perceptions can lead to a lower or null and void effort and members just take advantage of others' work. The second motivation, production matching, was also suggested by other researchers (e.g. Paulus & Dzindolet, 1993) and connects inefficiency to brainstorming's novelty. This type of group activity could be completely unexplored for some members who could be insecure about the appropriate performance that should be kept in the meeting. Therefore subjects match their effort to the mean of the group, but the question is: what would happen if the mean is very low? The performance of the whole group would become fundamentally poor because regulated on a low level of productivity.

The tendency to align performance is something already observed by researchers interested in group activities and behaviour, conformity is divided in two subcategories (Deutsch & Gerard, 1955):

- *Normative social influence*. Defined as the influence to conform with the expectations of other people, it was observed that this tendency increases in people working in groups rather than those working individually.
- *Informational social influence.* Defined as the influence to accept information taken by another as evidences of reality. It means that in some situations we tend to take for granted ideas coming from other people, this event is more likely to happen when one's knowledge of a specific topic is poor.

Going on analysing the motivations of productivity loss, cordination loss includes two subcategories: *evaluation apprehension* and *mutual production blocking*. The first one blames brainstorming for not defeating people's apprehension of assessment coming from group members. Even though Osborn shaped his pillars in order to avoid criticism, apprehension is still present and somehow decreases the potential of group activity. Last, but not least, comes production blocking that eventually was defined as the main cause of productivity loss in brainstorming. Since the latter is a face-to-face group activity, participants are supposed to wait other members to finish their speech before starting their speaking time. According to Stroebe and Diehl (1994), we are not able to exploit the waiting time in an efficient way and we can identify several reasons which

determine this bias. It could happen because ideas occurring during the waiting time are prohibited to share, so we simply forget them or avoid to report, because we consider them less relevant. Productivity loss could also spread from the inability of thinking when other people are speaking, due to limitations of short term memory or to distraction coming from other speeches. We also have to consider that people working in groups have less speaking time comparing to people working alone, this could be a further constraint.

Above we mentioned a bias related to criticism: Osborn claimed that avoiding negative feedbacks, apprehension would have been defeated and creativity would have been released. It is curious that exactly one pillar of brainstorming was charged of decreasing creativity, in opposition to the initial assumptions. Nemeth, Personnaz, Personnaz and Goncalo (2004), supported by several experiments, found that imagination can thrive on conflict and criticism allows people to avoid predictable ideas digging below the surface of imagination. These authors recognized that debate could be unpleasant, but it will provide more productivity and they hypothesized that critiques can enhance freedom. After having reported this insight, it is important highlighting that this is just one point of view, other authors supported the idea of avoiding critiques as assumed by Osborn (e.g. Paulus & Dzindolet, 1993).

So far we have reported studies concerning just one step of brainstorming that is idea generation, but the activity does not stop here, there is one more crucial step: idea selection. Groups usually conceive lots of ideas, but not all of them can become reality. It would be impossible and ineffective striving on many ideas, so most of the times groups are asked to focus and develop one of them, keeping some ideas as backup plans. It is important that the idea selected within all the possibilities is the most feasible and appropriate at the same time; most of the people neglect the importance of selection, but the latter is as important as production. Rietzschel, Nijstad and Stroebe (2006) after having analyzed the productivity of nominal and real groups (as expected nominal outperformed normal), studied the second step aforementioned. Beside the differences observed between the two settings in the first step, groups performed slightly in the same way in the second one. Participants appeared to be “unable to distinguish good from poor ideas”, regardless their satisfaction they were not effective in selection as in

production. This is not the only study coming to this conclusion, Simonton (2003) stated that people are not that good in recognizing the best ideas and the problem is that this skill does not improve in the career. Here it comes a hint for a new problem, that is how people discriminate ideas and which are the criteria used in this process. When assessing group performance, we cannot only take into account the quantity, but also the quality of the outcome. Therefore, we have two metrics to consider and it would be even more regrettable if good ideas produced would be wasted in the selection process.

Since literature is abundant of studies concerning brainstorming, we are providing below a chart with the main findings concerning the topic.

Authors	**Title**	**Findings**
Brown, V., Tumeo, M., Larey, T. S., & Paulus, P. B. (1998).	*Modeling cognitive interactions during group brainstorming.*	• the exposure to the ideas of others should have a positive influence on the brainstorming productivity • it is attention that serves to link the individuals in a brainstorming group, group's behavior changes as a function of it
Camacho, L. M., & Paulus, P. B. (1995).	*The role of social anxiousness in group brainstorming*	• social anxiousness plays a major role in brainstorming, this technique may be best suited for people who are low in social anxiety
Dennis, A. R., & Valacich, J. S. (1993).	*Computer brainstorms: More heads are better than one.*	• electronic communication among members improves the idea-generation performance of large groups • the size of electronic groups should not be constrained to a small number • performance effects occur because electronic brainstorming introduces no more process losses while enabling process gains
Diehl, M., & Stroebe, W. (1991).	*Productivity loss in idea-generating groups: Tracking down the blocking effect*	• waiting time is the factor responsible for the

		productivity loss in brainstorming groups • causes of illusion of group effectivity: o people enjoy working in groups much more than working individually o the baseline fallacy, common assumption that "two heads are better than one"
Dugosh, K. L., & Paulus, P. B. (2005).	*Cognitive and social comparison processes in brainstorming.*	• exposure to more ideas affects in a positive fashion both the total number of non-redundant ideas generated and the number of unique ideas generated • the likelihood of generating unique ideas increases with the total number of ideas generated
Gallupe, R. B., Dennis, A. R., Cooper, W. H., Valacich, J. S., Bastianutti, L. M., & Nunamaker, J. F. (1992).	*Electronic brainstorming and group size.*	• productivity of electronic brainstorming groups is higher than that of non-electronic brainstorming groups • members of electronic brainstorming groups reports less apprehension than do members of non-electronic brainstorming groups
Kiesler, S., & Sproull, L. (1992).	*Group decision making and communication technology.*	• physical order arises from natural limitations and opportunities of space and time • technology can stimulate change in the social order of groups and thus have a second-level effect on group behavior and decision making
Nijstad, B. A., Stroebe, W., & Lodewijkx, H. F. (2003).	*Production blocking and idea generation: Does blocking interfere with cognitive processes?*	• production blocking interferes with the cognitive process of idea generation

Paulus, P. B., & Dzindolet, M. T. (1993).	*Social influence processes in group brainstorming*	• members of interactive groups are influenced by the performance of other group members as well as by information about performance of other groups
Paulus, P. B., & Yang, H.-C. (2000).	*Idea generation in groups: A basis for creativity in organizations.*	• the group-writing technique results in greater productivity than individual writing
Paulus, P. B., Dzindolet, M. T., Poletes, G., & Camacho, L. M. (1993).	*Perception of performance in group brainstorming: The illusion of group productivity.*	• there is a bias in favor of interactive group brainstorming • illusion of productivity in actual brainstorming groups • tendency to attribute a disproportionate amount of the group's performance to personal efforts
Rietzschel, E. F., Nijstad, B. A., & Stroebe, W. (2006).	*Productivity is not enough: A comparison of interactive and nominal brainstorming groups on idea generation and selection*	• group participants appear to be unable to distinguish good from poor ideas
Schunk, D. H. (1990).	*Goal setting and self-efficacy during self-regulated learning.*	• the belief that one has control over outcomes raises self-efficacy
Ziegler, R., Diehl, M., & Zijlstra, G. (2000).	*Idea production in nominal and virtual groups: does computer-mediated communication improve group brainstorming?*	• computer mediated communication does not result in any increase in creative idea production

Table 2. Main findings on brainstorming.

3 Research specifics

3.1 Research questions

Once read the outcomes of the studies conducted on brainstorming (a part of them), it is clear that this specific technique cannot be considered as effective as its creator was expecting. Researchers have found multiple aspects of this group activity which can affect the performance and the way we shape the activity is crucial for the outcome.
We have already discussed the importance of group manipulation for the productivity, among the different variables which have an effect on brainstorming, we reckoned this one as the most interesting. The study of this aspect can be further explored analyzing its subcategories, in particular we focused on setting and goal. The reason for choosing these variables is double because we had to find a trade-off between significance and feasibility of the experiments. Concerning the significance, it is widely acknowledged the superiority of nominal groups in term of productivity, therefore studying settings considered as nominal (brainstorming), normal (brainstorming) or individual seemed a valuable opportunity. Furthermore, in literature are present several hints suggesting that goal setting could have a strong effect on productivity. Rietzschel et al. (2006) claimed that it would be interesting studying whether fixing goals could influence both processes of production and selection and they recognized the importance of this topic for future studies. Furthermore, specific goals boost performance defining the fair amount of effort required for the task (Schunk, 1990) and it has been proved that people are influenced by others' performance (Paulus & Dzindolet, 1993). According to literature, we hypothesized that goal setting can trigger somehow a positive conformity mechanism which leads participants to reproduce the suggested performance. Since we had the chance to work with groups, it seemed also interesting studying the perception of individual performance within groups and testing whether our selected variables have an influence on it.
Feasibility of observations, both in term of practicality and data assessment, represented an important obstacle to overcome. It would have been interesting

studying features like the effect of group training (as observed by Paulus, Larey, & Ortega) or the fear of judgement (evaluation apprehension), but it would have been very difficult arranging groups for this kind of experiments and also analyzing the following data. Variables whose study is straightforward are usually the most objective, therefore measuring the effect of setting and goal on the number of ideas produced, came out as the most suitable option. In this way our observation aimed to assess empirical numbers with no need to enter subjective decisions.
Once selected the variables to be observed, we aimed to study the following features:

1. effect of setting and goal on groups' performance, computing whether these variables are both significant and statistically correlated with the number of ideas produced;
2. comparing personal perception of productivity with the real one observed in the experiment;
3. since there is a common bias supporting group superiority, comparing groups' and individuals' performance.

3.2 Research design

The following step was finding the right participants to enroll in the experiments; reliable experiments, in fact, are supported by an appropriate number of participants. Since ours were supposed to be held in the university, which can provide a broad number of potential subjects, we focused on Ca' Foscari's students. All of them belonged to the same year and course, this was not made by chance, but in order to decrease the effect of evaluation apprehension to the minimum level since all subjects were peers and no expert could be detected. As expected, it was also necessary finding a way to encourage students to join the experiments, for this reason a real "rewarding system" was adopted. All participants were enrolled in Decision Making, an eligible course for management students, under the consensus of the professor, the participation to the experiment would have been recognized as a contribution for the course. Adopting this system, we had a satisfactory sample for the first experiment, whereas participation

decreased for the second one since most of the course students had already accomplished their purpose. Even though it was not the topic of our study, we have experienced that rewarding systems accomplish their goals and, for sure, they have a crucial role in designing the HR policies.

The research questions of our thesis were studied in two experiments: questions 1 and 2 in the first experiment, meanwhile question 3 was studied in the second experiment. Subjects were allocated in groups of four people, as suggested in most experiments, in order to create the most suitable environment for group dynamics; furthermore, we had several participants working individually in accordance to the rule of the experiment. Since the rules provided changed in each experiment in order to achieve the research objective, we are going to present them separately for each case.

Participants of all our experiments were asked to solve a problem in which no specific expertise was necessary as it happens in most case studies, problems were invented specifically for our thesis. Groups and individuals had the chance to perform their tasks in detached spaces in order to avoid any interaction and checks were conducted by a supervisor or exploiting videotaping cameras.

4 Implementation and results

4.1 First experiment

4.1.1 Subjects

Subjects were 29 students of Ca' Foscari University of Venice (16 females and 13 males) enrolled in Business Administration, participating at this experiment as an eligible test encompassed in the Making Decisions course; subjects were signed in groups of four according to the different settings that we are going to discuss below, plus an individual that was taken as a control. Eventually we had seven groups simply named with ascending numbers starting from 1.

4.1.2 Task

Subjects, including the individual control, were asked to solve the following problem: *"List all benefits and difficulties that would arise if the minimum age required for accomplishing the driving license in Italy had been reduced at 16"*. This problem was invented for this precise experiment so we did not have any information concerning the outcome. No previous knowledge of the topic was requested to the participants; the task was disclosed the same day of the experiment.

4.1.3 Independent variables

The first brainstorming was characterized by two independent variables:

- *Setting*. In this experiment we adopted groups with two different characteristics, groups 1, 3, 5 and 7 were *normal* brainstorming. It means that subjects were allowed to discuss and share their ideas for the whole time available, our participants were

asked to write down as many ideas as possible; we decided to avoid Osborn's pillars since studies have proved that they are not efficient.

Groups 2, 4 and 6 performed their task with the *nominal* technique, therefore subjects brainstormed alone for the first part of the experiment and discussed their ideas with the whole group in the second part.

- *Goal*. We decided to provide our groups with different objectives regardless the type of group. In order to assess groups' performance, we provided groups 1, 2 and 7 with no objective, groups 3 and 4 with an objective of 15 ideas, groups 5 and 6 with 26. The target given to groups 3, 4, 5 and 6 was adjusted keeping as a reference point the performance of the previous session, but we are going to explain further this point in paragraph 4.1.7.

4.1.4 Dependent variables

There are usually two metrics exploited in literature in order to assess ideas conceived by groups: quantity and quality (e.g. Diehl & Stroebe, 1991; Paulus et al., 1993). Quantity is identified as the number of non-redundant ideas: once the session is over experimenters read the ideas submitted and discard the ones repeated. Concerning the second metric, researchers usually evaluate ideas considering feasibility and originality (or creativity), trying to find a trade-off of both perspectives; this process is usually performed by more than one person.

The problem bounded to quality is subjectivity, even though the assessment is checked and repeated by more than one person, the burden is still present. Since our objective was to provide a study as reliable as possible, we eschewed to measure quality and we worked with one dependent variable, that is *quantity*.

4.1.5 Objective

Eventually we had a 2x1 model with two independent variables (setting and goal) and one dependent variable (quantity); the objective of this experiment was testing the

effect of setting and goal on productivity, moreover we aimed to study whether the independent variables influence each other. During the experiment we increased the value of the goal in order to study more in depth the correlation with the outcome, in addition, the final questionnaire helped us to answer the second research question.

4.1.6 Procedure

Before starting both experiments participants were informed of the rules, groups and individuals had 30 minutes to perform their tasks and each group was located in a different room. We had two rooms available therefore two groups worked simultaneously while the others were waiting; in the end four sessions were held in which was brainstorming one normal and one nominal group at time. Working in this way we had the chance to evaluate the outcome of each session in order to tune the goal of the upcoming one. The operating process can be better understood looking at Table 3.

SESSION	**GROUP NUMBER**	**SETTING**	**GOAL**
FIRST SESSION	1	NORMAL	0
	2	NOMINAL	0
SECOND SESSION	3	NORMAL	15
	4	NOMINAL	15
THIRD SESSION	5	NORMAL	26
	6	NOMINAL	26
FOURTH SESSION	7	NORMAL	0
	CONTROL	INDIVIDUAL	0

Table 3. Allocation of the independent variables and sessions divisions, to these groups is added an individual working as a control

As previously mentioned we only asked our participants to write down as many ideas as possible, an additional suggestion was given just to groups with an objective. It is important remarking that the goal was not a compulsory threshold to be reached, the instruction given was: “Subjects who have already worked on this task were able to write 15/26 ideas (depending on the group setting), feel completely free to write as

many ideas as possible". Of course we were lying because we did not have any information about this task since it was brand new, we adjusted the goal depending on the performance of the previous session.

Normal groups had the chance to discuss and share their thoughts for the whole time available sitting together around a table, they were provided with a single piece of paper encompassing the problem given and they were supposed to write down all their ideas in that sheet; there was no restriction for participants in using other sheets or taking any other kind of notes. The supervisor was present inside the room only at the beginning of the experiment in order to explain the rules and provide the piece of paper; he came back at the end of the 30 minutes just to collect the sheet. Although our experiment was focused on studying performance in term of number of ideas, we were interested in observing the behavior of participants during the group sessions; for this reason, under consensus, we videotaped two normal sessions.

Nominal groups' participants spent the first 10 minutes brainstorming alone sitting on a chair pointed towards the edge of the room, each participant was provided with a sheet with the task written, in which writing personal ideas. After this first part, students could turn around and discuss their ideas with each other for 20 minutes. They were asked to list all ideas in a single new sheet and discard redundant ones, no restriction was given concerning new ideas, members had the chance to further develop or add new ones. This time a supervisor was physically present during all sessions as suggested by literature (Potter et al., 2004), he observed that no one of the participants was sharing ideas during the first ten minutes. Once ten minutes passed, the supervisor let group members turn and they could start their discussion, the new group sheet was provided in this moment. Having a supervisor present within the room gave us once again the chance to observe group behavior making a comparison with normal group.

Last but not least, the student working as individual spent 30 minutes brainstorming alone on the given task in a separate space, no observation was conducted at this stage.

At the end of the experiment each subject was supposed to fill a questionnaire, of course the individual one had some differences because groups questions were not present, the aim was testing the satisfaction towards the experiment and a personal feedback concerning personal and group performance (both questionnaires are available in the

appendix). When filling the questionnaire all participants were asked to not share their information and their behavior was observed by the supervisor.

4.1.7 Results

SESSION	GROUP NUMBER	SETTING	GOAL	NO. OF IDEAS
FIRST SESSION	1	NORMAL	0	9
	2	NOMINAL	0	15
SECOND SESSION	3	NORMAL	15	26
	4	NOMINAL	15	24
THIRD SESSION	5	NORMAL	26	34
	6	NOMINAL	26	27
FOURTH SESSION	7	NORMAL	0	15
		INDIVIDUAL	0	22

Table 4. Results provided by the first experiment

Before entering the topic analyzing our data, it is important clarifying the way in which we fixed our goals moving within sessions. The highest outcome of the first session was 15 (group 2), therefore we decided to provide groups of the second session with a goal equal to the latter value. As a result, the productivity increased to 26 and 24 ideas, once again we decided to change the objective for the following session providing the highest value of the previous one. Productivity increased again, eventually we experienced an increase of almost 2.5 times from the first session, without a goal, to the last one with the highest goal, the effect of goal seems evident.

Table 4 reports the observed results, as a reference point we want to highlight first the individual productivity corresponding to 22 ideas. Comparing this number to group 1 and 2 we can immediately see that groups' production is lower than individual's one (60% less for group 1 and 32% less for group 2). If we just compare the productivity of the first two groups, we find a data which seems consistent with literature (Diehl & Stroebe, 1991), in fact the nominal group outperformed the normal group. But if we keep on analyzing the number of ideas, our study shows a slightly higher productivity for normal groups, in opposition with literature; moreover, group 7 which worked under the normal setting produced the same number of ideas of the second group. This is the first finding of this experiment: the independent variable *setting* does not have a

relevant influence on productivity, this assumption will be later confirmed by the statistical analysis as well. It is important analyzing the difference of this outcome: we believe that the observed inconsistency with literature is mainly due to the length of our sessions. We decided to provide different group settings with the same amount of time, that is 30 minutes, but the time available for group sharing amounted to 20 minutes in nominal groups since members spent their first 10 minutes brainstorming alone, whereas normal groups brainstormed together for the whole time available. We can hypothesize that leaving the same length of time for individual brainstorming people would have outperformed normal groups. There is something to keep in mind underlying the first outcome: time can have an effect on performance. Moving towards the second independent variable *goal*, at a first glance it is easily identifiable an increase in number of ideas following an increase in the objective, it seems that a correlation is present, but we are going to analyze more in depth this point later on.

In order to support our findings with relevant data, we ran an analysis of variance (ANOVA) conducted with the add-on "Solver" of MS Excel; the significance used in all our experiments, 95%, was the same used in literature so that data can be compared. At first we studied the overall significance of the model conducing an f-test[2], Solver provided a value of 0.013, since this number is lower than our selected α (0.05) we can state that the model is significant. The following step was studying the significance of each variable conducing this time a t-test[3]: the p-value of *setting* was 0.65[4], *goal* showed a value of 0.0052; the latter variable can be considered significant (< 0.05) meanwhile we cannot say the same thing for *setting* since the value is higher than α.

[2] Test based on the Fisher-Snedecor distribution aiming to study the variance of two populations both with a normal distribution, a variable is considered significant if the f-test provides a number lower than the selected α

[3] Parametric test aiming to study whether the average value of a distribution is significantly different from a selected reference value, a variable is considered significant if the p-test provides a number lower than the selected α

[4] Statistical results presented from this point ahead are reported rounding with two significant digits

In the end of our statistical analysis, we computed the correlation of Pearson: as expected no correlation was found between *setting* and number of ideas (≅ 0.061), on the other hand an important correlation (≅ 0.94) is present between goal and the dependent variable. This finding is consistent with our initial hypothesis, so we can conclude that differences according to *setting* can be casual, on the opposite, *goal* strongly affects the output.

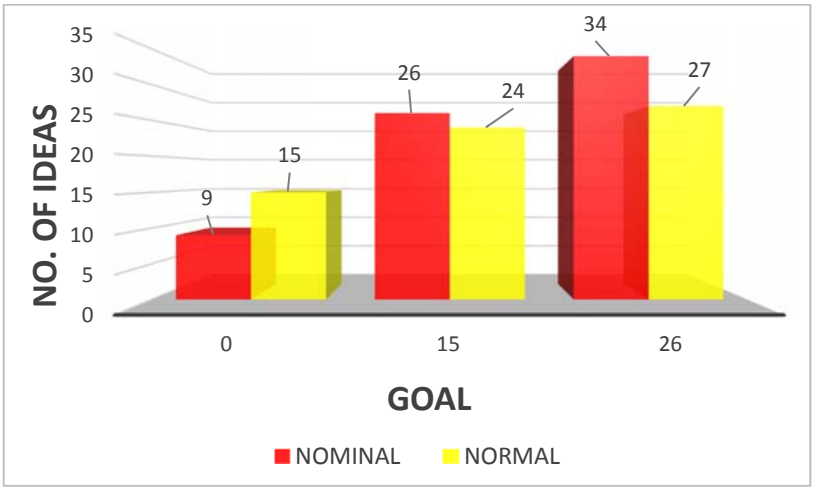


Table 5. Positive correlation between goal and no. of ideas

4.1.8 Behavior

We also want to provide some information concerning the behavior of our participants since some interesting data were collected. As far as nominal groups are concerned, we can realistically hypothesize that students' behavior was influenced by the presence of a supervisor within the room since at time he left the room to test the behavior and when it happened laughs and noise could be heard from outside. Regardless the objective given to our groups, all of them finished their task before the end of the time, since the sharing time for nominal groups was lower than the one given to normal on average they finished closer to the deadline. This behavior was not a surprise since Diehl and Stroebe (1987) reported that interactive brainstorming groups often run out of ideas before the end of the session.

We said before that it was not forbidden to our subjects taking notes during the experiment, of course each nominal participant was forced to write down ideas due to the experiment setting, but what we observed from our videos was that no one of the normal participants decided to take notes during the experiment, the only sheet used was the one given at the beginning. Anyway, it is almost impossible making any hypothesis concerning the effect of notes since we do not have a reference point, but we can assume that a difference would not have been observed under normal condition since note-taking increases productivity mainly when communication is not available (Diehl & Stroebe, 1991).

4.1.9 Ideas

The aim of this experiment was measuring the productivity, therefore it was not conducted a real analysis on the content, even so something came to our attention and it is going to be reported in this paragraph. The task given concerned benefits and problems that would arise decreasing the age for accomplishing the driving license, this event is unlikely to happen in Italy, but it is part of the everyday life in the United States. All groups came out with ideas concerning street safety, responsibility, insurance costs, pollution and so on, ideas that we can define straight forward. When we provided our participants with a goal they had to dig further their creativity in order to find more ideas, examples are car-sharing or the possibility to help grandparents instead of make them taking public means of transport. The most creative people wrote within the benefits the possibility to drive a car at the eighteen birthday party or even more funny, the fact that having more cars, young drivers would have a safe place for "personal business" leading to a higher number of pregnancies.

Despite the nature of these ideas there is a very important point: we did not ask our participants to reach the goal, we just gave them an advice, nevertheless none of the "goal" groups produced less ideas than the amount suggested. This means that an objective does not only affect the productivity, but it can somehow trigger creativity which is necessary to reach superior performance. This outcome cannot be taken for granted because it is consistent with something already observed in literature: the

likelihood of generating unique ideas increases with the total number of ideas produced (Dugosh & Paulus, 2005).

4.1.10 Questionnaire

The last step of each experiment consisted in a close questionnaire with seven questions. Despite of number 7 in which each participant was asked to write a number, all the other questions had a sequence of numbers from 0 to 10; further information can be found in the appendix. The questionnaire aimed to assess participants' satisfaction towards the experiment, but also to have some data concerning personal perception of performance.
Below the list of our questions:

1. Did you enjoy the experiment?
2. How would you assess your performance in this experiment?
3. If you had been asked to brainstorm alone on this problem, do you think you would have generated more or less ideas than you did in this group session?
4. Have you reported all the ideas that had occurred to you?
5. How hard have you tried to find as many ideas as possible?
6. How hard have you strived for a good group performance?
7. How many, of the final ideas listed by your group, come from your suggestions?

We computed means and standard deviation looking for differences according to *setting* and *group*, but it was not observed any significant correlation, therefore we are presenting in this section the overall statistics of our experiment (further information can be found in the appendix).

	QUESTION 1	*QUESTION 2*	*QUESTION 3*	*QUESTION 4*	*QUESTION 5*	*QUESTION 6*
GROUP 1	8	7,75	4,5	8,5	6,25	4,25
GROUP 2	7,5	6,5	3,25	7,25	6,75	6
GROUP 3	8	6,75	3,5	7	6,75	7,75
GROUP 4	8	7	2,5	8,25	8,25	8
GROUP 5	7,75	7,5	4	9	8,5	8,25
GROUP 6	7	5,5	3,25	9,25	6	5,5
GROUP 7	7,75	6,75	3,5	6,5	7,25	5,25
MEAN	7,71	6,82	3,50	7,96	7,11	6,43

Table 6. Means for each question shown by groups, the overall row reports means concerning the entire experiment

Concerning the overall satisfaction (question 1), we can say that our participants enjoyed the experience since the final mean was close to 8, where the maximum grade (10) stood for "a lot". Personal perception of performance was not very high regardless the two independent variables (question 2), this fact could be link to the result of question 6 since participants admitted to have not committed themselves as much as possible for a good group performance. Noteworthy is the result of question 3, underlying this answer there is one of the main and most common bias concerning group activity: all our participants said they would have produced less ideas working alone on this task. It is important remarking this point, it will be the object of study of the second experiment. Keeping on analyzing our results we find in question 4 a data which seems in contrast with Osborn's perception of brainstorming, even though groups were only composed by peers, not many of our participants reported all their ideas. There could be several causes of this behavior (e.g. evaluation apprehension, free riding, production blocking, etc.), but the point is clear: brainstorming cannot unleash individual potential entirely. Concerning the effort experienced in this task (question

5), we can say that group members did have some difficulties, once again it is almost impossible finding the reason of this outcome, for instance it could spread from the unlikelihood of the event or the poor existing knowledge of the topic.
We now want to discuss the result of the last question, we asked each participant to tell us how many of the final ideas came from his/her suggestion, afterwards we computed data of each group, in Table 7 are shown the results.

SESSION	GROUP	GOAL	DECLARED	REAL	RATIO
FIRST SESSION	GROUP 1	0	12	9	1,33
	GROUP 2	0	34	15	2,27
SECOND SESSION	GROUP 3	15	26	26	1,00
	GROUP 4	15	30	24	1,25
THIRD SESSION	GROUP 5	26	31	34	0,91
	GROUP 6	26	25	27	0,93
FOURTH SESSION	GROUP 7	0	22	15	1,47

Table 7. Results of question 7 reported group by group

This particular computation was conducted in order to answer the second research question related to personal perception of performance, comparing observed outcome with personal perception seemed the most suitable and reliable solution. The column "Declared" includes the computation of the answers of each member of the group, the column beside ("Real") shows the real number of non-redundant ideas produced by each group as reported in Table 4; finally, in the last column on the right, we decided to calculate a ratio of the previous two columns computed as "Declared" / "Real".
After reporting data, it was compulsory a statistical analysis of the new "Ratio", in order to understand whether any significance and correlation could be detected. At first, it was observed a statistical significance of the model since the *f-value* was lower than α (f=0.013, <0.05), therefore our hypothesis of assessing personal perception of performance can be considered reliable. Analyzing the single independent variable, we did not observe a relevant significance of *setting*, on the opposite, *goal* resulted once again significant (p=0.02, <0.05) with a relevant negative correlation (-0.76) with "Ratio". This means that the changes observed cannot be defined casual, moreover,

while the goal is increasing, the ratio value decreases. So far we have just discussed numbers, now we have to find a link with reality and a concrete meaning, the graphical representation of Table 8 could help us.

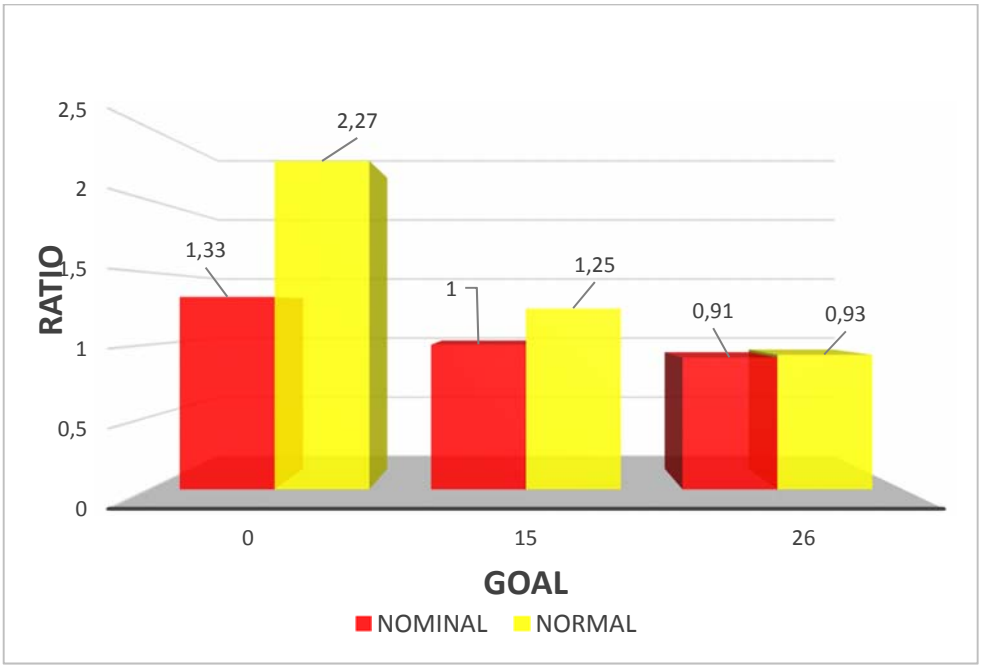
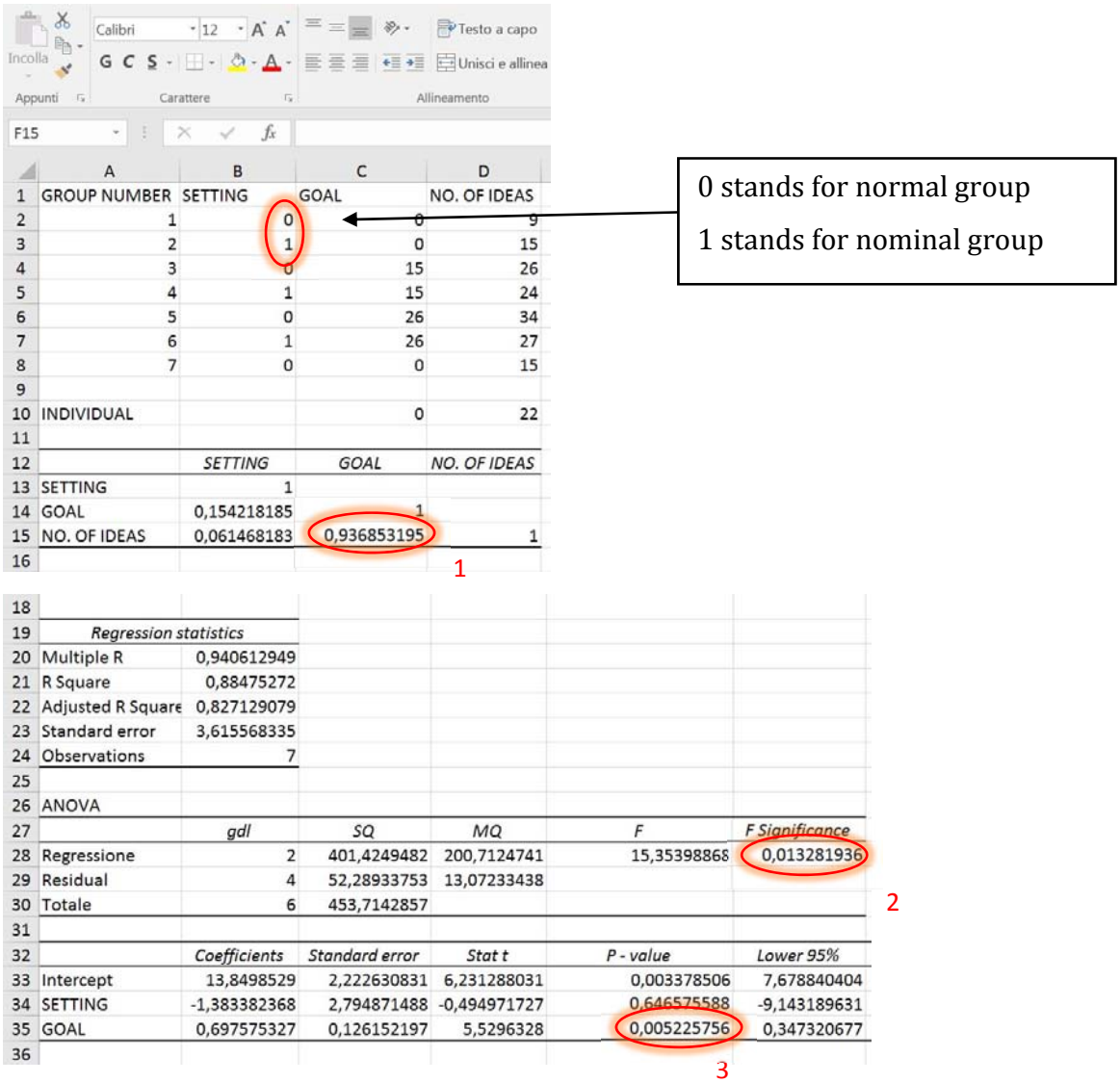


Table 8. Bar chart representing the modification of ratio according to different goals

Our ratio tells us how many declared ideas correspond to real one, using as an example group 2, for each real idea conceived, members declared 2,27 more ideas meaning that they overestimated their productivity. Overestimation is not a novelty, it is already known that people are motivated to view themselves positively (Dunning, 2005) and we also need to remember that when working in groups we are not effective in distinguish our own ideas (Paulus et al., 1993). There is something more to add, as data confirm, the way our subjects assessed their performance changed in a negative way as the goal was increasing meaning that they moved from overestimation (at the beginning) to underestimation (in the end). The observed overestimation bounded to low goals could be explained with human general self-overestimation when the feedback is poor and imprecise, this seems to be our case indeed. Feedback becomes the reference point, but it seems to work until a certain threshold because we

experienced underestimation with higher goals. The latter event could happen when people are facing a difficult task (Moore & Kim, 2003), it could be the explanation of the results in the “26 goal” groups. Regardless potential explanations there is an undeniable point, goal setting affects not only productivity, but also personal perception in a strong and significant way.

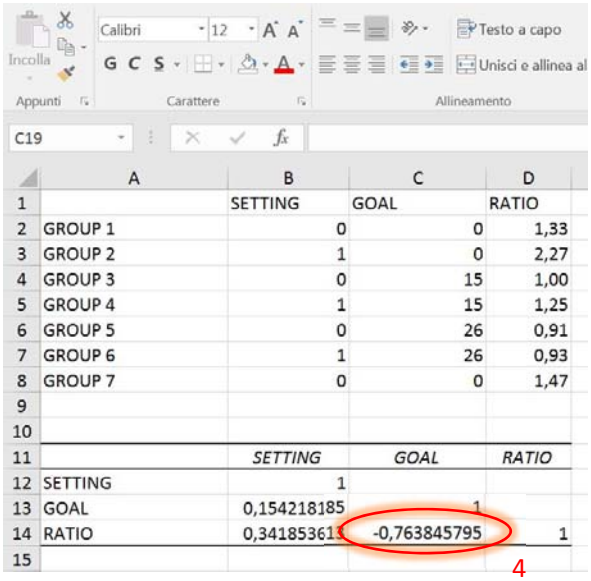
4.1.11 Statistical appendix



	A	B	C	D
1	GROUP NUMBER	SETTING	GOAL	NO. OF IDEAS
2	1	0	0	9
3	2	1	0	15
4	3	0	15	26
5	4	1	15	24
6	5	0	26	34
7	6	1	26	27
8	7	0	0	15
9				
10	INDIVIDUAL		0	22
11				
12		*SETTING*	*GOAL*	*NO. OF IDEAS*
13	SETTING	1		
14	GOAL	0,154218185	1	
15	NO. OF IDEAS	0,061468183	0,936853195	1
16				

18						
19	*Regression statistics*					
20	Multiple R	0,940612949				
21	R Square	0,88475272				
22	Adjusted R Square	0,827129079				
23	Standard error	3,615568335				
24	Observations	7				
25						
26	ANOVA					
27		*gdl*	*SQ*	*MQ*	*F*	*F Significance*
28	Regressione	2	401,4249482	200,7124741	15,35398868	0,013281936
29	Residual	4	52,28933753	13,07233438		
30	Totale	6	453,7142857			
31						
32		*Coefficients*	*Standard error*	*Stat t*	*P - value*	*Lower 95%*
33	Intercept	13,8498529	2,222630831	6,231288031	0,003378506	7,678840404
34	SETTING	-1,383382368	2,794871488	-0,494971727	0,646575588	-9,143189631
35	GOAL	0,697575327	0,126152197	5,5296328	0,005225756	0,347320677
36						

Results of Experiment 1 extrapolated from MS Excel. Reference 1 is the Pearson correlation between *goal* and no. of *ideas*; ref. 2 is the overall significance of the model computed with the *f-test*; ref. 3 reports the significance of the independent variable goal computed with the *p-test*. All previous data are shown in paragraph 4.1.7. In cell B14, we show that no correlation is present between *goal* and *setting*.



	A	B	C	D
1		SETTING	GOAL	RATIO
2	GROUP 1	0	0	1,33
3	GROUP 2	1	0	2,27
4	GROUP 3	0	15	1,00
5	GROUP 4	1	15	1,25
6	GROUP 5	0	26	0,91
7	GROUP 6	1	26	0,93
8	GROUP 7	0	0	1,47
9				
10				
11		*SETTING*	*GOAL*	*RATIO*
12	SETTING	1		
13	GOAL	0,154218185	1	
14	RATIO	0,341853613	-0,763845795	1
15				

4

17						
18	*Regression statistics*					
19	Multiple R	0,89436469				
20	R Square	0,799888198				
21	Adjusted R Square	0,699832298				
22	Standard error	0,259501614				
23	Observations	7				
24						
25	ANOVA					
26		*gdl*	*SQ*	*MQ*	*F*	*F Significance*
27	Regression	2	1,076704937	0,538352	7,994413042	0,040044733
28	Residual	4	0,26936435	0,067341		
29	Totale	6	1,346069288			
30						
31		*Coefficients*	*Standard error*	*Stat t*	*P - value*	*Lower 95%*
32	Intercept	1,520862031	0,15952576	9,533645	0,000675948	1,077947514
33	SETTING	0,417229972	0,200597415	2,079937	0,10603051	-0,139717738
34	GOAL	-0,033455693	0,009054371	-3,69498	0,020927264	-0,058594658
35						

5

6

Analysis of question 7conducted with MS Excel. Ref. 4 defines the Pearson correlation between the dependent variable *goal* and the computed ratio; ref. 5 and 6 represent the significance of the model and variable respectively.

4.2 Second Experiment

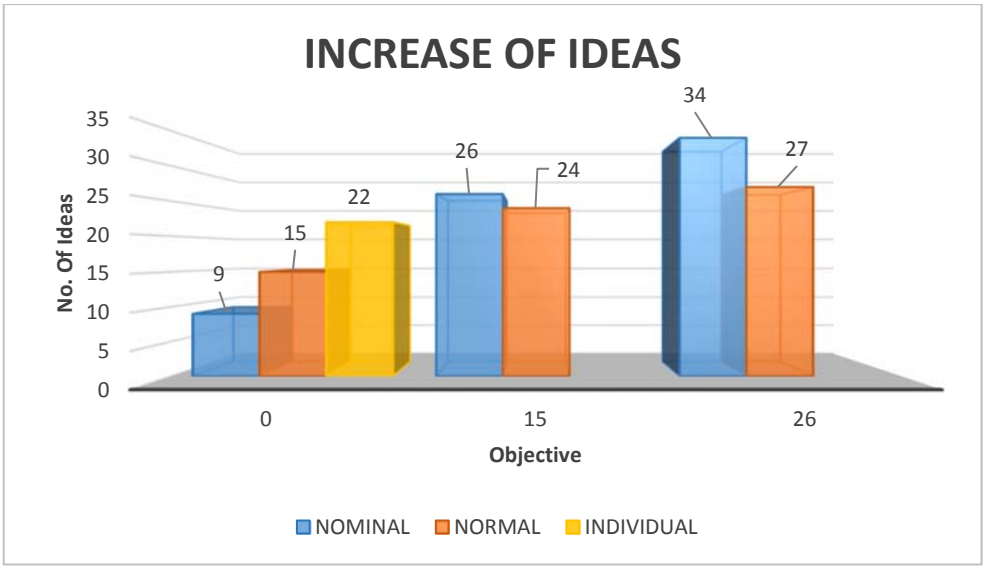


Table 9. Productivity of the first experiment including the individual information

Table 9 shows the results of the first experiment, the representation is slightly similar to the one in Table 5, but this time we are also introducing the productivity of our control, which worked individually. As it can be immediately seen, the individual outperformed both normal and nominal groups in the first session, unfortunately we do not have data to be compared with sessions two and three, but we can hypothesize that the same trend would have been observed.

The superior performance of individuals is widely acknowledged and our control confirmed this assumption, moreover another important point spread from experiment one: in the final questionnaire all our participants affirmed they would have produced less ideas working alone. Taking into account these two outcomes we decided to design a new experiment which aimed to compare the productivity of groups and individuals.

4.2.1 Subjects

The experiment was conducted once more in Ca' Foscari University of Venice with 11 students (7 females and 4 females) enrolled in Business Administration, participating

at the experiment as an eligible test encompassed in the Making Decisions course. Seven participants of this experiment took also part to the first experiment, but this time they were allocated to a different setting in order to make them experience a different system and to avoid any biases. Subjects were allocated in two groups of four people (one nominal and one normal) plus three individuals working alone.

4.2.2 Task

As in the previous experiment we gave our participants a novel task to work on, this time the topic proposed was the following: *"List all benefits and difficulties that would arise if university had been compulsory for all citizens"*. No previous knowledge of the topic was requested to the participants, the task was disclosed the same day of the experiment.

4.2.3 Independent variable

On the opposite of the previous experiment, we worked just with one independent variable, named as before *setting*. However, this time the independent variable had a different meaning, it meant either group or individual, we did not make any differences between nominal and normal groups because looking for differences within group activities was the goal of Experiment 1.

4.2.4 Dependent variable

Since measuring productivity was the objective of this experiment, the dependent variable was the same of Experiment 1, the *quantity* which was identified as the number of non redundant ideas produced. Any kind of further study was eschewed because we reckoned assessing the quality of ideas too subjective and not useful for our aim.

4.2.5 Objective

Starting from the outcomes of Experiment 1, the aim was assessing whether the common perception expressed by participants about the superior performance of groups was true. We also wanted to study the statistical influence and importance of settings on productivity.

4.2.6 Procedure

Participants were informed about the rules of the experiment just before the beginning of the session, there was one room available therefore groups worked one at time meanwhile individuals were working in different locations. In order to make the two experiments as comparable as possible, none of Osborn's rules was given, we simply asked our participants to write as many ideas as possible.
All students had 30 minutes to complete the task, the procedure for the nominal group was the same adopted in Experiment 1; this time session were not videotaped. Individuals were provided with a single piece of paper each of them including the proposed task to work on, one sheet was also given to the normal group; members of the nominal group received one sheet at the beginning of the experiment and a new one after ten minutes in order to collect all ideas and add or modify new ones.
At the end of the experiment we asked our participants to fill the same questionnaire of Experiment 1, moreover we ran an interview with those who took part to both experiments.

4.2.7 Results

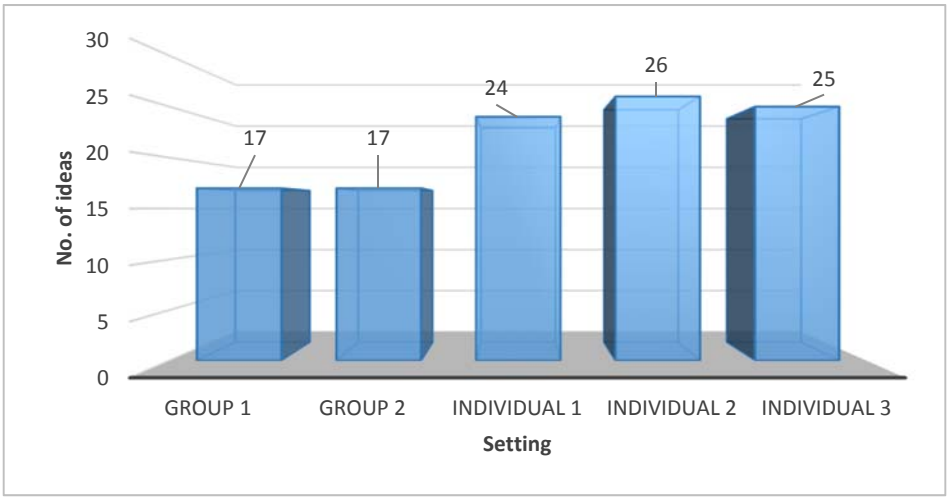


Table 10. Performance according to different settings

Table 10 reports the productivity of the second experiment, starting from the left we find the performance of our groups, afterwards are located the bars corresponding to individuals. It is important remarking that there was no difference in the rules given to the participants and no hint was provided.

Groups conceived 17 ideas each, meanwhile individuals performed 24, 26 and 25 ideas respectively; all final sheets collected were checked in order to discard redundant ideas. The outcome is straight forward: individuals outperformed groups producing on average 29% more ideas. This was exactly the outcome forecasted according to the broad literature claiming the superiority of individuals, it is also remarkable the productivity of groups since there was one normal and one nominal, regardless their setting it was observed the same productivity.

As we did before, the reliability of our data was statistically measured testing the significance of the model and computing the correlation between *setting* and the number of ideas produced, in order to perform this analysis it was exploited once again the tool "Solver" of MS Excel. Since we had a 1x1 model, f-test and p-value had the same value, working once again with a 95% significance the value corresponded to 0.0017, lower than 0.05 therefore we can assume the significance of our model. Afterwards, the

correlation was computed providing a remarkably strong positive value of almost 0.99, it is now clear that deciding to work in group rather than individually has a crucial impact on performance.

4.2.8 Questionnaire

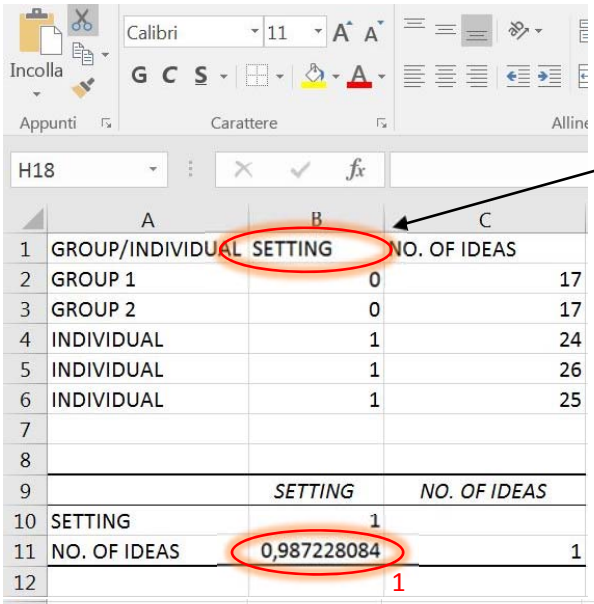
	QUESTION 1	*QUESTION 2*	*QUESTION 3*	*QUESTION 4*	*QUESTION 5*	*QUESTION 6*
GROUP 1	7,25	7,25	4	10	6,5	9,25
GROUP 2	8	6,75	3,25	7,25	7	5,25
MEAN	7,63	7	3,63	8,63	6,75	7,25

Table 11. Average scores of the questionnaire

Scores of the second questionnaire are mainly in line with the previous one, we just want to emphasize the outcome of question 4 for group 1 (nominal group), it is the only group in which all participants reported to have shared all their ideas. If we consider the whole sample of our experiments, just one out of the nine groups reported a perfect sharing of ideas, we acknowledge that reaching a perfect process of ideas' sharing is impossible, but for sure brainstorming does not fix problems arising in group activities. Subjects reported a significant low reliance on individual performance, a value of 3.63 was observed which is similar to the 3.5 computed in Experiment 1, meaning that participants reckoned they would have produced less ideas working alone. We observed once more that a remarkable bias towards group productivity is always present, in this experiment as well, none of our participants reported a higher perception of performance for individuals.

The latter outcome was also confirmed by the interview held with second time participants, two out of the seven students worked as individuals this time, whereas they brainstormed in groups in the first experiment. Since they experienced both settings it could be expected a different answer, anyhow both stated they would have produced more ideas working in groups even they also reported a poor group attitude.

4.2.9 Statistical appendix



	A	B	C
1	GROUP/INDIVIDUAL	SETTING	NO. OF IDEAS
2	GROUP 1	0	17
3	GROUP 2	0	17
4	INDIVIDUAL	1	24
5	INDIVIDUAL	1	26
6	INDIVIDUAL	1	25
7			
8			
9		*SETTING*	*NO. OF IDEAS*
10	SETTING	1	
11	NO. OF IDEAS	0,987228084	1
12			

1

15						
16	*Regression statistics*					
17	Multiple R	0,987228084				
18	R Square	0,974619289				
19	Adjusted R Square	0,966159052				
20	Standard error	0,816496581				
21	Observations	5				
22						
23	ANOVA					
24		*gdl*	*SQ*	*MQ*	*F*	*F Significance*
25	Regression	1	76,8	76,8	115,2	0,001729355
26	Residual	3	2	0,666666667		
27	Total	4	78,8			
28						
29		*Coefficients*	*Standard error*	*Stat t*	*P - value*	*Lower 95%*
30	Intercept	25	0,471404521	53,03300859	1,47665E-05	23,49978042
31	SETTING	-8	0,745355992	-10,73312629	0,001729355	-10,37205542

2

3

Results of Experiment 2 extrapolated from MS Excel. Ref. 1 is the Pearson correlation between *setting* and no. of *ideas*; ref. 2 is the overall significance of the model computed with the *f-test*; ref. 3 reports the significance of the independent variable goal computed with the *p-test* (as expected is equal to the *f-test*). All previous data are shown in paragraph 4.2.7.

5 Statistical control

The objective of statistical analysis is providing data and information that should be as reliable as possible, even though computations are conducted in an appropriate manner, sometimes it could happen that metrics studying the same aspect come up with different results. For instance, Hauke and Kossowski (2011) studied variables' correlation with the Spearman and Pearson coefficient demonstrating that the Spearman significance does not necessarily lead to Pearson significance even for big sets of data. In order to avoid any kind of pitfalls we checked all our data for a second time exploiting a different metric.

So far we have presented values computed with MS Excel, the correlation shown is calculated with the Pearson coefficient which measures the strength of the linear relationship between two variables[5]. The coefficient is computed with the following formula (Ross, 2005):

$$\rho_{x,y} = \frac{cov\ (X, Y)}{\sigma_x \sigma_y}$$

cov: is the covariance

σ_n: is the standard deviation of the n variable

The check of our first statistic was ran exploiting the Spearman coefficient, a nonparametric (distribution-free) rank statistic proposed as a measure of the strength of the association between two variables[5]. This coefficient assesses the degree in which an arbitrary monotonic function can describe the relationship between two variables regardless their frequency; it does not require a linear relationship and can be used for variables measured at the ordinal level[5].

[5] Hauke, J., & Kossowski, T. (2011). Comparison of values of Pearson's and Spearman's correlation coefficients on the same sets of data. *Quaestiones Geographicae*, 30(2), 87–93.

Since variables have to be translated in ordinal ones, the first step consisted in the computation of ranks for each observation, the calculation was conducted with the "Rank" function of MS Excel. After the first calculation, Spearman coefficient is simply computed as the Pearson correlation between ranks[5]. We held this process for each variable in both our experiments, data are presented in the Tables below.

GROUP	GOAL	NO. OF IDEAS	Rank (Objective)	Rank (No. of ideas)
GROUP 1	0	9	1	1
GROUP 2	0	15	1	2
GROUP 3	15	26	4	5
GROUP 4	15	24	4	4
GROUP 5	26	34	6	7
GROUP 6	26	27	6	6
GROUP 7	0	15	1	2
		STANDARD DEVIATION	2,29	2,27
		COVARIANCE	5,05	
		SPEARMAN COEFFICIENT	**0,97**	

Table 12. First experiment, correlation between goal and no. of ideas

GROUP	SETTING	NO. OF IDEAS	Rank (Setting)	Rank (No. of ideas)
GROUP 1	0	9	1	1
GROUP 2	1	15	5	2
GROUP 3	0	26	1	5
GROUP 4	1	24	5	4
GROUP 5	0	34	1	7
GROUP 6	1	27	5	6
GROUP 7	0	15	1	2
		STANDARD DEVIATION	2,14	2,27
		COVARIANCE	0,29	
		SPEARMAN COEFFICIENT	**0,059**	

Table 13. First experiment, correlation between setting and no. of ideas. Concerning setting, 0 identifies normal groups, while 1 identifies nominal groups

GROUP/ INDIVIDUAL	SETTING	NO. OF IDEAS	Rank (Setting)	Rank (No. of Ideas)
GROUP 1	0	17	1	1
GROUP 2	0	17	1	1
INDIVIDUAL 1	1	24	3	3
INDIVIDUAL 2	1	26	3	5
INDIVIDUAL 3	1	25	3	4
		STANDARD DEVIATION	1,10	1,79
		COVARIANCE	1,80	
		SPEARMAN COEFFICIENT	**0,92**	

Table 14. Second experiment, correlation setting and no. of ideas. Concerning setting, 0 identifies groups, while 1 identifies individuals

After ranks, for each variable was calculated its standard deviation and the covariance between the two, eventually the coefficient was computed applying the Pearson formula to ranks, results are highlighted in bold. The coefficient was also calculated with the MS Excel "Pearson" formula applied directly to ranks, outcomes were exactly equal to the ones shown in our tables.

Spearman coefficient can be read in the same way of Pearson, therefore 1 corresponds to a positive strong correlation whereas -1 is related to a negative strong correlation. Comparing data shown in tables above and Pearson coefficient computed in paragraph 4.1.7 and 4.2.7, it can be easily observed that they are perfectly aligned, for an easier observation values are reported in Table 15.

Experiment	Correlation	Spearman Coefficient	Pearson Coefficient
First	Goal – No. of Ideas	0.97	0.94
First	Setting (normal/nominal) – No. of Ideas	0.059	0.061
Second	Setting (group/individual) – No. of Ideas	0.92	0.99

Table 15. Comparison between Spearman and Pearson coefficient

The threat of over interpretation is always likely to happen when discussing numbers because it has always to be kept in mind that reality cannot be explained by simple numbers. Once remarked this point, it can be affirmed that these results strengthen the assumptions supported so far and the outcome is remarkably important since we worked with smaller samples comparing to the ones available in literature.

6 Why companies still use brainstorming?

Now that we have acquired a deeper knowledge of brainstorming and its downsides, it would be fair wondering why companies and other organisations still use brainstorming. Which is the underlying assumption fostering the use of brainstorming since in some organisations it is the starting point of all types of projects (IDEO and Google could be suitable examples)?

A first answer arises from the results of both our questionnaires, as previously reported all our participants stated they would have produced more ideas working in groups even though it has been proved that this assumption is far from reality. It means that on average we prefer working in groups and despite the lower productivity the use of brainstorming can create more desirable working place. Of course the first goal of all kind of companies is effectiveness, but they also have to take care of the environment in which workers perform their activities. We have already mentioned that group members report a higher perception of their own performance after brainstorming, this could be also a benefit for companies because satisfied workers could be more productive. Activities within organisations are not only limited to idea production and a slightly lower performance (in term of ideas) associated with a more suitable working environment could lead to a higher performance of the overall organisation.

Researchers have also tried to address this question, Furnham (2000) provided three main reasons supporting the use of brainstorming:

- *increase decision acceptance*, since people are involved in conceiving ideas it is more likely that the rate of acceptance is wide and easier to reach; if people are not actually involved in this process, it would be possible that they understand better the idea;
- *pool resources*, related to a common bias that the performance of a group is greater than the sum of individuals themselves, according to this thought, the amount of knowledge needed to make a good decision would increase;

– *benefit from specialisation of labour*, working in groups, people tend to always repeat the task for which they are best suited leading to a real specialisation for the individual and a higher performance for the group.

It could be hypothesized that companies making a massive use of brainstorming accept the downsides of this techniques finding a trade-off between productivity and satisfaction of their employees. Companies which try to find this balance cannot be blamed and we acknowledge that it would be more likely to find people willing to work in this kind of "trade-off" companies.
There is also one more possibility supporting the use of brainstorming, it could be that companies simply neglect the variety of literature demonstrating the inferior performance of brainstorming and since it is unlikely to have internal comparison of performance, they keep on using this technique. We also have to consider that nowadays group activities are widely exploited and sharing their use can be reckoned both fashion and somehow useful to increase the employer branding. Students of many universities grow up acquiring an attitude of group activities because they are used to work in this way therefore it is normal that once in the labour market they keep on working with group attitude.

7 Managerial implications

Critics are useful only if it is also provided a set of solutions to fix problems, so far we have discussed several downsides of brainstorming, in this chapter we would like to provide possible solutions in order to make a better use of the Osborn's technique.

The results of our experiments have demonstrated the strong effect that goal setting has on the productivity of brainstorming, even though participants were not asked to conceive a precise number of ideas, they were triggered by the information provided. Goal should have an unconscious effect on people's mind and it is something to keep in mind when working in groups. The objective we decided to provide to our participants was a numeric goal, but we can hypothesize that also qualitative goal could influence productivity. Objective could work not only as a target to be reached, but also as a suggestion for the kind of outcome expected and somehow a way to define the path which has to be taken.

The aim of reaching the most suitable outcome could be helped naming a trained facilitator as suggested for the nominal technique (Potter et al., 2004), if this position is forecasted for a group activity it is important defining also the duties of which he/she will be in charge. For instance the facilitator does not have to prevent criticism because it has been proved that imagination strives on conflict (Nemeth et al., 2004), but he/she could be useful to keep members on the right track. We mentioned a "trained" facilitator because the person identified for this task must know how to make people working in the proper way, without blocking creativity. The facilitator could monitor that everyone has a chance to speak and share his opinion, moreover he/she could provide notebooks to prevent people to forget their ideas and overcome the problem of the waiting time.

Writing down ideas on a piece of paper has been identified as a useful technique to improve brainstorming (Wilson, 2006), in literature it is called *brainwriting* and it consists in making all group participants noting their ideas and passing all sheets among them. The aim is once again overwhelming production blocking, but also triggering creativity making all group members aware of others' ideas. Once a member has listed all his ideas, the page is passed along to the next person that is urged to add

something new, this process is repeated several times and in the end all ideas are listed on a board for a final discussion. *Brainwriting* is a useful approach when someone in the group could be inhibited by other members or when quarrels are likely to happen, the indirect contact helps avoiding undesirable behavior of participants. Switching face-to-face meetings with the writing technique could be also a suitable solution when groups are composed by a consistent number of people and letting all of them speaking would be not only difficult, but also loud. Lastly, *brainwriting* is advisable when there is no enough time to arrange a real brainstorming and ideas are needed in a short time (Wilson, 2006).

A help for brainstorming comes from the new technologies as well, several authors identified electronic brainstorming, which could be considered an evolution of *brainwriting*, as a possible solution for productivity loss. Since technology has such a relevant importance in the current times, we are going to discuss further this topic in the next paragraph.

We are used to think that diversity could foster creativity, we are not denying this assumption, but when it comes to groups also diversity can become a pitfall. Diversity could lead some group members to consider other participants as experts on the topic and now we know that these kind of preconceptions negatively affect productivity. It would be better not having in group members that could scare other people increasing the evaluation apprehension; it is desirable that members have at least a minimum awareness of all participants and when it is not possible, introducing new entrants to the whole group would be useful (Wilson, 2006), a facilitator could help in this effort.

Most of the times brainstorming is forerun by individual brainstorming, participants are asked to be already prepared on the topic before engaging the group session, in the following group activity they will produce the final ideas. Brown and Paulus (2002) studied the opposite setting, which consists in switching group meeting and individual brainstorming: subjects involved have at first a group brainstorming, meanwhile the idea production process is ended individually. Eventually they observed that the latter technique is more productive and especially the cognitive facilitation occurring in the group meeting carries over in the individual session. The magnitude of this setting is even stronger when adopted for more heterogeneous groups, it is something to keep in

mind when arranging a group activity because a simple change in the schedule would affect strongly the overall productivity (Brown & Paulus, 2002).
In the previous chapter we have discussed the "attitude" of group activity that modern students are used to develop studying at the university, someone could argue that training for a long time in group dynamics could help people improving the "group ability". It would not be strange such an outcome since generally speaking practicing helps efficiency, but the same thing cannot be stated for brainstorming. Indeed, it was observed that such a training does not help individuals overcoming the different sort of problems arising from brainstorming (Paulus et al., 1995). This point is a suggestion for not committing too much time and energies in teaching activities since they do not have a real impact, it is something that could become important for companies willing to develop a group attitude among their employees.

7.1 Electronic brainstorming (EBS)

Nowadays we live in a society where technology is present in all moments of our days, it has become fundamental in all kind of activities from the very simple to the most difficult ones. A couple of decades ago technology would have been identified just in PCs and a few other items, whereas in the 21st century we have super fast smartphones, wrist watches with HD screens, but also self-driving cars and real artificial intelligences. Of course all these possibilities have also changed the way in which people can communicate, it is not necessary spending too much time describing social networks and the huge and different services they can offer. The increasing affordability of electronic devices is making communication easier day by day, people at the opposite side of the world can not only speak, but see each other on a screen live in high quality. It is straight forward that there is also an effect on the way groups can held their meeting, for this reason we do not just have face-to-face brainstorming, but also the so called *electronic brainstorming*, frequently synthesized in EBS.
Studies on meetings conducted without physical interaction have started in the 70s exploiting telephones, moving to computer and keyboards between the 80s and the 90s. Gallupe, Bastianutti and Cooper (1991) demonstrated that the use of computer for

brainstorming increases productivity not only in groups brainstorming, but also in nominal settings. People benefit of the exposure to a broad range of ideas, eschewing the side effect of the verbal "traffic jam" detected in face-to-face brainstorming (Brown & Paulus, 2002); moreover, since ideas are saved in the conversation, they can be further retrieved and could trigger the development of new ideas lowering the waste of potential future ideas.

The productivity of electronic brainstorming was proved to increase with size of groups, but for sure this effect could not be constant and linear incrementing group members[6]. This point provides a useful hint for the use of EBS, it would be desirable a face-to-face meeting when working in pairs or with three participants, meanwhile groups of four people or more can increase their productivity exploiting technological devices.

EBS does not only affects productivity, it is convenient when the expected members of a meeting are dispersed in different location and it would be almost impossible arranging a face-to-face group, just think about managers of multinational companies located worldwide. In this sense electronic meetings give the chance to not allocate too much responsibility on a single person who can make decisions with others' point of view[6].

Studies concerning the effect of technology did not focus just on productivity, but also on the behavior of subjects involved. Members of interactive groups found the task easier, witnessing lower apprehension and higher perception of participation[6]; this means that the use of EBS, in association with interactive technique, does not only have an effect on productivity, but provides a more convenient mood for working.

There are two main features in electronic brainstorming which could be responsible of the increase in productivity:

[6] Gallupe, R. B., Bastianutti, L. M., & Cooper, W. H. (1991). Unblocking brainstorms. Journal of Applied Psychology, 76(1), 137.

- *anonymity*, since subjects are not meeting face-to-face they experience less fear of other people and feel more free to share their thoughts[7]; this point is related to one of the main causes of productivity loss previously reported which is *evaluation apprehension*, its effect is lower while working in EBS;
- *parallel and immediate entry*, communication held with keyboards eschews *production blocking* (another cause of productivity loss) because people can use better the waiting time with no need of rehearsing ideas as they are free to enter the discussion whenever ideas occur[7].

Abovementioned anonymity, encompasses also an effect on mutual perception of participants, people rate of sharing is lower when they perceive that within groups there could be experts, EBS can reduce the threat of hierarchy equaling the importance of members[7]. On the other hand, real interaction creates a social context which identifies the behavior that has to be held, what Kiesler and Sproull (1992) called social *context clues*. Clues have a strong effect on the way people interact, the lack of a social context makes it hard for people to perceive and adapt to the "social order-social structure" roles and situational norms[8]. These circumstances lead to what Kiesler and Sproull (1992) named "second level effect" (second because it is an indirect outcome of technology) identified in self-centered and unregulated behavior. People are less concerned about the appearance they make to other people as they do not have an immediate feedback, eventually it was observed a more extreme, impulsive and less socially differentiated behavior. This is something we experience everyday on social networks, it is very common finding people hurling pitiful insults even on silly discussion and without no real meaning; it seems like no threshold is present and people feel completely free to share their annoyance in the way that is perceived most suitable. Even though second level effects are widely acknowledged, it has not been

[7] Gallupe, R. B., Dennis, A. R., Cooper, W. H., Valacich, J. S., Bastianutti, L. M., & Nunamaker, J. F. (1992). Electronic brainstorming and group size. Academy of Management Journal, 35(2), 350–369.

[8] Kiesler, S., & Sproull, L. (1992). Group decision making and communication technology. Organizational Behavior and Human Decision Processes, 52(1), 96–123.

identified yet the psychological mechanism which triggers people towards the unregulated behavior.

So far we have discussed the effect of EBS on one step of brainstorming which is the generation process, indeed it outperforms face-to-face meetings both in term of quantity and quality, but there are still doubts concerning its effect on the other group tasks[7]. Considering the effect of EBS on behaviour it would be possible that other activities, like idea organisation or the stakeholder benefits' analysis, would be negatively affected by this technique. It is desirable a proper use of electronic features according to the expected results, people involved in the meeting and the topic that has to be discussed.

EBS can be useful when the previous knowledge about a topic is poor or before a real meeting in order to define the main points of the following discussion; on the other hand face-to-face meeting would be desirable when it is going to be discussed a complex problem or when parties involved in the discussions are in formal relationships and unregulated behaviour is undesirable.

8 Conclusions

This thesis has aimed to provide an added value to the brainstorming theory trying to fill the poor knowledge which is usually faced about this topic; a lot of people are aware of brainstorming, but just a few can exploit it effectively. It is not just about making people working together, it is about finding the right trade-off among all the different perspectives discussed so far in order to reach the most efficient and effective solution. We have focused mainly on two aspects of brainstorming: goal and setting. The first metric strongly affects the output of group meetings regardless the way they are arranged; the statistical analysis supports all our findings providing an important suggestion for the aspect to develop when arranging a brainstorming. Data arising from both our experiments are aligned with literature and this is important to confirm that we worked on the right path.

Concerning the second metric, we observed slightly different data from the expectations: setting is significant when referred to the decision group/individual, but it is not relevant concerning the difference nominal/normal brainstorming. There was no surprise for the first part of our results since experiments have always supported the idea that individuals outperform groups, on the other hand it is usually observed a higher productivity for nominal groups comparing to the one of normal brainstorming. It is very important trying to find a possible explanation of the observation conducted in Experiment 1, we believe that the non-adequacy with literature is mainly related to one aspect: time. In the first experiment we gave the same amount of time to all our groups, this meant that people working in nominal groups had ten minutes less to brainstorm together comparing to normal groups. In literature, the individual brainstorming session of the nominal group usually can exploit the same amount of time provided for the whole normal brainstorming. This means that in our experiments nominal subjects had less time available, therefore our data are not completely comparable with literature. It can be hypothesized that with more time available the observed results would have been aligned with literature, but there is also another hypothesis that could be made: time somehow affects productivity. Researchers have

already studied this aspect, a further comparison of the "time effect" reducing the availability could be an interesting field of research.

Questionnaires held at the end of the experiments confirmed that a strong bias in favor of group productivity is widely spread, even after experiencing both individual and group sessions subjects confirmed they would have produced more ideas working in groups. This also confirms that the knowledge of brainstorming is on average very poor, it is even more important this outcome because all participants were management students, therefore people that in the future would be in charge of arranging and supervising group meetings. We know from literature that one of the main problem of brainstorming is related to ideas' sharing, people usually do not disclose all their production although brainstorming was conceived in order to avoid any fears of evaluation apprehension. The final questionnaire confirmed this data since just a few of our participants reported to have shared all their ideas, moreover empirical data demonstrated this behaviour both in nominal and normal brainstorming. The latter outcome is remarkably important because it means that evaluation apprehension is a very difficult obstacle to overcome even when groups are composed by peers as it happened in our experiments.

When wondering whether or not conducing a brainstorming there are several points to consider before taking a decision, for instance if an organization has talented and motivated people they should be encouraged to work individually if efficiency is the higher priority (Furnham, 2000). Brainstorming is not always the best solution especially when time available is limited and negative competition is likely to happen. The goal of this thesis has not been discouraging the use of brainstorming at all, but focusing on aspects that are neglected most of the times. The importance of this study is that all findings have practical implications because, as stated in the Research Questions, we focused on objective assessment eschewing any kind of subjectivity. Moreover, we demonstrated that they are not only objective, but also influent therefore a real value added has been provided.

We acknowledge that brainstorming could be useful in specific situations, but cannot be exploited as a standard in all activities. Further studies on the effect of goals on

creativity for instance could help in designing the most suitable objective for each group meeting because in our work creativity has not been considered.

As Sutton and Hargadon (1996) stated, "*it is premature to conclude that face to face brainstorming groups are ineffective*", it would be more fair saying that it is a technique which needs further improvement, but encompasses a great potential when it is not abused and it is tailored for the specific situation.

9 APPENDIX

1. Did you enjoy the experiment?

Not at all										A lot
0	1	2	3	4	5	6	7	8	9	10

2. How would you assess your performance in this experiment?

Very							poor	Very good		
0	1	2	3	4	5	6	7	8	9	10

3. If you had been asked to brainstorm alone on this problem, do you think you would have generated more or less ideas than you did in this group session?

Many less ideas								Many	more
ideas									
0	1	2	3	4	5	6	7	8	9	10

4. Have you reported all the ideas that had occurred to you?

None of them									All of them
0	1	2	3	4	5	6	7	8	9	10

5. How hard have you tried to find as many ideas as possible?

Very easy									Very
hard									
0	1	2	3	4	5	6	7	8	9	10

6. How hard have you strived for a good group performance?

Not at all										A lot
0	1	2	3	4	5	6	7	8	9	10

7. How many, of the final ideas listed by your group, come from your suggestions? (write a number)

Group questionnaire provided in both experiments

1. Did you enjoy the experiment?

Not at all										A lot
0	1	2	3	4	5	6	7	8	9	10

2. How would you assess your performance in this experiment?

Very poor										Very good
0	1	2	3	4	5	6	7	8	9	10

3. If you had been asked to brainstorm in group on this problem, do you think you would have generated more or less ideas than you did in this group session?

Many less ideas										Many more ideas
0	1	2	3	4	5	6	7	8	9	10

4. How hard have you tried to find as many ideas as possible?

Very easy										Very hard
0	1	2	3	4	5	6	7	8	9	10

Individual questionnaire provided in both experiments

	A	B	C	D	E
1					
2		GOAL	NO. OF IDEAS	Rank GOAL	Rank NO. OF IDEAS
3		0	9	1	1
4		0	15	1	2
5		15	26	4	5
6		15	24	4	4
7		26	34	6	7
8		26	27	6	6
9		0	15	1	2
10					
11			ST. DEV.	2,2887	2,2678
12			COV.	5,0476	
13					
14			SPEARMAN COEFF.	0,9725	
15					
16				*Rank GOAL*	*Rank NO. OF IDEAS*
17			Rank GOAL	1	
18			Rank NO. OF IDEAS	0,9725	1
21					
22		SETTING	NO. OF IDEAS	Rank SETTING	Rank NO. OF IDEAS
23		0	9	1	1
24		1	15	5	2
25		0	26	1	5
26		1	24	5	4
27		0	34	1	7
28		1	27	5	6
29		0	15	1	2
30					
31			ST. DEV.	2,1381	2,2678
32			COV.	0,2857	
33					
34			SPEARMAN COEFF.	0,05893	
35					
36				*Rank SETTING*	*Rank NO. OF IDEAS*
37			Rank SETTING	1	
38			Rank NO. OF IDEAS	0,05893	1

1

2

3

4

Spearman coefficient computation for Experiment 1 as reported in chapter 5. Ref. 1 and 3 highlight standard deviations computed for each rank and the related covariance; below these variables is calculated the coefficient with the formula mentioned in chapter 5. In order to check the computation, in ref. 2 and 4 the same coefficient was computed applying the MS Excel tool “Data analysis” directly to ranks.

	QUESTION 1	QUESTION 2	QUESTION 3	QUESTION 4	QUESTION 5	QUESTION 6	QUESTION 7
GROUP 1	7	8	5	10	8	7	4
GROUP 1	7	7	2	10	6	5	3
GROUP 1	9	6	6	9	4	5	3
GROUP 1	9	10	5	5	7	0	2
MEAN	8	7,75	4,5	8,5	6,25	4,25	3
GROUP 2	6	6	3	2	2	5	12
GROUP 2	8	6	3	7	7	7	12
GROUP 2	8	7	3	10	10	8	5
GROUP 2	8	7	4	10	8	4	5
MEAN	7,5	6,5	3,25	7,25	6,75	6	8,5
GROUP 3	7	7	5	10	7	8	8
GROUP 3	8	7	3	10	6	6	8
GROUP 3	7	6	3	0	6	8	3
GROUP 3	10	7	3	8	8	9	7
MEAN	8	6,75	3,5	7	6,75	7,75	6,5
GROUP 4	8	7	2	10	9	7	5
GROUP 4	7	4	0	5	10	9	7
GROUP 4	10	9	5	8	8	8	8
GROUP 4	7	8	3	10	6	8	10
MEAN	8	7	2,5	8,25	8,25	8	7,5
GROUP 5	8	8	4	10	8	8	8
GROUP 5	7	7	4	7	8	7	6
GROUP 5	8	7	3	9	8	8	7
GROUP 5	8	8	5	10	10	10	10
MEAN	7,75	7,5	4	9	8,5	8,25	7,75

	QUESTION 1	QUESTION 2	QUESTION 3	QUESTION 4	QUESTION 5	QUESTION 6	QUESTION 7
GROUP 6	7	6	4	10	6	6	6
GROUP 6	6	3	3	10	7	8	6
GROUP 6	7	6	4	10	6	5	10
GROUP 6	8	7	2	7	5	3	3
MEAN	7	5,5	3,25	9,25	6	5,5	6,25
GROUP 7	8	7	5	3	8	6	6
GROUP 7	10	6	3	3	9	5	4
GROUP 7	6	7	3	10	6	7	8
GROUP 7	7	7	3	10	6	3	4
MEAN	7,75	6,75	3,5	6,5	7,25	5,25	5,5

Results of the group questionnaire for Experiment 1. For privacy reasons we are not reporting real names of group members, but the name of the corresponding group. After each group is reported a “mean” line with the average computed for each question.

	A	B	C	D	E
1					
2		SETTING	NO. OF IDEAS	Rank SETTING	Rank NO. OF IDEAS
3		0	17	1	1
4		0	17	1	1
5		1	24	3	3
6		1	26	3	5
7		1	25	3	4
8					
9			ST.DEV.	1,0954	1,7889
10			COV.	1,8000	
11					
12			SPEARMAN COEFF.	0,9186	
13					
14				*Rank SETTING*	*Rank NO. OF IDEAS*
15			Rank SETTING	1	
16			Rank NO. OF IDEAS	0,9186	1

1

2

Spearman coefficient computation for Experiment 2 as reported in chapter 5. Ref. 1 highlights standard deviation computed for each rank and the related covariance; below these variables is calculated the coefficient with the formula mentioned in chapter 5. In order to check the computation, in ref. 2 the same coefficient was computed applying the MS Excel tool “Data analysis” directly to ranks.

	QUESTION 1	QUESTION 2	QUESTION 3	QUESTION 4	QUESTION 5	QUESTION 6	QUESTION 7
GROUP 1	7	6	4	10	8	8	4
GROUP 1	7	7	5	10	1	9	2
GROUP 1	7	8	2	10	7	10	17
GROUP 1	8	8	5	10	10	10	6
MEAN	7,25	7,25	4	10	6,5	9,25	7,25
GROUP 2	9	7	1	6	7	6	5
GROUP 2	7	6	7	4	8	7	5
GROUP 2	7	6	3	10	9	8	5
GROUP 2	9	8	2	9	4	0	10
MEAN	8	6,75	3,25	7,25	7	5,25	6,25

Results of the group questionnaire for Experiment 2. For privacy reasons we are not reporting real names of group members, but the name of the corresponding group. After each group is reported a "mean" line with the average computed for each question.

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