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How to facilitate a brainstorming session: The effect of idea generation techniques and of group brainstorm after individual brainstorm

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ABSTRACT

There is a growing recognition that creativity is a key factor to an organization's innovation capacity. When facing challenging problems, organizations tend to rely on facilitated idea generation sessions. During these sessions, people are progressively applying different creativity techniques to generate creative solutions. The aim of the current paper was to examin the effect of four idea generation techniques—Silence, Evolution, Random Connections, and Scamper— on the ability to generate creative solutions, and to shed light on the question whether the idea-generation techniques built on each other. The number of solutions generated did not differ between techniques, suggesting that ideation does not get exhausted. With regard to idea quality all four techniques brougth about equal levels of originality. A difference was found between the techniques on usefulness and flexibility, technique 'Random connections' outperformed technique 'Evolution'. Moreover, the current paper examined whether idea generation in groups after individual idea generation has any benefit over-and-above generating ideas individually. The number of ideas generated in groups did not increase nor decrease. Importantly, however, overall the originality did significantly increase, suggesting that generating ideas in a group after generating ideas individually has a beneficial effect on the quality of the ideas generated.

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creativity; innovation; brainstorming; group; individual

1. Introduction

Creativity has always been vital to survival and success, and the expansion of the human species can be considered a story of creativity (Puccio 2017). While most individuals no longer have to use creativity to face physical threats, life and work in our complex and fast-changing world heavily relies on creative thinking skills, and creativity has become a key concern for most organizations and businesses (Runco 2004). Creativity is an inborn skill—we are all wired to be creative (Ritter and Mostert 2017).

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However, we are not all the same. Like with any other skill, we vary in the degree of creative ability that we have. Maybe even more important, we often don't use our creative skills to the best of our ability.

Creativity is defined as the generation of ideas or products that are original and useful (e.g., Hennessey and Amabile 2010; Sawyer 2012), and it entails divergent and convergent thinking. Divergent thinking is the ability to generate many ideas, and convergent thinking is vital for the evaluation and selection of the most promising options for implementation. To be creative, one has to be able to switch between these two modes of thinking (Ritter and Rietzschel 2017). As stated by Runco (2004, p. 5), 'Most educational efforts emphasize convergent thinking, and therefore may do very little, if anything, for creative potential'. Instead of stimulating and teaching students how to think divergently, the current education system—which puts a heavy focus on standardization—encourages individuals to find the single right answer. However, most complex and ill-defined questions don't have one single, correct answer. To successfully deal with problems and challenges in our complex and fast-changing world, we have to rely on and trigger our divergent thinking skills.

Due to the globalization of competition and the increasing pace of change in the business environment, there is a growing recognition that creativity is a key factor to an organization's innovation capacity and long-term success. Organizations have to make the best use of their available creativity human resource. When facing challenging problems, many organizations rely on idea generation sessions (e.g., brainstorms) to come up with creative ideas and solutions. However, in idea generation sessions, people often move too quickly to convergence, instead of trying to come up with many different ideas. Individuals and groups arrive at a point where no new ideas are generated, that is, where ideation gets exhausted. To overcome this, and support creativity and innovation, many organisations and business draw on facilitated idea generation sessions. To postpone exhaustion, in such sessions, participants progressively apply several different idea-generation techniques to generate creative ideas for problem. The current paper aims to shed light on the question whether a series of well-chosen idea-generation techniques built on each other, or whether ideation still gets exhausted. Moreover, the effect of each of the four techniques in isolation on the ability to generate creative ideas for a real-life problem is examined.

The four techniques to facilitate creative idea generation—Silence, Evolution, Random Connections, and Scamper (for a description of the techniques, see below)—were selected by a creativity researcher and a creativity facilitator, and the selection made was based on knowledge about the creative process and creativity enhancement, as well as lessons and insights learned from facilitating creative processes in more than 250 idea-generation workshops in various organisations world-wide. Participants employed the techniques to solve a real-life challenge (i.e., how the next generation sponge could look like). Per technique, the idea quantity (i.e., Fluency) and the quality (i.e., Originality and Usefulness) of ideas generated was assessed, as well as the use of different cognitive categories and perspectives while generating ideas (i.e., Cognitive Flexibility). Moreover, as participants first applied each technique to generated ideas for the real-world probem individually and then in a small group, the current paper also follows up on the question (as introduced in Ritter and Mostert 2017) whether idea generation in groups after individual idea generation has any benefit over-and-above generating ideas individually, and whether this depends on the idea generation technique used. In the remaining part of the introduction, we first provide information about the four creativity-training techniques, and then summarize earlier findings on individual, group and hybrid idea generation.

1.1. Techniques to facilitate creative idea generation

1.1.1. Silence

This technique relies on providing no concrete guidelines and instructions with regard to the thought process during idea generation—the person determines herself how to approach the idea generation process. The only information explicitly communicated at the beginning of the silence period is related to goal setting: generate as many creative ideas as possible. This approach relies on earlier research findings, which have shown that both conscious, focused processes (Nijstad, De Dreu, Rietzschel, and Baas 2010) as well as unconscious and less-focused processes (e.g., Ritter, van Baaren, and Dijksterhuis 2012; Ritter, Strick, Bos, van Baaren, and Dijksterhuis 2012) can lead to creative ideas. It's up do the person how to spent the available time on generating ideas.

1.1.2. Lines of evolution

This technique is grounded in the findings of a Russian engineer, Genrikh Altshuller, who studied thousands of patents. His observation was that the evolution of breakthrough ideas follows universal principles. For example, a line of evolution could include changes in the form of an object using the following pattern: from solid, to powder or pieces, to liquid, to foam, to gel, to mechanics, to electronics, to spheres. A possible line of evolution for real-world inventions could be that what was once a chocolate bar can become mini chocolates or a chocolate drink. In essence, Lines of Evolution stimulates the idea generation process by triggering people's thoughts about how the current form of an idea or product can be changed into the next evolutionary form.

1.1.3. Random connections

Creative ideas often arise by making connections between seemingly unrelated concepts or objects. Accordingly, in some situations, true creative thinking relies on associative processes. Random connections stimulates associative thoughts by selecting a random stimulus—for example, an object in the room or a picture in a newspaper—and trying to generate as many associations related to this stimulus as possible. Next, one can connect these associations with the problem that needs to be solved. To illustrate this process, imagine the following example: the problem at hand is to generate a new sun cream, and the random object chosen is a ballpoint pen. Associations can be generated from the ballpoint pen, such as writing, color, and roller. By connecting these associations to the sun cream problem, one might generate the idea of colored sun cream (i.e., the sun cream is changing colour during application, showing level of absorption), a roll-on sun cream, or a roll-on sun cream containing colored sun cream. Thus, by facilitating the generation of random connections, this technique helps to create associations and finally ideas that would very likely not emerge intentionally.

1.1.4. Scamper

During idea generation, new ideas may emerge when forced to think of possible changes to an existing idea or product. Hereby, a list of suggestions for possible changes can be helpful. A list with seven possible change approaches is provided by the technique SCAMPER (Osborn 1953; Eberle 1971): substitute (remove some part of the accepted situation, thing, or concept and replace it with something else), combine (join, affiliate, or force together two or more elements of your subject matter and consider ways that such a combination might move you toward a solution), adapt (change some part of your problem so that it works where it did not before), modify (consider many of the attributes and change them if necessary; attributes can include size, shape, texture, color, attitude, position), purpose (put the product to some other use), eliminate (remove any or all elements of your subject, simplify it, or reduce it to its core functionality), reverse (change the direction or orientation; turn it upside-down, inside-out, or make it go backwards/against the direction it was intended to move or be used), and rearrange (modify the order of operations or any other hierarchy involved in the product).

1.2. Individual, group and hybrid idea generation

Sharing ideas in groups can be cognitively stimulating (Nijstad and Stroebe 2006; Paulus and Brown 2007), and enhances idea generation due to increased associative processes (Dugosh, Paulus, Roland, and Yang 2000; Nijstad, Stroebe, and Lodewijkx 2002) and exposure to different idea categories (e.g., Deuja, Kohn, Paulus, and Korde 2014). Moreover, fMRI research suggests that enhanced creativity due to cognitive stimulation may be caused by modulation of bottom–up attention, enabling individuals to produce more original ideas (Fink et al., 2010). Moreover, groups can benefit from the idea exchange process, as it enables them building on each other's ideas (Kohn, Paulus, and Choi 2011).

Although idea sharing in groups can be stimulating, it can also distract from one's own 'train of thought', a process called cognitive interference. As illustrated in Ritter and Rietzschel (2017, p. 112), 'When generating ideas in a group, people have to take turns in expressing their ideas. If we have to wait for somebody else to stop speaking, not only can we easily forget an idea we have just come up with, but it is also difficult to continue thinking about the problem to come up with new ideas, since our cognitive resources are engaged in listening to the other person.' Moreover, generating ideas in a group setting may lead to a decreased feeling of responsibility for generating ideas and, hereby, may result in fewer ideas.

A possible solution to these problems is to have individuals participate in both individual and group idea generation sessions, as this enables unconstrained ideation in individual idea generation and stimulation of additional ideas by exposure to ideas of group members. Recently, Korde and Paulus (2017) examined the efficacy of hybrid idea generation, that is, brainstorming that involves alternation of individual and group idea generation sessions (they examined two hybrid versions: individual-group-individual-group and group-individual-group-individual). The hybrid ideation conditions outperformed traditional individual and group idea generation conditions in terms of number of ideas generated, and this effect was strongest in comparison to the group idea generation condition.

Moreover, a limited number of studies has focused on the benefits of one particular order of combining individual and group idea generation. One might expect that brainstorming in a group would be most beneficial after a period of individual idea generation, as it allows to first generate ideas in an unconstrained fashion and, thereafter, the group setting facilitates the generation of additional ideas due to stimulating ideas and idea categories from group members. Whereas one study has found that it is most beneficial to first brainstorm individually and then as a group (Baruah and Paulus 2008), other research suggest that it is better to first brainstorm as a group and then individually (e.g., Paulus and Yang 2000). In the current study, we examin whether group brainstorming has impact over-and-above individual brainstorming on the Fluency, Originality, and Usefulness of the ideas generated, and on the use of different cognitive categories and perspectives while generating ideas (Cognitive Flexibility). Moreover, the impact of group brainstorming over-and-above individual brainstorming is explored for the different idea generation techniques used (i.e., Evolution, Random Connections, Scamper).

In sum, the aim of the current article is (i) to examin the impact of each of the four different techniques in isolation on the ability to generate ideas for a real-life problem, (ii) to test whether a series of well-chosen idea generation techniques built on each other or whether ideation gets exhausted, and (iii) to examin whether idea generation in a group has impact over-and-above individual idea generation.

2. Method

2.1. Participants

A total of 32 (12 males, 20 females) Dutch participants, aged 18–34 years old ($M = 23.13$, $SD = 5.76$), gave written informed consent to participate in the study. The study was conducted according to the principles expressed in the Declarations of Helsinki and according to the guidelines of the institutional review board (Ethics Committee Faculty of Social Sciences, Radboud University, the Netherlands). Ethical approval was at the time of data collection not required by the Institution's guidelines and national regulations, as the research was not of a medical nature, no minors or persons with disability were involved, and there were no potential risks to the participants. Participants were recruited for voluntary participation via the online research participation system (Sona) of Radboud University. The participants were from varied educational backgrounds,including MBO (EQ National Diploma or Vocational training; $n = 1$), HAVO/VWO (EQ High School Diploma; $n = 2$), HBO (EQ Applied Bachelor's degree; $n = 2$), and WO (EQ University Bachelor's degree; $n = 27$). Participants were given a choice of earning course credit (2.5 points) or €15 (approximately $16.70 USD) for their participation. Finally, the data were collected as part of a creativity training that took place on March 30, 2015 at the laboratory of the Behavioural Science Institute, Radboud University, the Netherlands (see, Ritter and Mostert 2017).

2.2. Material

2.2.1. Techniques

The four techniques that were applied—Silence, Evolution, Random Connections, and Scamper—are described in the Introduction.

2.2.2. Creativity measures

Creativity is defined as the generation of ideas that are both original and useful (e.g., Hennessey and Amabile 2010; Sawyer 2012). In the current study expert evaluations were provided for each of the ideas (in total 879 ideas). The ideas were evaluated on *originality* on a scale from 1 (not at all original) to 5 (very original) and on *usefulness* on a scale from 1 (not at all useful) to 5 (very much useful). Moreover, *cognitive flexibility* was assessed by examining the number of distinct idea categories used. To give an example, when asked how the new generation sponge looks like, the ideas "text on sponge" and "picture on sponge" and "4-color sponge" would lead to a cognitive flexibility score of 1, as each of the three ideas is assigned to the category "design", whereas the ideas "sponge with vibration function" and "biodegradable sponge" and "health-plaster sponge" would lead to a cognitive flexibility score of 3, as each of the three ideas is assigned to another category, i.e., the categories "mechanical", "environment", "other function", respectively.

2.3. Procedure

Participants were welcomed individually at the lab entrance. Once all of the participants who were scheduled for the idea generation session had arrived, they were accompanied to the room where the study took place. In the room, the experimenter briefly introduced herself and the creativity facilitator and informed the participants of how the study would be conducted (see, Ritter and Mostert 2017).

During 1.5 hours, participants applied the four techniques to the real-life problem. The real-world problem required generating ideas for what the next generation sponge might look like (i.e., in Dutch: 'Hoe ziet de volgende generatie spons eruit?'). For each of the four idea generation sessions—one per techniques—the participants completed two procedures. First, the cognitive mechanism underlying the technique, and how the technique can be applied were explained by the facilitator. Second, the participants applied the technique to the real-world problem; first alone, and then in a small group. Finally, participants completed the demographic questions.

3. Results

3.1. Idea generation

The first measure of idea generation performance is *Fluency*, operationalized as the total number of ideas generated. In addition to idea *quantity*, it is investigated whether the techniques used lead to differences in the *quality* of the ideas generated. Creative idea quality manifests itself in two core aspects; the *Originality* of the generated ideas and the *Usefulness* of the generated ideas. In addition, techniques are compared on *Cognitive Flexibility*. Cognitive Flexibility manifests itself in the use of different cognitive categories and perspectives while generating ideas.

Before running analyses, standard checks were performed to check whether the assumption of normality was adhered to. As only a few minor violations were found ($Skew(X)/SES < -2$ or $Skew(X)/SES > 2$), it was decided not to transform the data, considering that the repeated-measures ANOVA is quite robust to such minor violations. For each repeated-measures ANOVA it was also checked whether the assumption of sphericity was met. This held true for all analyses. For the post-hoc analyses, the *t*-statistic was computed by performing paired-samples t-tests that compared the two techniques in question.

3.1.1. Fluency

In most brainstorm-sessions, individuals arrive at a point where no new ideas are generated, that is, where ideation gets exhausted. Therefore, in facilitated brainstorm-sessions, participants are instructed to progressively apply a couple of different techniques to generate ideas. In order to examine whether the series of techniques built on each other, a one-way repeated-measures ANOVA with creativity training technique (*Silence*, *Evolution*, *Random connections*, *Scamper*) was performed on individual creative idea generation performance. No significant difference was found between the techniques ($F(3, 93) = 2.38$, $p = .075$, Partial $\eta^2 = .07$). Thus, the number of ideas generated per technique did not differ — each technique resulted in a comparable amount of ideas generated. As the difference between techniques approached significance, planned contrasts were performed on an explorative basis to compare the effects of the techniques with each other. Participants generated more ideas using the third technique, *Random connections* ($M = 6.22$, $SD = 2.15$), compared with the second technique, *Evolution* ($M = 4.75$, $SD = 2.27$, $t(31) = 3.36$, $p = .013$). Overall, these findings seem to suggest that throughout the whole four-technique procedure, ideation does not get exhausted.

3.1.2. Originality

A one-way repeated-measures ANOVA with technique (*Silence, Evolution*, *Random connections*, *Scamper*) did not reveal a significant difference between the techniques on originality ($F(3, 93) = 1.04$, $p = .378$, Partial $\eta^2 = .03$). Further explorative contrasts did not indicate that individual techniques differed either. These findings suggest that all four techniques bring about equal levels of originality in idea generation.

3.1.3. Usefulness

A one-way repeated-measures ANOVA with technique (*Silence, Evolution*, *Random connections*, *Scamper*) revealed a significant difference between the techniques on usefulness ($F(3, 93) = 2.92$, $p = .038$, Partial $\eta^2 = .09$). Simple contrasts revealed that the difference between techniques *Random connections* and *Evolution* was significant ($t(31) = 3.28$, $p = .015$), participants generated more useful ideas using technique *Random connections* ($M = 20.84$, $SD = 1.46$) than technique *Evolution* ($M = 15.34$, $SD = 1.51$). These results seem to suggest that the technique *Random connections* is most effective – at least when directly compared with *Evolution* – as a tool for the stimulation of useful idea generation.

3.1.4. Cognitive flexibility

A one-way repeated-measures ANOVA with creativity training technique (*Silence, Evolution*, *Random connections*, *Scamper*) revealed a significant difference between the techniques on cognitive flexibility ($F(3, 93) = 5.07$, $p = .003$, Partial $\eta^2 = .14$). Simple contrasts revealed that the difference between techniques *Random connections* and

Evolution was significant ($t(31) = 3.79$, $p = .004$), participants generated more distinct idea categories using technique *Random connections* ($M = 5.34$, $SD = 2.18$) than technique *Evolution* ($M = 3.75$, $SD = 1.78$). These results suggest that *Random connections* is most beneficial – at least when directly compared with *Evolution* – for cognitive flexibility.

3.2. The impact of group brainstorming after an individual brainstorm on creative performance

An examination of the impact that group brainstorming has over-and-above individual brainstorming was performed. To calculate group performance, the number of ideas, originality rating of the ideas, usefulness ratings of the ideas, and cognitive flexibility score were assigned to each member of that group.

As technique *Silence* could not be performed in a group brainstorm, this technique was not included in the current analyses, and the comparison between individual and group performance is restricted to the following techniques: *Evolution*, *Random connections*, and *Scamper*. When standard checks were performed using the aforementioned thresholds, these analyses adhered to the assumptions of normality, and the assumption of sphericity was unless otherwise stated met.

Initially, the experimental training techniques (*Evolution*, *Random connections*, and *Scamper*) were collapsed, and the measures for groups and individuals were compared using a series of paired-samples t-tests. Following this series of analyses, the impact of the group across the different techniques was examined using a 3×2 repeated-measures ANOVA comparing training technique (*Evolution*, *Random connections*, and *Scamper*) for individual and group brainstorm (*Individual*, *Group*). After analyzing all possible contrasts, paired-samples *t*-tests were performed in order to compare group performance with individual performance for each of the creativity measures.

3.2.1. Fluency (Number of Ideas)

3.2.1.1. Groups vs. individuals. Overall, when collapsing across the three training techniques (*Evolution*, *Random connections*, and *Scamper*), no significant difference was found between the number of ideas generated at an individual level ($M = 16.53$, $SD = 5.00$), when compared with the number of ideas produced within groups ($M = 17.19$, $SD = 8.04$, $t(31) = -.48$, $p = .638$, $d = -.08$). That is, irrespective of the training condition, the number of ideas generated in groups after generating ideas alone did not increase nor decrease.

3.2.1.2. Groups vs. individuals for each technique. A 3×2 repeated-measures ANOVA for training (*Evolution*, *Random connections*, and *Scamper*) and group level (*Individual*, *Group*) on cognitive fluency revealed no main effects for training type ($F(2, 62) = 2.07$, $p = .135$, Partial $\eta^2 = .06$) or for group level ($F(1, 31) = .23$, $p = .638$, Partial $\eta^2 = .01$). However, a significant interaction effect between technique and group level emerged ($F(2, 62) = 19.80$, $p = .027$, Partial $\eta^2 = .11$), as is displayed in Figure 1. Planned contrasts revealed that the increase in fluency that was visible when the technique *Evolution* was performed on group basis after being performed individually, differed significantly from the trends found for both the *Random connections*

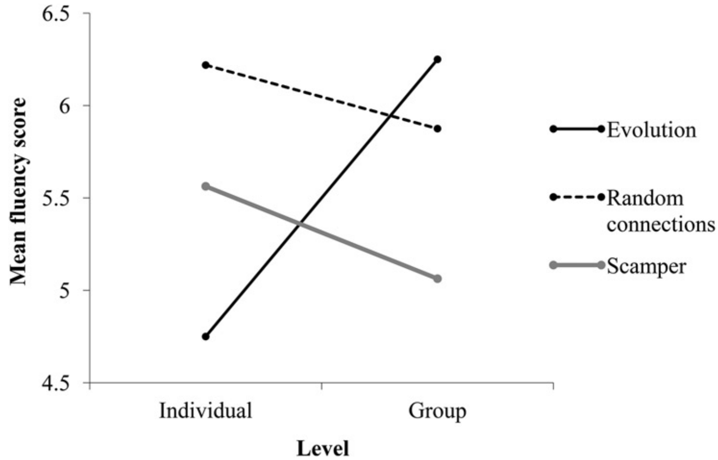

Figure 1. Mean number of ideas generated alone and in groups using each of the creativity training techniques: Evolution, Random connections, and Scamper.

($F(1,\ 31) = 5.89$, $p = .021$, Partial $\eta^2 = .16$), and *Scamper* ($F(1,\ 31) = 4.48$, $p = .042$, Partial $\eta^2 = .13$). The trends of the techniques *Random connections* and *Scamper* did not differ ($F(1,\ 31) = .05$, $p = .821$, Partial $\eta^2 = .002$). Post-hoc paired-samples t-tests revealed that for the technique *Evolution,* a marginally significant greater number of ideas was produced within groups ($M = 6.25$, $SD = 3.93$) when compared with the number of ideas generated alone using this technique ($M = 4.75$, $SD = 2.27$, $t(31) = -1.99$, $p = .055$, $d = -.35$). For the *Random connections* ($t(31) = .62$, $p = .541$, $d = .11$) and *Scamper* ($t(31) = .79$, $p = .438$, $d = .14$) techniques, there was no significant difference between the individual and group-wise performances.

3.2.2. Originality

3.2.2.1. Groups vs. individuals. Overall, when collapsing across the different training techniques (*Evolution*, *Random connections*, and *Scamper*), a significant difference was found between the originality of the ideas generated at an individual level ($M = 54.50$, $SD = 19.53$) when compared with the originality of the ideas produced within groups ($M = 67.88$, $SD = 32.01$, $t(31) = -2.47$, $p = .019$, $d = -.44$). That is, irrespective of the technique, the originality of the ideas generated in groups after generating ideas alone did significantly increase.

3.2.2.2. Groups vs. individuals for each technique. A 3×2 repeated-measures ANOVA for technique (*Evolution*, *Random connections*, and *Scamper*) and group level (*Individual*, *Group*) on originality revealed – similarly to the previous performed paired-samples *t*-test – a main effect for group level ($F(1,\ 31) = 6.11$, $p = .019$, Partial $\eta^2 = .17$), but did not for technique ($F(2,\ 62) = 1.14$, $p = .325$, Partial $\eta^2 = .04$). Likewise, the interaction effect between technique and group level proved to be non-significant ($F(1.60,\ 49.68) = 1.37$, $p = .260$, Partial $\eta^2 = .04$; reported with Greenhouse-Geisser corrected degrees of freedom, as the assumption of sphericity was violated. Post-hoc paired-samples t-tests revealed that for the technique *Evolution,* a significantly greater originality score was reached within groups ($M = 23.81$, $SD = 15.52$)

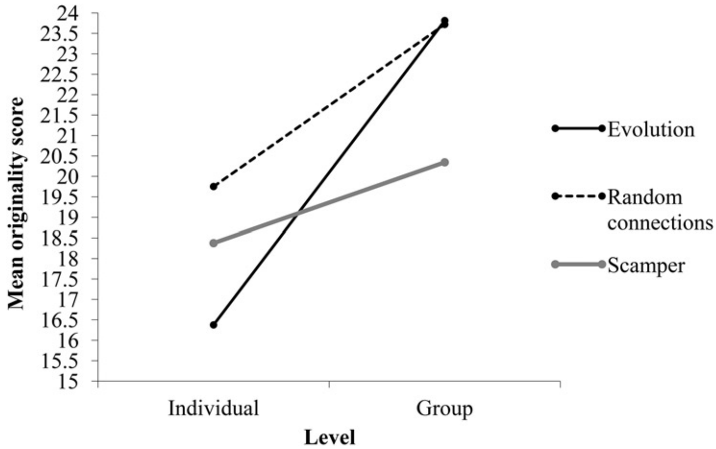

Figure 2. Mean originality of ideas generated alone and in groups using each of the techniques: Evolution, Random connections, and Scamper.

when compared with the originality score of the ideas generated alone using this technique ($M = 16.38$, $SD = 8.73$, $t(31) = -2.46$, $p = .020$, $d = -.43$). For the *Random connections* ($t(31) = -1.72$, $p = .096$, $d = -.30$) and *Scamper* ($t(31) = -.78$, $p = .443$, $d = -.14$) techniques, there was no significant difference between the individual and group-wise performances (see Figure 2).

3.2.3. Usefulness

3.2.3.1. Groups vs. individuals. Overall, when collapsing across the different training techniques (*Evolution*, *Random connections*, and *Scamper*), no significant difference was found between the usefulness of the ideas generated at an individual level ($M = 54.00$, $SD = 17.03$) when compared with the usefulness of the ideas produced within groups ($M = 50.53$, $SD = 24.14$, $t(31) = .76$, $p = .450$, $d = .14$). That is, irrespective of the technique, the usefulness of the ideas generated in groups after generating ideas alone did not increase nor decrease.

3.2.3.2. Groups vs. individuals for each technique. A 3 x 2 repeated-measures ANOVA for technique (*Evolution*, *Random connections*, and *Scamper*) and group level (*Individual*, *Group*) on usefulness revealed no main effects for technique ($F(2, 62) = .70$, $p = .502$, Partial $\eta^2 = .02$) or for group level ($F(1, 31) = .58$, $p = .450$, Partial $\eta^2 = .02$). However, a significant interaction effect between technique and group level emerged ($F(2, 62) = 6.92$, $p = .002$, Partial $\eta^2 = .18$), as is displayed in Figure 3. Planned contrasts revealed that the increase in usefulness score that was visible when the technique *Evolution* was performed on group basis after being performed individually, differed significantly from the trends found for both the *Random connections* ($F(1, 31) = 15.60$, $p < .001$, Partial $\eta2 = .34$), and *Scamper* ($F(1, 31) = 4.76$, $p = .037$, Partial $\eta^2 = .13$) techniques – where a decrease was visible instead. The trends of the techniques *Random connections* and *Scamper* did not differ ($F(1, 31) = 1.60$, $p = .215$, Partial $\eta^2 = .05$). Post-hoc paired-samples *t*-tests revealed that for the technique *Random connections,* a significantly lesser usefulness score was achieved within groups ($M = 15.44$, $SD = 7.21$)

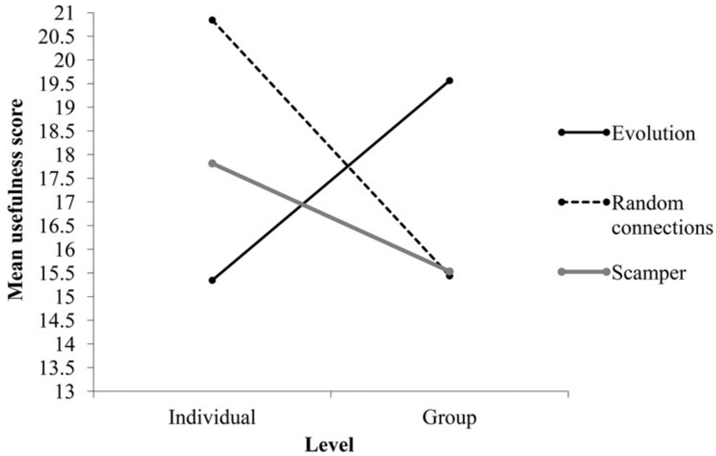

Figure 3. Mean usefulness of ideas generated alone and in groups using each of the techniques: Evolution, Random connections, and Scamper.

when compared with the usefulness score generated alone using this technique ($M = 20.84$, $SD = 8.27$, $t(31) = 3.10$, $p = .004$, $d = .55$). For the *Evolution* ($t(31) = -1.60$, $p = .119$, $d = -.28$) and *Scamper* ($t(31) = 1.16$, $p = .256$, $d = .20$) techniques, there was no significant difference between the individual and group-wise performances.

3.2.4. Cognitive flexibility

3.2.4.1. Groups vs. individuals. Overall, when collapsing across the different training techniques (*Evolution*, *Random connections*, and *Scamper*), no significant difference was found between the amount of distinct idea categories generated at an individual level ($M = 13.38$, $SD = 4.43$) when compared with the amount of distinct idea categories produced within groups ($M = 13.53$, $SD = 5.11$, $t(31) = -.15$, $p = .881$, $d = -.03$). That is, irrespective of the technique, the amount of distinct idea categories generated in groups after generating ideas alone did not increase nor decrease.

3.2.4.2. Groups vs. individuals for each technique. A 3×2 repeated-measures ANOVA for training (*Evolution*, *Random connections*, and *Scamper*) and group level (*Individual*, *Group*) on cognitive flexibility revealed a marginally significant main effect for training type ($F(2, 62) = 2.70$, $p = .075$, Partial $\eta^2 = .08$), but none for group level ($F(1, 31) = .02$, $p = .881$, Partial $\eta^2 = .001$). In addition, a significant interaction effect between technique and group level emerged ($F(2, 62) = 4.63$, $p = .013$, Partial $\eta^2 = .13$), as is displayed in Figure 4. Planned contrasts revealed that overall, participants had significantly higher scores on cognitive flexibility when using the technique *Random connections* ($M = 4.89$, $SD = .23$) compared to using the technique *Scamper* ($M = 4.27$, $SD = .30$, $F(1, 31) = 6.10$, $p = .019$, Partial $\eta^2 = .16$), and marginally significantly higher when compared to *Evolution* ($M = 4.30$, $SD = .31$, $F(1, 31) = 3.54$, $p = .069$, Partial $\eta^2 = .10$). In addition, contrasts revealed that the increase in cognitive flexibility that was visible when the technique *Evolution* was performed on group basis after being performed individually, differed significantly from the trend found for the technique of *Random connections* ($F(1, 31) = 7.94$, $p = .008$, Partial $\eta^2 = .20$). Post-hoc

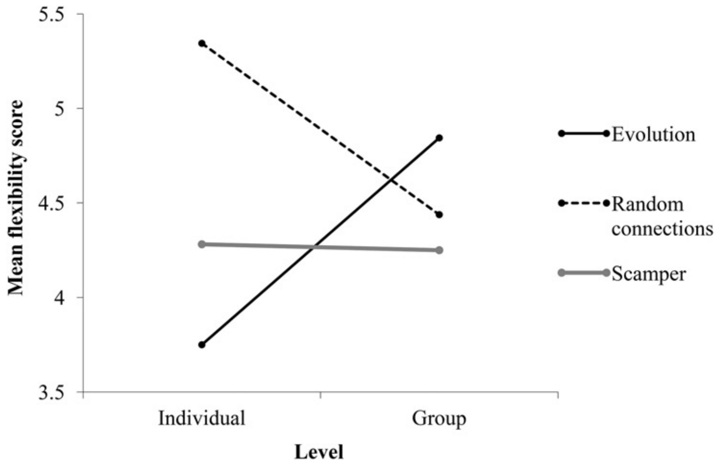

Figure 4. Mean flexibility of ideas generated alone and in groups using each of the techniques: Evolution, Random connections, and Scamper.

paired-samples t-tests revealed that for the technique *Evolution,* a marginally significant higher score on cognitive flexibility was achieved within groups ($M = 4.84$, $SD = 2.77$) when compared to that achieved alone using this technique ($M = 3.75$, $SD = 1.78$, $t(31) = -2.04$, $p = .050$, $d = -.36$). Conversely, a marginally significant lower score on cognitive flexibility was achieved within groups ($M = 4.44$, $SD = 1.50$) for the technique *Random connections,* when compared to individual use of the technique ($M = 5.34$, $SD = 2.18$, $t(31) = 1.91$, $p = .065$, $d = .34$). For the technique *Scamper*, there was no significant difference between the individual and group-wise performances ($t(31) = .06$, $p = .953$, $d = .01$).

4. Discussion

4.1. Summary of the current findings

The first aim of the current paper was (i) to shed light on the question whether a series of well-chosen idea-generation techniques built on each other or whether ideation gets exhausted, and (ii) to examin the effect of each of four idea generation techniques—Silence, Evolution, Random Connections, and Scamper (for a description of the techniques, see Introduction)— on the ability to generate creative ideas for a real-life problem. Importanlty, the number of ideas generated per technique did not differ—each technique resulted in a comparable amount of ideas generated. These findings suggest that throughout the whole four-technique procedure, ideation does not get exhausted. With regard to idea quality (the originalty and the usefulness of the ideas generated) some differences were oberved between the techniques. Whereas all four techniques brougth about equal levels of originality in idea generation, a difference was found between the techniques on usefulness, participants generated more useful ideas using technique 'Random connections' than technique 'Evolution'. Moroever, participants participants displayed a more flexible thinking style (i.e., they generated more distinct idea categories) when using technique 'Random connections' than technique 'Evolution'. In sum, these findings suggest that—as long as participants are stimulated to generate original ideas—the technique chosen to obtain this goal is not of vital importance. However, when one aims to trigger a flexible thinking style, it is wise to make a carful selection of the techniques applied in individual idea generation.

The second aim of the current paper was to examin whether idea generation in groups after individual idea generation has any benefit over-and-above generating ideas individually. Overall, when collapsing across the training techniques, the number of ideas generated in groups after generating ideas alone did not increase nor decrease. Importantly, however, the originality of the ideas generated in groups after generating ideas alone did significantly increase, while the usefulness of the idea generated, as well as the cognitive flexibility, did not decrease. These findings suggest that generating ideas in a group after generating ideas individually has a strong beneficial effect on the originality, and thus the quality of the ideas generated. These findings are in line with earlier findings demonstrating that sharing ideas in groups increased associative processes (Dugosh, Paulus, Roland, and Yang 2000; Nijstad, Stroebe, and Lodewijkx 2002) and enables building on each other's ideas (Kohn, Paulus, and Choi 2011). Although idea sharing in groups can be stimulating, it can also distract from one's own 'train of thought', a process called cognitive interference. Based on the current findings it can be assumed that this negative effect is ruled-out by first asking people to generate individually and, thereafter, in a group.

Moreover, we examined whether the observed benefit group idea generation has over-and-above generating ideas individually depends on the idea generation technique used. When the technique Evolution was used, a marginally significant greater number of ideas was produced within groups when compared with the number of ideas generated alone using this technique, and a significantly greater originality score was reached within groups when compared with the originality score of the ideas generated individually. Moreover, for the technique Evolution a marginally significant higher score on cognitive flexibility was achieved within groups when compared to that achieved when using this technique individually. However, for the technique *Random connections,* a significantly lower usefulness score and a marginally lower flexibility score was achieved within groups than when generating ideas individually. These findings suggest that it is vital to carefully consider which techniques a group brainstorm after individual brainstorm is most beneficial.

4.2. Limitations and suggestions for future research

In the current project, the effectiveness of the techniques was tested in the domain of product development. It might be possible that some techniques particularly lend themselves for specific creativity domains. In future research it may be interesting to test the effectiveness in different creativity domains and for different types of problems. Moreover, it remains unclar whether working with the techniques has an effect over and above generating ideas for the current problem. Theoretically it might be possible that people learn how to apply creative thinking techniques, and that they apply this knowledge at a later point in time—for example, when solving another problem. In future research, a follow-up study could inveisitage if (any of) the techniques (is) are succesfully applied later on. Finally, the participants in the current sample were western, mainly female, and had a high education level. This could limit the ecological validity of the findings. Future reearch could examin the effect of the techniques for people from different cultural backgrounds and for different age ranges.

4.3. Practical implications and conclusions

To enhance creativity in an organization, Human Resource practices do not only focus on the recruitement of creative individuals, but also on making the best use of the available creativity human resources. For example, by organizing idea generation sessions (i.e., brainstorms) to come up with creative ideas and solutions for complex problems. However, in idea generation sessions, people often arrive at a point where no new ideas are generated, that is, where ideation gets exhausted. The current findings suggest that, if one is afraid that ideas might get exhausted during the idea generation process, it might be wise to progressively apply a couple of different creativity techniques. The current study, moreover, compared the effect of different idea generation techniques, and idea quality differences were found between the techniques. This suggests that it is important to carefully think about the techniques one uses in an idea generation process. Another interesting finding is that idea generation in groups after individual idea generation has an important advantage in terms of idea quality—the originality of the ideas generated in groups after generating ideas alone did significantly increase. The current findings might provide some criteria how to facilitate people's ability to generate creative ideas. Creative employees are the source of an organization's innovation capacity (e.g., Amabile 1988), and they are core to the competitiveness of a firm in our fast-changing, knowledge-based economy (e.g., Lepak and Snell 2002).

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