UNIVERSITEIT VAN AMSTERDAM

Creative Problem Solving in Groups:

The Effects of Problem Construction on Creative Ideation and Selection

Julia Van Eijs
10785361

Arbeids- en Organisatiepsychologie
Universiteit van Amsterdam

Begeleider: Matthijs Baas

2e beoordelaar: Femke ten Velden

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Abstract

Problem construction refers to the process of defining the goals and objectives of the problem solving effort, and has been shown to result in positive effects for creativity at the individual level. However, little is known about problem construction's effects at the group level, nor is the full cycle of creative problem solving – problem construction, idea generation, and idea selection – examined in a single group study. Accordingly, we report on a group experiment that tested the prediction that groups engaging in problem construction would outperform control groups, both in terms of idea generation and idea selection. In addition, we proposed that a shared understanding of the task through problem construction would mediate this effect. Finally, we expected that a problem construction efforts would narrow the conceptual scope in the creative problem solving process, which would benefit groups when generating creative ideas and adopting selection criteria. Predictions were tested in an experiment with 84 three-person groups engaging in creative problem solving tasks, where half of the groups first engaged in problem construction efforts, whereas the other half of the groups immediately moved on to brainstorming and idea selection tasks. Results showed that problem construction indeed led to a narrow focus during idea generation, but did not find support for the other predictions. In fact, in contrast with predictions, groups engaging in problem construction generated and selected less creative ideas than control groups. Post-hoc analyses help to explain these unexpected findings: Problem construction groups elaborated on goals that were less original to begin with and tended to favour feasibility over originality. Implications and avenues for further research on group processes in problem construction are discussed.

“*We cannot solve our problems with the same thinking we used when we created them*” – Albert Einstein.

“*Given one hour to save the planet, I would spend 59 minutes understanding the problem and one minute resolving it.”* – Albert Einstein.

Introduction

Creativity, most commonly defined as the production of novel and useful ideas (Stein, 1974), is considered an important asset in organizations, because it is needed to deal with the challenges imposed by the current, dynamic work environment. Although individuals alone are certainly capable of finding creative solutions to relatively simple problems, more complex problems often require the integration of expertise and thinking skills of many people working together (Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000). Therefore, a lot of work is done by teams. For instance, the top of an organization consists of a team of managers or executives (Wiersema & Bantel, 1992), in hospitals, doctors work together in health care teams to deliver patient care (Mickan, 2005), and scientific research is generally conducted by a team of researchers collaborating on an article (Morris & Goldstein, 2007). Indeed, teams are often more effective than individuals in meeting the changing environmental demands and establishing competitive advantage within organizations (Katzenbach & Smith, 1992). Unsurprisingly, both in the workplace and research, the role of teamwork in creative problem solving has gained more and more importance.

Creativity research has identified three important steps that should be taken in creative problem solving (e.g., Amabile, 1988; Lubart, 2001; Montag, Maertz, & Baer, 2012; Zhou & George, 2003). First, one should identify and construct the problem one wants to solve. Second, one generates as many candidate solutions for the problem as possible. And finally, out of this possible pool of candidate solutions, one has to evaluate and pick the best solution for solving the problem. Unfortunately, and despite the importance of all three steps in creative problem solving, interventions in the workplace as well as research on individual and group creativity predominantly focus on the idea generation phase (Rietzschel, De Dreu, & Nijstad, 2009). Indeed, idea generation and, more specifically, the brainstorming technique (Osborn, 1957), has become standard practice in organizations and research has identified many factors determining brainstorming effectiveness, including positive affect (Grawitch, Munz, & Kramer, 2003), leadership styles (Isaksen & Gaulin, 2005), and different personality characteristics (Amabile, 1983). However, generating ideas for the "wrong" problem renders a successful brainstorming session meaningless, as does the inability to identify and select the best idea.

In this study, we focus on the role of the first step of creative problem solving in groups – the identification and construction of a problem – and examine its influence on the later stages in creative problem solving: idea generation and idea selection. We argue that the problem construction phase may be particularly important in groups. The integration of domain-relevant knowledge and skills of multiple group members holds great potential for reaching creative solutions, because these skills and knowledge are needed to recognize the right problem, identify relevant information, generate ideas, and recognize the value of an idea (Hargadon & Bechky, 2001). Importantly, because the quality of the later processes depends on the effort and quality of the earlier phases, problem construction provides the context for creative problem solving efforts in the later phases (Reiter-Palmon, Herman, & Yammarino, 2008). Accordingly, we propose that identifying and constructing a problem benefits idea generation and idea selection. This prediction will be tested in an experiment in which groups will generate and select solutions to a presented case, with half of the groups first engaging in problem construction efforts.

Creative problem solving

For an outcome to be considered creative, it needs to score high on both novelty (also termed “new” or “original”) and usefulness (also termed “appropriate” or “practical”; Sullivan & Ford, 2010). Creative problem solving entails a deliberate and systematic process with the aim to produce creative ways to solve so-called ill-structured problems, in which the objectives and solutions are not readily apparent (Brophy, 1998; Simon, 1960). An important aspect in which creative problem solving differs from more routine kinds of problem solving is the need for new solutions to be generated (Mumford & Connelly, 1992). The problems (e.g., challenges, opportunities) that benefit from creative problem solving are complex, non-routine, and often come with incomplete information (Ellspermann, Evans, & Basadur, 2007). Solving these types of problems requires controlled processing of information to more fully understand the problem and the generation of alternative solutions.

Many researchers have proposed stage-based models to capture the creative problem solving process (e.g., Amabile, 1988; Basadur, Runco, & Vega, 2000; Montag et al., 2012; Mumford, Mobley, Reiter-Palmon, Uhlman, & Doares, 1991; Zhou & George, 2003). Although these models vary in the specific processes that are being identified, most of them include the following three steps: problem identification and construction, idea generation, and idea evaluation. These processes or steps will be discussed in the following sections.

The outcome stages: Idea generation and selection

The idea generation phase is the stage that received the most attention in research on creative problem solving, and refers to the process of coming up with multiple alternative solutions to a problem. Idea generation is often associated with divergent thinking, which is the thought process used to produce a wide variety of ideas or options (Baer, 1993). Idea generation is often done in groups to allow for the exchange of ideas and perspectives, and the potential for stimulating group members' divergent thinking and the creation of associational links among ideas (Dugosh, Paulus, Roland & Yang, 2000; Montag et al., 2012). The most commonly used, and widely studied, idea generation technique in organizations is brainstorming. In this method, individuals, alone or in interaction with others, are instructed to record all tentative solutions to a presented problem that occur to them. Brainstorming is based on two principles. First, creative ideas are expected when people refrain from evaluation and judgment (Parnes & Meadow, 1959). The second principle is that "quantity breeds quality": the greater the number of ideas produced, the greater number of highly creative solutions will be among them (Taylor, Berry & Block, 1958). These principles result in four rules that people have to adhere to during brainstorming: Generate as many ideas as possible, refrain from criticizing and evaluating, focus on originality (freewheeling is encouraged), and combine and elaborate on the ideas of others (Osborn, 1957).

Osborn (1957) stated that, following these four rules of brainstorming, "the average person can think up twice as many ideas when working with a group than when working alone" (p.229). However, several negative factors of group brainstorming have been identified since (Diehl & Stroebe, 1987). First, the fact that only one group member can speak at a time disturbs the idea generation process and prevents that other group members can verbalize their ideas as they come to mind. Second, despite the explicit rule to refrain from criticizing, group members often feel inhibited to share original ideas, because they fear negative evaluation from other group members. A third potential negative factor is free riding, with group members reducing their effort because they feel their individual contribution is not identifiable in the group product (Diehl & Stroebe, 1987). These effects were less apparent in groups with no interaction, so-called nominal groups. In nominal groups, brainstorming is done individually and after brainstorming, the ideas of each individual are pooled together (with ideas mentioned by more than one individual counting only once). Research shows that nominal groups tend to generate twice as many (creative) ideas than real groups (e.g., Diehl & Stroebe, 1987; Mullen et al., 1991; Taylor et al., 1958). This has led some to conclude that we should be cautious in implementing group brainstorming (Mullen et al., 1991) and others have called for the need to search for interventions that may downplay the process losses during brainstorming while at the same time allowing for cognitive stimulation and sharing of perspectives (Nijstad, 2009; Taggar, 2002). Here we will focus on problem construction as a possible beneficial factor.

After the idea generation phase, many ideas exist within the group that vary in their potential to solve the problem at hand. The ultimate goal for organizations is to identify, select and implement high quality ideas – ideas that are both original and useful (Nijstad & De Dreu, 2002). Although it is generally true that the greater the number of ideas generated, the greater number of high quality ideas are among them (Diehl & Stroebe, 1987), a large number of ideas is only meaningful as long as people are able to identify and select the high quality ideas. Disappointingly, people – whether alone or in groups – do poorly in this selection phase (Rietzschel, Nijstad, & Stroebe, 2006). Although groups are slightly better than individuals, the quality of their selected ideas is only slightly better than would be expected on the basis of chance (Rietzschel et al., 2006; Rietzschel, Nijstad, & Stroebe, 2010). As an explanation for this poor result, Rietzschel and colleagues (2010) argued and demonstrated that people perceive the dimensions originality and feasibility to be in conflict with one another, which makes selecting ideas that are both original and useful difficult (also see Runco & Charles, 1993).

More than individuals do groups have the potential to recognize and select creative ideas. On the one hand, groups can share knowledge and discuss the selection of ideas (Rietzschel et al., 2006). The more knowledge groups have, the better they can recognize the value of new information and ideas and integrate these (Cohen & Levinthal, 1990).

Additionally, group members can provide monitoring on the problem solving process (Heller, Keith & Anderson, 1997), including the selection stage, which may be particularly favourable when considering groups' low selection effectiveness. In groups, members can remind each other to take into account both criteria of creativity, which may result in a better selection of creative ideas (Rietzschel et al., 2010). To bring out this potential, we consider problem construction as a possible beneficial factor.

Problem construction

Various terms have been used in the literature to describe the first phase of creative problem solving, including problem finding, problem identification, problem definition, problem recognition, and problem construction (Reiter-Palmon, Mumford, O'Connor Boes & Runco, 1997; Reiter-Palmon & Robinson, 2009). In this study, we use the term problem construction by Reiter-Palmon and colleagues (1997), because it implies a more active role of the problem solver. Problem construction is the process of defining the goals and objectives of the problem solving effort and designing a plan to structure and direct problem solving (Reiter-Palmon et al. , 1997). For instance, when the sales of a retail company drop, problem construction could focus on methods for engaging customers, such as conducting promotion campaigns, or means for increasing efficiency, such as a focus on employee training. Different formulations of a problem can offer new perspectives and make it possible to identify alternative solution (Basadur, Ellspermann, & Evans, 1994). In the case of the dropping sales of the retail company, possible methods for engaging more customers may be conducting promotion campaigns, whereas possible means for increasing efficiency may focus on employee training. A typical method used to manipulate problem construction is Baer's (1988) problem finding method. In this method, participants are asked to generate as many problem restatements as possible, starting with "How can I" or "How can we," after which they make a selection of their best problem restatements. While problem identification and construction often occurs automatically, this method creates active engagement in the problem construction process, facilitating creativity in the other problem solving phases (e.g., Reiter-Palmon & Robinson, 2009).

The benefits of spending more time on problem construction has been demonstrated by several studies. For instance, Rostan (1994) found that critically acclaimed artists and scientists devoted more time to finding and constructing the problem than professionally competent artists and scientists. Also, individuals with higher problem construction ability were able to generate more creative solutions to real-life problems (Mumford, Baughman, Threlfall, Supinski & Costanza, 1996; Reiter-Palmon et al. , 1997) and were more likely to find a problem solution that is personally suitable and meaningful (Reiter-Palmon, Mumford & Threlfall, 1998) than those with lower problem construction ability. However, the benefits of problem construction for creativity have only been shown at the individual level of analysis. To the best of our knowledge, there is no empirical research to date investigating the role of problem construction at the team level, nor is there research that has investigated the effects of problem construction on both idea generation and selection in a single study. In the following section, we will argue that problem construction in groups will benefit a shared representation of the problem. This, as well as other factors, will result in better idea generation and selection, something we turn to shortly.

Individuals construct a schema or a representation of a problem by considering their previous experience with the problem or kindred problems. They abstract relevant features of earlier problem solving efforts to construct a problem representation, which they use to define the problem (Mumford, Reiter-Palmon & Redmond, 1994). In their study, Mumford and colleagues (1994) proposed a model demonstrating how these individual problem representations contribute to the problem construction process at the group level. Each individual has a different problem representation from which relevant features, such as the goals, key information and procedures, are considered and shared for possible redefinitions of the problem at the group level. This, in turn, leads to a shared representation of the problem and task at hand, constraints and procedures of the problem, agreed-upon objectives, as well as knowledge about other team members and team processes (Reiter-Palmon et al., 2008). It also facilitates the identification of relevant information, and the dismissal of irrelevant information or problem definitions (Reiter-Palmon et al., 2008). In an earlier study, Gladstein (1984) argued that team members who agreed upon their goals communicated more effectively and considered more alternatives for solving the problem, stimulating group performance. This leads to our first Hypothesis:

Hypothesis 1: Groups engaging in problem construction will have more similar problem representations than control groups.

Idea generation. Idea generation will be guided by the results of the problem definitions in the earlier problem construction phase. For several reasons, a beneficial effect of problem construction on idea generation can be expected. First, it is important that the information represented regarding the problem is shared and agreed upon by all group members. Indeed, the degree to which task information is shared among team members is positively related to team performance and various team processes that are relevant to creativity, including coordination, cooperation and communication (e.g., Johnson & Lee, 2008; Waller, Gupta & Giambatista, 2004; Mathieu et al., 2000). In addition, by discussing the problem during the construction phase, groups share information about the task, and discuss constraints and procedures of the problem, thereby contributing new knowledge and offering new perspectives on the problem at hand (Gick & Holyoak, 1980).

Because participants make a small selection of their best problem restatements, solutions will be generated within in a limited range. Rietzschel, Nijstad and Stroebe (2014) demonstrated that, at the individual level, participants brainstorming on a narrow problem generated more creative ideas than participants working on a broader problem. In another study, they investigated the effects of brainstorming after being presented with primed subcategories (Rietzschel, Nijstad & Stroebe, 2007). It appeared that both individuals and dyads generated more creative ideas within these primed subcategories. These results demonstrate how creative ideas can be reached by deeper exploration of ideas within a given conceptual category (De Dreu, Baas, & Nijstad, 2008). Similarly, Finke, Ward and Smith (1992) noted that restricting domains of interpretation can improve creative performance because it refrains individuals from falling back on conventional lines of thought. The above studies highlight the importance of a good problem construction for idea generation by steering effort and exploration within a relatively narrow domain that is constrained by the problem definition. This may be particularly important for brainstorming groups as compared to individuals. Groups seemed to benefit more from elaborating upon a limited amount of ideas (Mumford, Feldman, Hein and Nagao, 2001). Additionally, groups tend to shift from one conceptual category to another when generating ideas (e.g., when brainstorming about ideas to improve and protect the environment, group members often switch, for example, between ideas focusing on reducing energy, to ideas focusing on the protection of wildlife, or ideas focusing on treatment of waste). Whereas brainstorming benefits from "trains-of-thought" (generating many incremental ideas within a particular thought domain), other group members often disturb these trains-of-thought by offering new ideas in entirely different conceptual domains (Nijstad, Stroebe & Lodewijkx, 2003). Constraining the problem during the problem construction phase may limit the constant shifting from perspectives and ideas, as well as allowing increased productivity and more creative ideas within this narrower problem. Because of these reasons and the positive effect of problem construction on idea generation at the individual level, we predict:

Hypothesis 2: Groups engaging in problem construction will generate ideas within more limited categories than groups in the control condition.

Hypothesis 3: Groups engaging in problem construction will generate more creative ideas than groups in the control condition.

Idea selection. There are two reasons why engagement in problem construction will lead to a better selection of creative ideas. First, as discussed before, the engagement in problem construction is expected to result in the generation of more creative ideas. Consequently, groups have a pool of potential ideas with higher quality to choose from. Second, as problems and ideas evolve, evaluation standards may change, especially in ill-defined problems where goals and procedures are not readily known in advance (Reiter-Palmon et al., 2008). It is therefore important to have clear directions and restrictions early in the problem solving process. This has been demonstrated in a study by Lubart (2001), where participants were asked to compose a short story (individually) on a still-life drawing, and evaluate their work during the writing process. Participants who evaluated their ideas early in the process wrote more creative stories than those who evaluated their work later on. Early evaluation thus seems promising in guiding creative processes. Because a good problem construction identifies the goals, restrictions and procedures early in the creative problem solving process, early standards for evaluating the creative process are set, potentially leading to the selection of more creative problem solutions. Additionally, Mumford et al. (2001) demonstrated that groups benefit from the elaboration and refinement of ideas, resulting in better selection criteria and thus better choices for problem solutions. A clearly defined problem brings opportunities for elaborating on these ideas, leading to better idea selection.

Hypothesis 4: Groups engaging in problem construction will be able to make a better selection of creative ideas than groups in the control condition.

So far, we have discussed possible benefits of problem construction within groups on the idea generation and selection phases. Here we propose that shared task representations account for these effects. We have argued before that problem construction groups have more similar task representations because they share relevant task features when redefining the problem (Hypothesis 1). Several studies found that a shared understanding of the task improves team performance (e.g., Jonker, Van Riemsdijk & Vermeulen, 2011; Mathieu, Heffner, Goodwin, Cannon-Bowers & Salas, 2005), including creativity and innovation (West, 2002). For example, Gilson and Shalley (2004) investigated different team creative processes and found that shared goals among team members were important for reaching group creativity. Based on these findings, we propose a mediating effect of shared task representations on the generation of creative ideas. We expect groups engaging in problem construction will have more similar task representations, which consequently leads to more creative ideas.

Hypothesis 5a: The degree of shared task representations mediates the relationship between problem construction and the generation of creative problem solutions.

Hypothesis 5b: The degree of shared task representations mediates the relationship between problem construction and the selection of creative problem solutions.

Exploratory Analysis

Satisfaction and enjoyment. To gain more insight into the creative problem solving process and inclusion of the task of problem construction, we presented participants at the end of the experiment with questions regarding satisfaction with their performance and enjoyment of the tasks.

Method

Participants and Design

In total, 252 students at the University of Amsterdam (73.4% female) with a mean age of 22.6 years (SD = 5.80) were recruited to participate in the experiment. All participants were randomly assigned to eighty-four groups of three persons. Half of these groups (N = 42) were randomly assigned to the problem construction condition, whereas the other half was assigned to the control condition. Participants received course credit or 15 Euros

Procedure

Participants came to the laboratory where they read and signed informed consent forms. Participants were then randomly assigned to three-person groups that were seated in a private room behind a computer that displayed all instructions and experimental tasks.

Participants in the problem construction condition were first presented with a problem and possible reformulations of this problem, which served as an example. We used the example as cited above, “In the last months, sales of our company dropped significantly”. Possible reformulations to this problem are “How can we engage more customers?”, “How can we make our products more attractive?”, and “How can we be more efficient?”. After these examples, groups were presented with the experimental problem ‘What solutions could be taken to preserve or improve the environment?' (Nijstad, Stroebe, & Lodewijkx, 2002) and asked to generate problem restatements, while not yet considering possible solutions to the problem. Similar to the procedure used by Baer (1988) problem reformulations all started with 'How can we…?'. In the first step, groups in the problem construction condition were given 5 minutes to generate problem reformulations, which were entered in the computer by one of the group members. In a second step, they were shown all their generated problem reformulations and were instructed to select their three best problem restatements. Upon selecting their three best problem restatements, groups moved on to the brainstorming phase. Groups learned about the four brainstorming rules by Osborn (1957): 1) generate as many ideas as possible, 2) freewheeling is encouraged, 3) criticism and evaluation are not allowed, and 4) combine and improve ideas, as well as the definition of creative ideas: ideas that are original and appropriate. They then spent 10 minutes brainstorming on creative solutions to the presented problem, taking into consideration their selected problem reformulations. Solutions were entered in the computer by one of the group members.

The forty-two groups in the control condition directly started with the brainstorming phase following the presentation of the experimental problem. In contrast to participants in the problem reformulation condition, they were not explicitly told to spend time on problem construction. This procedure is similar to Baer's study (1988) in which the control group received no treatment. Participants were provided the same four brainstorming rules and the definition of creative ideas, after which they spent 10 minutes brainstorming about the problem. Solutions were entered in the computer by one of the group members.

After the brainstorming task, groups in both conditions were presented with their generated ideas and were then asked to select their three most creative problem solutions and, finally, their most creative solution. Thereafter, groups were instructed to inform the experimenter they had completed the idea selection task. Each group member was then taken to an individual cubicle where the participant took place behind a computer. Here each participant answered a brief questionnaire about shared representation of the problem and satisfaction about the creative problem solving process. Upon finishing these individual questionnaires, participants were thanked and debriefed.

Creativity measures

Problem construction. First, we counted the number of generated problem reformulations per group. Second, problem restatements generated by the groups in the problem construction condition were rated by a trained judge on originality. Originality of the problem restatements was defined as the degree to which problem restatements were novel, offer a unique perspective on the problem, and were free from (as opposed to tied to) the problem presented, rated on a 5-points Likert scale (1 = very low quality; 5 = very high quality) (Redmond et al., 1993). We calculated the average originality of all problem formulations that were generated per group and the average originality of the three selected problem formulations.

Idea generation. Two trained and independent coders counted the number of non-redundant problem solutions generated per group (henceforth fluency). Furthermore, problem solutions were coded in semantic categories that cover the brainstorming topic (Nijstad et al., 2002). Fifty semantic categories are possible by crossing ten possible goals (e.g., to reduce waste, to reduce energy use, to protect animals) with five possible means (e.g., consumer behavior, treatment of waste, legislation), see Appendix. For example, the idea "when it is cold at home, instead of turning up the thermostat wear warm cloths" was assigned the goal "reduce energy use" and the mean "consumer behaviour." Initially, both coders rated 150 ideas to obtain an interrater reliability assessment. Interrater agreement was good, Cohen's K =.77. Assigned categories that differed between coders were discussed after which both coders assigned goals and means to the remaining ideas. The number of non-redundant categories per group was used as our measure of flexibility (Baas, De Dreu, & Nijstad, 2011; Guilford, 1967; Torrance, 1966). Additionally, a persistence score was calculated for each group by dividing the total number of ideas by the number of non-redundant categories used (Nijstad et al., 2002).

The problem solutions generated during brainstorming were rated by the same two independent coders on both creativity dimensions (originality and feasibility) on 5-point Likert scales (1 = very low originality/feasibility; 5 = very high originality/feasibility; see Baas, De Dreu, & Nijstad, 2011). Initially, both coders rated 130 ideas on these dimensions to obtain interrater reliability assessments. Interrater agreement was excellent, according to criteria set by Cicchetti and Sparrow (1981), with ICC = .93 for originality and ICC = .91 for feasibility. Ratings that differed between coders were discussed after which both coders each rated half of the remaining ideas. The mean originality and feasibility scores per group were used as dependent variables to correct for possible differences in fluency. Furthermore, on the basis of the feasibility and originality scores we derived a measure of creativity. Because creative ideas need to be both original and feasible, ideas were classified as being creative when they scored 3 or higher on both dimensions (N = 308; 14.3%). The number of creative ideas per group constituted our measure of creative group performance.

Idea selection. In the idea selection phase, groups first selected their three best ideas and then their single best idea. The selected ideas were assigned with the same originality, feasibility, and creativity score they received in the idea generation phase. This enabled us to extract the mean feasibility and originality estimates of the three selected ideas and the proportion of selected creative ideas (out of 3 ideas), and the feasibility and originality score of the final selected idea and whether or not the final idea was creative.

Manipulation check

Participants were presented with two questions to validate our problem construction manipulation. On a 7-point Likert scale (1 = not at all; 7 = very much), participants were asked to what extent they agreed to the following questions: ‘Within my group, we came up with different ways of reformulating the problem’ and ‘Within my group, we considered different perspectives on the problem’. Questions were answered by all group members individually.

Shared task representation

After the creative problem solving process, individuals were asked about similarities and differences in task approaches by group members to investigate the degree of shared task representation among group members. They were presented with 11 questions, all scored on a 7-point Likert scale (1= not at all; 7 = very much). Sample questions were ‘Within my group, we had a shared vision on how to approach the brainstorming problem’, ‘Within my group, we agreed on the goals we set for the task’, and ‘Within my group, we agreed on possible constraints when finding problem solutions’. Reliability of this scale was satisfactory, Cronbach’s alpha = .71.

Satisfaction and enjoyment

As part of an exploratory analysis, on a 7-point Likert scale (1 = not at all; 7 = very much), participants rated how satisfied they were with their performance during the different stages of creative problem solving (Rietzschel et al., 2006). Questions considered participants’ satisfaction with the number of generated ideas, quality of the generated ideas, quality of the selected ideas, and their individual performance (Cronbach’s α = .81). Finally, participants were asked what they thought of the topic (1 = very boring to 7 =very interesting) and how much they enjoyed the task in general (1 = very much to 7 = not at all; Nijstad, Stroebe & Lodewijkx, 1999). These ratings were combined to form an enjoyment scale, Cronbach's α = .76.

Results

Data treatment and analysis

Responses of individual team members were aggregated to the team level either because participants' individual ratings were affected by group membership and/or because they should match the level of the creativity outcome variables, which are at the group level (e.g., LeBreton & Senter, 2008). We computed intraclass correlations (ICC) with ICC (1) measuring the proportion of variance of individual level responses that can be attributed to team-level properties (LeBreton & Senter, 2008). For our manipulation checks, the ICC (1) for the extent to which group members came up with different ways of reformulating the problem was .18, p = .004, and that of the extent to which group members considered different perspectives on the problem was .11, p = .039. These values are comparable to those obtained in previous research and demand aggregation of individual scores to the group level (LeBreton & Senter, 2008). For task enjoyment (ICC (1) = .02, p = .355) and performance satisfaction (ICC (1) = .04, p = .266), ICCs were small and not significant but to correlate these measures with group performance outcomes, individual scores were nevertheless aggregated to the group level. Finally, to match the level of the creativity outcome variables, individual responses to measure our proposed mediator (shared task representations) were also aggregated to the group level (ICC (1) = .12, p =.028).

For comparing between groups, we used the creativity measures as indicators for group performance. For both the idea generation and idea selection phase, we compared differences in creativity scores, as well as in separate originality and feasibility scores, between problem construction and control groups.

Correlations among variables in the idea generation and selection phase

Table 1 shows the means and standard deviations, along with the correlations between our study variables. Shared task representations did not correlate with our creativity measures. We found strongly negative correlations between originality and feasibility scores, for both the generated and selected ideas, indicating that high scores on one creativity dimension come at the expense of the other dimension. Importantly, over both phases of idea generation and idea selection, originality scores were strongly and positively related to creativity scores, whereas feasibility scores were negatively related to creativity. Flexibility, but not persistence, was positively related to both the number of ideas and the number of creative ideas within the brainstorming task. However, neither flexibility nor persistence were related to creativity measures of the selected ideas (i.e., creativity, originality and feasibility scores).

Manipulation check

The effectiveness of our manipulation was verified with two questions, one tapping the extent to which group members came up with different ways of reformulating the problem, and the other tapping the extent to which group members considered different perspectives on the problem. Team scores on the manipulation checks were submitted to two one-way ANOVAs with condition as the between-subjects variable. These demonstrated that compared to groups in the control condition, those in the problem construction condition indicated they came up with more alternative ways to reformulate the problem (M_{control} = 3.66, SD = 1.03 vs. $M_{\text{experimental}}$ = 4.95, SD = 0.94), $F(1, 82) = 36.12$, $p < .001$, $\eta_p^2 = .31$, and they considered more perspectives regarding the problem (M_{control} = 4.18, SD = 1.02 vs.

$M_{experimental}$ = 4.98, *SD* = 0.84), $F(1, 82) = 15.23$, $p < .001$, $\eta_p^2 = .16$). These results indicate that our manipulation of problem construction was successful.

Shared task representation

We hypothesized that groups in the problem construction condition would have higher shared task representations than those in the control condition (Hypothesis 1). To test Hypothesis 1, we submitted shared task representation scores to a one-way ANOVA with condition as between-subjects variable. We found no significant difference between both conditions, $M_{control}$ = 5.36, *SD* = .44 vs. $M_{experimental}$ = 5.30, *SD* = .51; $F(1, 82) = .29$, $p = .592$, $\eta_p^2 = .00$. Disconfirming Hypothesis 1, these results indicate that groups in the problem construction condition did not have more similar task representations than those in the control condition. Table 1 also shows that shared task representations did not predict the creativity outcomes during the brainstorming and selection task. This renders mediation of the effect of condition on creativity outcomes by shared task representations (Hypothesis 5a and 5b) implausible.

Idea generation

Quantity of idea generation. To compare the number of ideas that were generated in both conditions, we submitted the number of ideas to a one-way ANOVA with condition as the between-subjects variable. Groups in the problem construction condition generated less ideas in the brainstorming task (*M* = 23.50, *SD* = 8.75) than groups in the control condition (*M* = 27.70, *SD* = 9.78), $F(1, 82) = 4.28$, $p = .042$, $\eta_p^2 = .05$. To test Hypothesis 2 that groups in the problem construction condition would generate ideas within more limited categories than groups in the control condition, we submitted persistence and flexibility to separate one-way ANOVAs with condition as between subjects variable. Groups in the problem construction condition were more persistent than groups in the control condition, M_{control} = 2.41, *SD* = .43 vs. $M_{\text{experimental}}$ = 2.91, *SD* = .81; $F(1, 82) = 12.80$, $p = .001$, $\eta_p^2 = .14$, indicating they generated relatively many ideas within a limited number of categories during brainstorming. Also in line with our expectations, groups in the problem construction condition considered fewer semantic categories during idea generation (i.e., they were less flexible) than groups in the control condition, M_{control} = 11.52, *SD* = 3.42 vs. $M_{\text{experimental}}$ = 8.50, *SD* = 3.59; $F(1, 82) = 15.64$, $p <.001$, $\eta_p^2 =.16$. These findings support Hypothesis 2 that groups in the problem construction condition elaborated on a more limited amount of categories.

Quality of idea generation. To test Hypothesis 3 that groups in the problem construction condition would generate more creative ideas, we conducted a one-way ANOVA of the number of creative ideas, with condition as between-subjects variable. Although the effect of condition only bordered on being significant, $F(1, 82) = 3.87$, $p = .053$, $\eta_p^2 = .05$, the descriptive means were actually opposite to what we predicted. Control groups (*M* = 4.36, *SD* = 3.30) tended to generate more creative ideas than those in the experimental condition (*M* = 2.98, *SD* = 3.13). Thus, while groups in the problem construction condition showed a relatively high degree of elaboration, this did not result in the generation of more creative ideas. It is, however, important to note that despite the explicit goal of brainstorming to generate creative ideas, groups in both conditions generated relatively few creative ideas. Only 12.7% of the entire pool of ideas in the problem construction condition (125 out of 988), and 15.7% of the pool of ideas in the control condition were creative (183 out of 1162).

Subsequently, we tested possible differences in feasibility and originality between conditions. Condition did not affect the feasibility of ideas, as indicated by a one-way ANOVA, $F(1, 82) = 1.03$, $p = .313$, $\eta_p^2 = .01$. However, ideas generated by control groups were more original (*M* = 1.80, *SD* = .26) than ideas generated by groups in the problem construction condition (*M* = 1.69, *SD* = 1.67), *F*(1, 82) = 5.21, *p* = .025, $\boldsymbol{\eta_p}^2$ = .06. Possibly, groups spending time on problem construction tend to focus less on the originality dimension than control groups.

Idea selection

Analyses in the idea generation phase demonstrated that groups in the problem construction condition did not produce more creative ideas than control groups in the idea generation phase. We hypothesized that groups in the problem construction condition would select more creative ideas than groups in the control condition (Hypothesis 4). Our results demonstrated, however, that of the three best selected ideas, control groups had a higher percentage of creative ideas (23.0%) than groups spending time on problem construction (10.3%), χ^2 (1) = 7.31, *p* = .007. In a similar vein, when selecting the best idea, 23.8% of the control groups and 7.1% of the problem construction groups managed to select a creative idea, χ^2 (1) = 4.46, *p* = .035. On the basis of these results, we reject Hypothesis 4, stating that groups in the problem construction would select more creative ideas.

From idea generation to idea selection

Creativity. To investigate selection effectiveness, we conducted a 2 (condition) x 2 (phase: idea generation vs. selection of best three ideas) repeated measures ANOVA with condition as the between-subjects factor, comparing the proportion of creative ideas in both the idea generation task (i.e., the number of creative ideas out of the total number of ideas generated) and idea selection task (i.e., the number of selected creative ideas out of the three ideas that were selected). We found no significant main effect for phase, *F*(1, 82) = 2.19, *p* = .14, $\boldsymbol{\eta_p}^2$ = .026, indicating there was no difference between the proportion of creative ideas in the idea generation as compared to the idea selection phase. However, a significant main effect of condition (F (1, 82) = 5.81, p = .018, η_p^2 = .066) showed that groups in the control condition showed higher proportions of creative ideas than groups in the problem construction condition. Finally, the interaction effect between phase and condition was significant, F(1, 82) = 5.39, p = .023, η_p^2 = .06. Compared to groups in the problem construction condition ($M_{\text{proportion generated ideas}}$ = .12, SD = .12; $M_{\text{proportion selected ideas}}$ = .10, SD = .17, control groups tended to be better in selecting creative ideas (M_{control} = .23, SD = .27; F(1, 82) = 6.59, p = .01, η_p^2 = .07) than in generating creative ideas (M_{control} =.15, SD = .09; F(1, 82) = 1.49, p = .23, η_p^2 = .02)[1]. These results demonstrate that not groups in the problem construction condition, but control groups were more efficient in identifying the creative ideas among their generated ideas.

Creativity dimensions: feasibility and originality. Mean scores on the separate creativity dimensions for both idea generation and idea selection are presented in Table 2. To compare whether groups in both conditions differed in their performance in terms of originality and feasibility during idea generation as compared to idea selection, we conducted a 2 (condition) x 2 (dimension: originality vs. feasibility) x 2 (phase: idea generation vs. selection of three best ideas) repeated measures ANOVA with the latter two factors within-subjects. We found a significant main effect for dimension, F(1, 82) = 1277.33, p < .001, η_p^2 = .94, showing that feasibility scores were higher than originality scores (also see Figure 1). There were no main effects of condition, F (1, 82) = 3.06, p = .084, η_p^2 = .04, and of phase, F(1, 82) = 0.21, p = .646, η_p^2 = .00. No two- or three-way interaction effects emerged (Fs < 1.83, ps> .181), except for a two-way interaction between dimension and condition, F(1, 82) = 4.83, p = .031, η_p^2 = .056. Investigating this two-way interaction shows that across the idea generation and selection phase, control groups showed higher originality scores than groups in the problem construction condition, F(1, 82) = 6.57, p = .012, η_p^2 = .07; across phases, groups in the problem construction condition showed higher feasibility scores than control groups, as indicated by the mean scores, but the effect of condition was not significant, $F(1, 82) = 1.94$, $p = .167$, $\eta_p^2 = .02$. These results indicate that regardless of the phase in the creativity process, control groups focused more on originality than groups in the problem construction condition.

Finally, we repeated the above analysis focusing on the best selected idea with a 2 (condition) x 2 (dimension: originality vs. feasibility) x 2 (phase: idea generation vs. selection of best idea) repeated measures ANOVA with the latter two factors within-subjects.

We found a significant main effect for dimension, $F(1, 82) = 632.33$, $p < .001$, $\eta_p^2 = .885$, showing that feasibility scores were higher than originality scores. There were no main effects of condition, $F(1, 82) = 2.00$, $p = .162$, $\eta_p^2 = .024$, and of phase, $F(1, 82) = 1.34$, $p = .162$, $\eta_p^2 = .016$. However, the repeated measures ANOVA demonstrated a two-way interaction between dimension and condition, $F(1, 82) = 4.83$, $p = .031$, $\eta_p^2 = .056$. Investigating this two-way interaction shows that across the idea generation and selection phase, control groups showed higher originality scores than groups in the problem construction condition, $F(1, 82) = 7. 71$, $p = .007$, $\eta_p^2 = .086$; across phases, groups in the problem construction condition tended to show higher feasibility scores than control groups, $F(1, 82) = 3.61$, $p = .061$, $\eta_p^2 = .042$. In addition, a significant three-way interaction between phase, dimension and condition,

$F(1, 82) = 2.14$, $p = .040$, $\eta_p^2 = .05$. Investigating this three-way interaction shows that, only for the control condition, there was a significant interaction between phase and dimension, $F(1, 41) = 4.23$, $p = .046$, $\eta_p^2 = .09$. For the problem construction condition, no interaction effect was apparent, $F(1, 41) = .74$, $p = .395$, $\eta_p^2 = .02$. Within control groups, originality scores of the best selected idea were higher than those of generated ideas, $F(1, 41) = 4.42$, $p = .042$, $\eta_p^2 = .10$; feasibility scores were not different across phases, $F(1, 41) = 1.39$, $p = .246$, $\eta_p^2 = .033$. This leads to the conclusion that control groups were more effective in identifying original ideas when selecting.

Table 2.
Mean Originality and Feasibility Scores for Generated and Selected Ideas per Condition.

	Problem construction	Control
	M (*SD*)	*M* (*SD*)
Originality idea generation	1.67 (0.27)	1.80 (0.26)
Originality best 3 selected ideas	1.62 (0.52)	1.90 (0.61)
Originality best selected idea	1.60 (0.83)	2.12 (1.09)
Feasibility idea generation	4.25 (0.22)	4.19 (0.33)
Feasibility best 3 selected ideas	4.29 (0.42)	4.15 (0.48)
Feasibility best selected idea	4.36 (0.69)	4.05 (0.82)

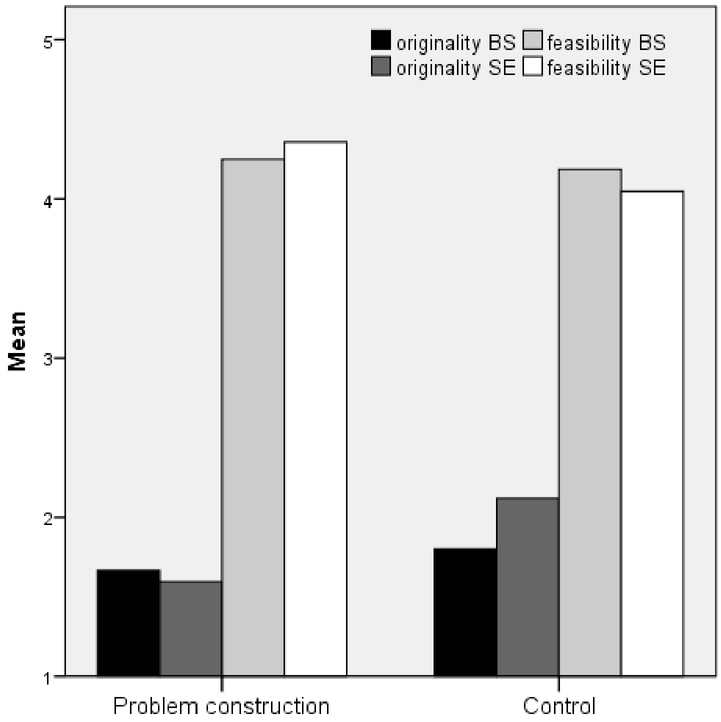

Figure 1. Mean originality and feasibility scores for groups in problem construction and control conditions for generated ideas and the selected best idea.

Note. BS = brainstorming task SE = selection task (best idea)

Exploratory Analyses

Problem construction correlates. To compare differences within problem construction groups, we investigated the correlations of problem construction measures with variables in idea generation and selection phase, which can be found in Table 1. We found that the number of problem reformulations was positively related to originality scores of the reformulations. Additionally, we found positive correlations of the number of problem reformulations with the number of ideas generated in the brainstorming task, as well as the number of creative ideas and originality scores of those ideas. Finally, the number of problem reformulations was positively related to the degree of persistence in idea generation. Again, originality scores seemed important as highly original problem reformulations were associated with more ideas, more creative ideas, and more original and less feasible ideas in the brainstorming task. Yet, besides a negative correlation between originality of the problem reformulations and feasibility of the selected ideas (see Table 1), we found no significant correlations between the originality of problem reformulations and idea selection variables.

Satisfaction. A one-way ANOVA with condition as the between-subjects variable revealed no significant differences between problem construction groups and control groups regarding their satisfaction with their performance, $F(1, 82) = .04$, $p = .843$, $\eta_p^2 = .00$. Despite the observation that relatively few creative ideas were generated and selected by groups in both conditions, participants were generally satisfied with their performance on the tasks ($M_{\text{control}} = 5.43$, $SD = 0.60$ vs. $M_{\text{experimental}} = 5.45$, $SD = 0.59$). Furthermore, satisfaction scores showed weak and non-significant correlations with actual performance, as measured by the number of creative ideas generated ($r = .07$, $p = .546$) and the final selection of creative ideas ($r = -.00$, $p = .991$ for best three and $r = -.09$, $p = .433$ for best idea).These results point out that groups indicated to be satisfied about their performance, independent of their actual performance.

Enjoyment. Mean scores show that participants enjoyed the tasks in this study, ($M_{\text{control}} = 4.92$, $SD = 0.79$ vs. $M_{\text{experimental}} = 5.21$, $SD = 0.65$), with no significant differences in enjoyment ratings between problem construction and control groups, $F(1, 82) = 3.34$, $p = .071$, $\eta_p^2 = .04$. Comparable to satisfaction scores, enjoyment ratings showed weak and non-significant correlations with task performance, $r = .00$, $p = .970$ for the generation of creative ideas, and $r = -.15$, $p = .175$ and $r = -.11$, $p = .305$ for selection of the best three ideas and best idea, respectively.

Post-Hoc Analyses

Because the findings in this study were for the most part inconsistent with our expectations, we conducted additional, post-hoc analyses to gain more insight into the underlying effects of the observed creativity differences. First, we proposed two mediators accounting for the lower creativity scores found in problem construction groups. Second, we investigated whether the consideration of different goals was related to originality and creativity.

Originality as a mediator. This study demonstrated higher creativity scores for control groups compared to the groups engaging in problem construction. Additionally, investigation of the separate creativity dimensions indicated higher originality scores for control groups relative to problem construction groups. Because originality scores seem to determine creativity scores much more than the feasibility dimension, we propose originality to account for the differences in creativity scores found between groups in the two conditions. We conducted a regression analysis with the number of creative ideas in the brainstorming task as the dependent variable. In the first step, condition was added as the predictor variable, B = 1.38, SE = 0.70, $t(82)$ = 1.97, p = .053 (marginal). In the second step, originality of the generated ideas was entered into the analysis. Originality significantly predicted the number of creative ideas generated, B = 8.91, SE = 0.90, $t(81)$ = 9.86, $p < .001$; the effect of condition decreased after controlling for the mediator, B = 0.20, SE = 0.49, $t(81)$ = 9.86, p = .689. These results indicate that originality may mediate the relationship between condition and the generation of creative ideas. To examine this, we tested the indirect effect of condition on creative idea generation through originality by generating bootstrap confidence intervals (N_{boot}=5000; Preacher & Hayes, 2008). The analyses indicated that the indirect effect was statistically significant at the .05 level (B_{boot}=1.18, SE_{boot}=.50; 95%CI = [0.17,2.12]). Put differently, decreased original thinking associated with the act of problem construction explained the variance in the generation of creative ideas.

Subsequently, we assessed whether originality of idea generation would have the same mediating effects in the idea selection phase. Regression analyses demonstrated that originality of the generated ideas mediated the effects of condition on both the selection of the best 3 ideas (*B* = 1.21, *SE* = 0.25, *t*(81) = 4.87, *p* < .001; effect of condition dropped from *B* = 0.38, *SE* = 0.15, *t*(82) = 2.57, *p* = .012 to *B* = 0.22, *SE* = 0.14, *t*(81) = 1.62, *p* = .109.To examine the indirect effect of condition on creative idea selection through original ideation, we generated the same bootstrap confidence intervals. The analyses indicated that the indirect effect was statistically significant at the .05 level (B_{boot}=0.16, SE_{boot}=.08; 95%CI = [0.03,0.36]). Put differently, decreased original thinking associated with the act of problem construction explained the variance in the selection of creative ideas. Thus, original ideation demonstrated to be a robust mediator, accounting for the effects of condition on creativity in both the idea generation and selection phase.

The mediating effects of flexibility and fluency. Flexibility is an important mechanism underlying creativity (De Dreu, Baas, & Nijstad, 2008). Control groups were higher on flexibility than problem construction groups, $F(1, 82) = 15.64$, $p < .001$, $\eta_p^2 = .06$; $M_{control}$ = 11.52, *SD* = 0.53, $M_{experimental}$ = 8.50, *SD* = 3.59, and, as can be seen in Table 1, flexibility was a positively correlated with originality (*r* = .26, *p* = .018) and creativity (*r* = .47, *p* < .001) of ideas in the brainstorming task. This could indicate that the consideration of different categories helped control groups in generating more creative ideas. To investigated this proposition, we conducted a hierarchical regression analysis with the number of creative ideas generated as the dependent variable. In the first step, we entered condition in the analysis, flexibility was added in a second step. When flexibility was added to the analysis, it significantly predicted creative ideas in the brainstorming task, *B* = 0.40, *SE* = 0.09, *t*(81) = 4.33, *p* < .001, and, additionally, the previous effect of condition on creativity (*B* = 1.38, *SE* = 0.70, *t*(82) = 1.97, *p* = .053) dropped considerably, *B* = 0.18, *SE* = 0.70, *t*(81) = 0.26, *p* = .799. These results indicate that flexibility may mediate the relationship between condition and the generation of creative ideas. To examine this, we tested the indirect effect of condition on creativity through flexibility by generating bootstrap confidence intervals (see above). The analyses indicated that the indirect effect was statistically significant at the .05 level (B_{boot}=1.20, SE_{boot}=.41; 95%CI = [0.55,2.22]). Put differently, decreased flexible thinking associated with the act of problem construction explained the variance in the generation of creative ideas. When focusing on idea selection, flexibility could not explain the effects of condition on creativity scores when focusing on the selection of the best three ideas (regression effects of flexibility: *ß* = .018, p = .186; B_{boot}=0.01, SE_{boot}=.07; 95%CI = [-0.14,0.13]).

Goals in problem construction. Findings thus far show that across the idea generation and selection phase, groups in the problem construction condition showed lower originality scores than control groups. One possible reason for this finding could be that problem construction groups chose specific problems to think about that were less original to begin with, and that would lead to less original idea generation. To test this possibility, we first investigated the goals groups in the problem construction condition focused on when reformulating the problem and generating problem solutions. We used the coding scheme by Nijstad et al. (2002), within the problem construction condition, to assign the goal that the three selected problem reformulations were focused on (i.e., 10 possible goals). For example, the problem formulation “how can we reduce CO_2 emission?” was assigned the goal “reduce air pollution”. Subsequently, we assessed whether these goals determined originality of problem formulations and idea generation.

Out of ten possible goals to focus on in the environmental topic, all groups in the problem construction condition used only 8 goals when constructing the problem (see Table 3). Of all selected problem formulations (N = 126), 65.8% fell in two goals: 33.3% of the problem reformulations focused on the goal ‘protect climate and atmosphere’ and 32.5% focused on ‘reduce air pollution’. Using a univariate ANOVA with the originality score of the reformulation as the dependent variable and the goal as the between-subjects factor, we examined whether goal determined the originality of problem formulations. As can be seen in Table 3, goal affected originality of the chosen problem formulation, $F(7, 118) = 4.97$, $p < .001$, $\eta_p^2 = .23$. Because one goal was only mentioned once, post-hoc Tukey tests could not be performed. Instead, a follow-up independent samples t-test in which we compared the originality of the problem formulations that focused on the two goals that were most often selected (goal 4 and 6, see Table 3) to the originality of those formulations focused on less-considered goals, showed that problem formulations with often selected goals were less original (*M* = 2.06, *SD* = 0.76) than problem formulations with less often selected goals (*M* = 2.41, *SD* = 0.50); $t(125) = 0.26$, $p = .007$. Earlier, we demonstrated that more original selected problem reformulations were associated with the generation of more original ideas ($r = .51$, $p = .001$) and more creative ideas ($r = .34$, $p = .027$) during the brainstorming task.

Table 3
Frequencies of Goals that Selected Problem Reformulations Focused on and Their Respective Originality Scores

Goal	Frequency (Percentage)	Originality *M* (*SD*)
1. Reduction in the production of waste	10 (7.9%)	2.30 (0.48)
2. Reduce the use of chemical and toxic substances and avoid chemical waste	0 (0.0%)	-
3. Reduce water pollution	0 (0.0%)	-
4. Reduce air pollution	41 (32.5%)	1.85 (0.69)
5. Reduce pollution of the soil	3 (2.4%)	2.33 (0.58)
6. Protect climate and atmosphere	42 (33.3%)	2.26 (0.77)
7. Reduce energy consumption and increase of green energy	17 (13.5%)	2.06 (0.24)
8. Reduce use of natural resources	1 (0.01%)	3.00 [b]

9. Protect landscape	8 (0.06%)	3.00 (0.00)
10. Protect animals and plants	4 (0.03%)	3.00 (0.00)

Note. $N = 126$.
[b] this goal was only chosen once, so no *SD* was available.

Goals during idea generation. Similar to the procedure we used for categorizing problem formulations, all ideas generated in the brainstorming task by groups in both conditions were assigned one of 10 goals. Although all generated ideas during brainstorming ($N = 1250$) covered all 10 goals, one goal, 'protect climate and atmosphere', was used very often during brainstorming (50.9%). We investigated whether the goal an idea was focused on was related to creativity outcomes. A univariate ANOVA with goal as the between-subjects factor demonstrated significant differences in originality scores of the generated ideas ($F(9, 2140) = 47.78$, $p < .001$, $\eta_p^2 = .17$), similar to findings for originality of problem reformulations. Moreover, we found significant differences when comparing the proportions of creative ideas (i.e., the number of creative ideas divided by the total number of ideas) between the different goals of the generated ideas ($F(9, 2140) = 73.81$, $p < .001$, $\eta_p^2 = .24$). Post-hoc Tukey tests indicated that the most frequently used goal ('protect climate and atmosphere') was associated with significantly less creative ideas than four other goals (*p*s < .001; mean proportions are presented in Table 4). It thus seems that, when focusing on goals for idea generation, falling into this 'common goal' focus, makes it more difficult to generate creative ideas. Finally, goal also affected feasibility of the generated ideas, $F(9, 2140) = 15.87$, $p < .001$, $\eta_p^2 = .06$.

In order to any differences in goals for idea generation between both conditions, we performed a Chi-square test. The relation between goal and condition was significant, $\chi^2(9) = 55.99$, $p < .001$, indicating that both conditions differed in the goals they focused on during idea generation. We performed an independent samples t-test to investigate whether groups in both condition differed in their use on the frequent goal (‘protect climate and atmosphere’), comparing the proportion of ideas focused on this goal (i.e., the number of ideas focused on ‘goal 6’divided by the total number of ideas or fluency) for both conditions. Results indicated that problem construction groups seemed to focus more on the goal ‘protect climate and atmosphere’ (M = 0.59, SD = 0.22) than control groups (M = 0.45, SD = 0.17), $t(82) = 3.38$, $p = .001$, which was generally associated with relatively low originality and creativity scores. Thus, control groups seemed to focus more on ‘common goals’ when generating ideas, while the consideration of less common goals demonstrates to be beneficial for creative ideation.

Table 4

Frequencies and Scores on Creativity Measures of the Goals in Idea Generation.

Goal	Frequency (Percentage)	Originality *M* (*SD*)	Feasibility *M (SD)*	Creativity *M* (*SD*)
1. Reduction in the production of waste	227 (10.6%)	1.84 (0.65)	4.37 (0.71)	0.11 (0.32)
2. Reduce the use of chemical and toxic substances and avoid chemical waste	26 (1.2%)	2.54 (0.58)	3.92 (0.80)	0.46 (0.51)
3. Reduce water pollution	26 (1.2%)	2.15 (0.78)	3.88 (0.82)	0.38 (0.50)
4. Reduce air pollution	113 (5.3%)	1.82 (0.97)	4.00 (0.79)	0.17 (0.38)
5. Reduce pollution of the soil	32 (1.5%)	1.66 (0.60)	4.81 (0.40)	0.06 (0.25)
6. Protect climate and atmosphere	1094 (50.9%)	1.64 (0.75)	4.24 (0.78)	0.08 (0.27)
7. Reduce energy consumption and increase of green energy	330 (15.3%)	1.50 (0.78)	4.20 (0.69)	0.10 (0.30)
8. Reduce use of natural resources	131 (6.1%)	1.72 (0.55)	4.40 (0.78)	0.03 (0.17)
9. Protect landscape	104 (4.8%)	2.58 (0.66)	3.59 (0.76)	0.52 (0.50)
10. Protect animals and plants	67 (3.1%)	3.00 (0.52)	3.88 (0.54)	0.88 (0.33)
Total		1.76 (0.81)	4.20 (0.77)	0.14 (0.35)

Note. $N = 2150$.

Discussion

To solve problems creatively, groups often need to go through several stages: from examining the problem at hand, through the generation of candidate solutions, to the identification of the best solutions for implementation purposes. Although all stages are important, both researchers and teams in organizations focus mainly on the idea generation phase, while ignoring the other stages of creative problem solving. Group research on the idea selection phase is scant (e.g., Faure, 2004; Rietzschel et al., 2006; 2010) and studies on problem construction were typically carried out at the individual level. Additionally, to our knowledge, no research to date investigated the complete creative problem solving process, incorporating all stages. Therefore, the aim of this study was to gain insight into the group processes associated with the act of problem construction, and to examine the effects of problem construction on the later phases of creative problem solving in groups: idea generation and idea selection.

In this study, three-person groups engaged in creative problem solving processes, with half of the groups first spending time on construction of the problem. The other half of the groups started directly with the brainstorming task and finally, selecting their best ideas. Compared to control groups, groups spending time on problem construction generated a relatively large number of ideas within a more limited set of categories. However, this deep exploration of only a few categories did not result in the generation of more creative ideas, nor did we find support for the prediction that groups engaging in problem construction would be better at selecting creative ideas. Quite on the contrary, we observed that compared to control groups, those engaging in problem construction generated less creative ideas, selected less creative ideas, and were relatively less efficient in identifying creative ideas among their generated ideas. Finally, we expected more similar representations of the task in problem construction as compared to control groups and that shared task representations would account for the positive effects of problem construction on creative problem solving processes. However, problem construction groups did not report having more similar task representations than control groups, nor did shared task representations influence performance in idea generation and selection. In the remainder of this Discussion, we will reflect on these findings and highlight avenues for future research.

Why control groups outperform problem construction groups

We propose three reasons for the finding that control groups reached more creative ideas in the brainstorming and selection task. The first explanation derives from the brainstorming principle “quantity breeds quality” (Osborn, 1957): the more ideas will be generated, the more creative ideas will be among them, and this is also supported by meditational analyses in this study. Problem construction groups generated less ideas than control groups, probably because the act of problem construction limited the problem scope before brainstorming. Therefore, control groups had a greater pool of ideas and a higher probability of generating a larger number of creative ideas. For idea selection, however, the number of brainstorming ideas was not related to creativity scores. Most likely, having a large pool of ideas to choose from makes it difficult to make an effective selection of the best ideas. The second reason is based on our finding that the goals that the ideas in the brainstorming task are focused on determined the originality and creativity scores of those ideas. When brainstorming, problem construction groups seemed to focus on goals that were associated with less original and less creative ideas, compared to control groups. Third and finally, one of the most intriguing findings of this study was that groups showed differences in focus on the separate dimensions of creativity: originality and feasibility. While both groups showed higher feasibility than originality scores, problem construction groups scored lower on originality than control groups, both in the brainstorming task and in the selection task. Our results showed that these higher originality scores in control groups explained the differences in creative ideas in both the idea generation and idea selection phase.

Originality versus feasibility

Although control groups outperformed problem construction groups, it is important to note that, consistent with findings of Rietzschel et al. (2006), relatively little creative ideas were generated (14.3%) and selected by both groups (16.7%), despite explicit instructions to generate and select creative ideas. Groups seem to find it difficult to take into account both criteria of originality and feasibility. Consistent with earlier findings (e.g., Rietzschel et al., 2010) our study demonstrates that these two creativity dimensions are strongly negatively correlated. Thus, although control groups seemed to generate more creative ideas and make a better selection of creative ideas, there seems to be much room for improvement in creative problem solving. Interestingly, groups were generally satisfied with their performance, regardless of actual performance. This suggests that groups are not aware of their poor performance on creative problem solving tasks and that group members may use different criteria in judging their performance. Relatedly, Mueller, Melwani, and Goncalo (2011) demonstrated that people have ambivalent feelings toward originality relative to practicality and this bias against originality was stronger when people experienced uncertainty. Perhaps, the strong focus in our study on solving “problems” increased uncertainty and a focus on preventing losses and negative outcomes (Higgins, 1998), which consequently, reduced (enhanced) the appreciation of originality (feasibility). Because groups in the problem construction condition spent much time and effort on redefining “problems,” this may help explain the finding that problem construction groups had a stronger emphasis on feasibility (vs. originality) than control groups. These findings are unfortunate, given the great importance of originality in all stages of the creative problem solving process.

How to improve problem construction?

It seems that when focusing on the goals of the creative problem solving process, an important step in problem construction, people should adopt a more flexible approach to explore goal domains that are not commonly considered (cf. Nijstad et al., 2010). One way through which this can be achieved is by acknowledging that multiple problem perspectives exist and by focusing on goals than are not habitually considered. This might shift problem construction groups' focus from feasibility to originality, and increase originality and creativity scores for problem construction groups throughout all problem solving stages. Thus, when redefining the problem, it seems particularly important to rely on two criteria: originality of the problem reformulations and the goal that the problem reformulation is focused on. In our study, groups engaging in problem construction seemed to focus on producing relatively unoriginal problem reformulations, while our findings simultaneously demonstrate that more original problem reformulations were associated with more original and more creative ideas during brainstorming. Therefore, it seems important that groups focus more on, or should be trained at, generating more original problem reformulations. Research by Ellspermann et al. (2007), at the individual level, supports the notion that problem construction can be trained, and found that training resulted in positive effects on originality and quality of the problem reformulations. By investigating the separate stages of creative problem solving, our study highlights the importance of training and demonstrated the possible beneficial effects of more original problem reformulations on the generation and selection of creative ideas. Possibly, individuals perceive the process of problem construction as more difficult than idea generation or brainstorming, and, therefore, merely instructing participants to engage in problem construction does not immediately result in the possible beneficial effects. Support for this notion is found by Reiter-Palmon et al. (1997), claiming that people need a basic level of problem construction ability before they can carry out the problem construction process efficiently. We suggest further research to focus on the specific content of training problem construction within groups.

Limitations and avenues for future research

We shortly mentioned that problem construction did not affect the degree of shared task representations. Perhaps this finding was due to insufficient information sharing. While group members each have different representations of the problem, including different representations of goals, objectives, and constraints, these different representations might be insufficiently shared and integrated when simply listing as many problem reformulations as possible. Although this manipulation of problem construction has been used in past research at the individual level (Baer, 1980), a different manipulation that is focused on reaching a complete understanding of the problem at hand as well as the explicit instruction to share information and perspectives would be more suitable at the group level to increase both problem construction efforts and shared task representations. Additionally, the fact that we have a fairly homogenous group of participants (mostly female university students) may even have more strongly limited the exploration of problem perspectives, as homogenous groups tend to search for agreement more easily (Reiter-Palmon et al., 2008). We suggest further research could benefit from using groups that are more diverse, where we might expect more dissent and mutual discussion.

Another limitation of our research design is the difference between conditions in the amount of time spent in groups on creative problem solving. Problem construction groups spent an additional five minutes on reformulating the problem before brainstorming, whereas control groups directly started with the brainstorming task. Although this control condition has been used in previous work on the effects of problem construction (Baer, 1980), spending 5 more minutes on problem constructions may have resulted in unanticipated effects, including increased boredom and fatigue. We can rule out possible effects of boredom, as groups reported to enjoy the tasks, with no differences between conditions. However, we cannot rule out the possibility that because problem construction groups spent time and effort on the reformulation task, they started brainstorming with lower energy levels than control groups. Future research might include a control condition in which groups engage in a control task involving the participation of all group members, while not relying on creative problem solving processes. Finally, one should note that participants in this study were university students participating for research credit or money. Direct generalization of these results might not be possible, as teams within organizations most likely work for a common purpose and might be more motivated to reach their goals.

Conclusions

Einstein once mentioned that "*Given one hour to save the planet, [he] would spend 59 minutes understanding the problem and one minute resolving it.*" Supporting the importance of problem construction on creative problem solving, previous work that has mainly shown positive effects of problem construction at the individual level. Our study provided insight into problem construction processes at the group level and its effects on the later creative problem solving stages idea generation and idea selection. Problem construction effects at the group level diverged from those at the individual level. Compared to control groups, groups focusing on problem construction demonstrated diminished creative performance in both the idea generation and selection phase. Post-hoc analyses shed light on this unexpected finding. Engaging in problem construction seemed to direct groups to focus on feasibility at the cost of originality; it also seemed to result in a narrower focus on the problem at hand and the generation of less (creative) ideas, and a focus on goals during creative problem solving that are inherently less creative. These insights provide valuable guidelines for future research to gain further understanding into the group processes of problem construction and its effects on creativity outcomes.

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Table 1. *Descriptive statistics*

Variable	*M*	*SD*	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1. Shared task representation	5.33	0.47	-												
Idea generation															
2. Number of ideas (fluency)	25.60	9.46	.08	-											
3. Number of creative ideas	3.67	3.27	.09	.58**	-										
4. Originality	1.73	0.27	.07	.27*	.75**	-									
5. Feasibility	4.22	0.28	.02	-.17	-.52**	-.72**	-								
6. Flexibility	10.01	3.80	.09	.80**	.47**	.26*	-.14	-							
7. Persistence	2.67	0.69	-.03	.18	.05	-.06	.02	-.40**	-						
Idea selection (best 3)															
8. Number of creative ideas	0.50	0.70	.12	.16	.49**	.51**	-.39**	.12	.01	-					
9. Originality	1.76	0.58	.01	.21	.42**	.53**	-.41**	.14	.06	.80**	-				
10. Feasibility	4.22	0.46	.08	-.12	-.36**	-.50**	.55**	-.04	-.04	-.44**	-.60**	-			
Problem reformulations[a]															
11. Number of reformulations	15.33	5.95	.17	.61**	.40**	.19	-.18	.20	.38*	.12	.25	-.23	-		
12. Originality	2.30	0.19	.01	.51**	.31*	.40***	-.50**	.39*	.09	.12	.20	-.40**	.35*	-	
13. Originality selected 3 reformulations	2.18	0.39	.11	.06	.34*	.51**	-.50**	.18	-.20	.16	.02	-.21	.23	.56**	-

Note: *N* = 84 [a] *N* = 42

* p < .05 ** p < .001

Appendix A

Environment categories

(Nijstad, Stroebe & Lodewijkx, 2002)

Goals

1	Reduction in the production of waste
2	Reduce the use of chemical and toxic substances and avoid chemical waste
3	Reduce water pollution
4	Reduce air pollution
5	Reduce pollution of the soil
6	Protect climate and atmosphere
7	Reduce energy consumption and increase of green energy
8	Reduce use of natural resources
9	Protect landscape
10	Protect animals and plants

Means

A	Consumption
B	Production
C	Treatment of waste
D	Information
E	Organization and Action