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Creativity

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For many years there was a strong research interest in creativity as an individual activity (Simonton, 1984, 1999; Sternberg, 2006), emphasizing the impact of such personal factors as developmental experiences and thinking styles. Great discoveries in science were mostly attributed to personal genius (Simonton, 1984, 2004). However, in the past 20 years there has been an increasing awareness of the social dynamics involved in creativity (Amabile, 1983; Dacey & Lennon, 1998; Purser & Montuori, 1999), and there has been a strong interest in innovation in work teams and organizations (Choi & Thompson, 2005; Zhou & Shalley, 2007). This interest has led to increased research on the group creative process (Mannix, Neale, & Goncalo, 2009; Paulus & Nijstad, 2003).

CREATIVE COLLABORATION, GROUP CREATIVITY, AND TEAM INNOVATION

Creativity is typically defined as the generation or development of novel ideas or products that have some degree of utility or acceptance (Amabile, 1983; Woodman, Sawyer, & Griffin, 1993). This definition makes sense since it is certainly more difficult to come up with useful or acceptable ideas or products than those that are simply novel. Famous paintings, symphonies, and theories represent just some of the products that are both novel and have gained acceptance, and televisions and computers are among the many novel products that have been very useful. Much of the group creativity literature has distinguished between the generation of novel ideas and their utility since these may reflect different processes. Often the creative process is seen as involving different phases, such as idea generation, selection of feasible ideas, development of ideas into

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potentially useful innovations, and finally implementation, engineering, and marketing of the innovation (Parnes, 1975).

Creative collaboration is a term that is often encountered and can be used to encompass a wide variety of creative activities that involve social interaction. In the scholarly literature this term is often used when describing longer-term creative relationships of two or more individuals. Several books have described these types of collaborations among highly creative individuals (Farrell, 2001; John-Steiner, 2000). The term is also often used for educational practices in which students work on joint projects (collaborative learning; pair learning). It is presumed that such experiences have important educational benefits and may enhance innovative learning (Kanev, Kimura, & Orr, 2009).

Much research on collaborative creativity has involved structured task groups in short-term laboratory settings (what we call *group creativity*). Task groups can be defined as collections of three or more individuals working on a common task or goal. Two individuals working together are called a dyad and are often not considered a group (Moreland, 2010). However, many of the same processes that play a role in creative groups also play a role in creative dyads (John-Steiner, 2000), so there is no strong theoretical rationale for excluding pairs of creative collaborators from our discussion.

Collaborative creativity also takes place in organized work teams. Team scholars tend to define teams as two or more individuals who work collaboratively through specific roles toward some shared goal (Salas, Rosen, Burke, & Goodwin, 2009). Most of the research on creativity in teams has involved work teams in organizational settings. The team studies typically involve an assessment of the creative process through surveys of team members and ratings of innovative outcomes by team members and/or supervisors (Hülsheger, Anderson, & Salgado, 2009). Whereas most of the creativity research involving laboratory groups has focused on the ideation phase of creativity, research on teams often focuses on actual implementation of innovations (West, 2003, 2004). For this reason studies of team creativity often use the term *team innovation* to label the process being studied. Since researchers studying laboratory groups and work teams have somewhat different foci, these two areas of research are often viewed as two distinct areas (Paulus & Van der Zee, 2004). However, since teams are groups, there is little justification for ignoring the team literature in a review of group creativity (Moreland & Levine, 2009). So in this review we will take a broad view of the group creative process, taking into account the literatures on group creativity, team innovation, and other types of creative collaborations.

In many studies of group creativity, interacting individuals are compared with the same number of non-interacting individuals, labeled a nominal group. This kind of comparison provides information on the extent to which the group interaction enhances creativity. Many studies using the brainstorming paradigm in which individuals try to generate a large number of ideas as a group have found that such groups actually generate fewer ideas than do nominal groups (Diehl & Stroebe, 1987; Mullen, Johnson, & Salas, 1991). Interestingly, participants in group brainstorming perceive their performance more favorably than do solitary performers (Paulus, Dzindolet, Poletes, & Camacho, 1993; Stroebe, Diehl & Abakoumkin, 1992). In other words, group members have the perception that group interaction enhanced their performance while in fact it hindered their performance. What does this mean? Should teams not work together on innovation projects, or are these findings limited to the performance of ad hoc groups in a short term setting? Does the illusion of productivity found in laboratory groups explain the positive evaluations often obtained in work teams? That is, are the positive perceptions obtained in work teams simply illusory? We will address these questions below.

In our review we will focus on the group creativity literature and its relevance for a broader theory of group creativity (Nijstad & Stroebe, 2006; Paulus & Brown, 2007; Paulus & Dzindolet, 2008). We will then relate this perspective to the literatures on team innovation and creative collaboration in long-term groups. This will suggest potential avenues for broadening and enriching the research on group creativity.

COGNITIVE, SOCIAL, AND MOTIVATIONAL PROCESSES IN GROUP CREATIVITY

Paulus and his colleagues have developed a model that integrates the cognitive, social, and motivational processes involved in group creativity (Paulus & Brown, 2003, 2007; Paulus & Dzindolet, 2008; see Figure 1). This model, which has roots in an earlier cognitive-motivational model of group task performance (Paulus, 1983), provides a useful framework for organizing much of the literature on group creativity (see Paulus, Dugosh, Dzindolet, Coskun, & Putman, 2002; Paulus, Levine, Brown, Minai, & Doboli, 2010). The model identifies several group, task, and situational variables, which influence group creativity and innovation via their impact on cognitive, motivational, and social processes Rather than discussing the model in detail, we will first summarize some of the social and motivational processes involved in group creativity and then discuss some of the cognitive processes.

Social and Motivational Processes

A critical social process is the sharing of ideas, which is influenced by some of the same factors that influence other social processes. For example, Paulus and Dzindolet (1993) found that the sharing process is influenced by the natural tendency of individuals to compare their performance with that of others (Festinger, 1954). It is presumed that group brainstormers are attuned both to the rate and the quality of the ideas generated by their fellow group members. There is a tendency in groups for the performance of the brainstormers to converge, or become more similar over time, both in terms of rate and type of ideas (Camacho & Paulus, 1995; Paulus, Larey, & Dzindolet, 2000; Roy, Gauvin, & Limayem, 1996; Ziegler, Diehl & Zijlstra, 2000). Thus most group brainstormers

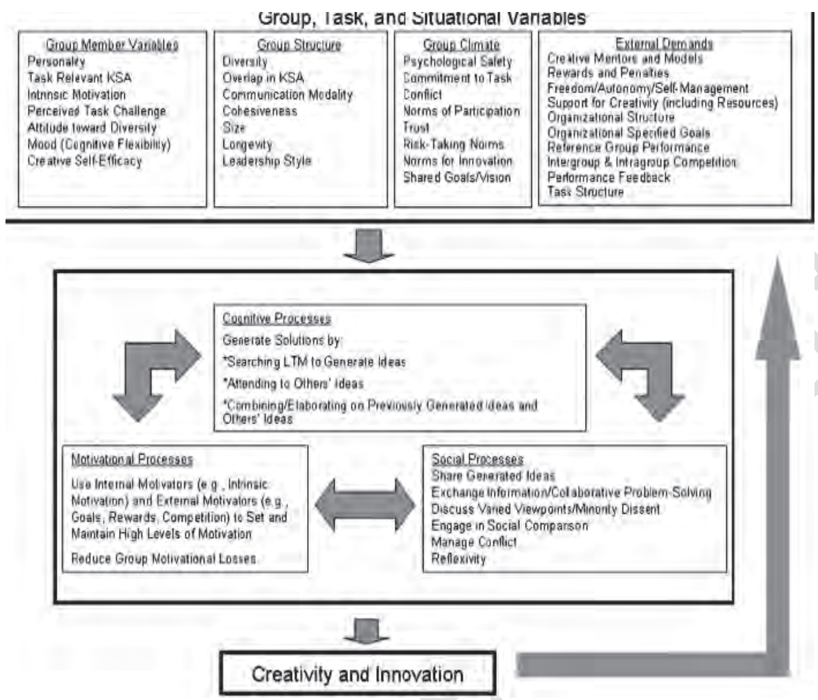

Figure 9.1 An integrative model of group creativity and team innovation (from Paulus & Dzindolet, 2008).

view their performance as fairly comparable to that of their fellow brainstormers. Individual brainstormers do not have such a basis of comparison for their performance. One consequence, mentioned above, is that group brainstormers evaluate their performance more favorably than do individual brainstormers (Paulus et al., 1993; Paulus, Larey, & Ortega, 1995; Stroebe et al., 1992).

Social processes (in particular social comparison) can help to explain production losses in groups (performance deficits in interacting groups relative to nominal groups). The various constraints on the performance of groups, such as production blocking (having to wait one's turn to share ideas) and evaluation apprehension (worrying about how others will evaluate one's contributions) (Diehl & Stroebe, 1987), insure that groups initially perform at a low level. Through the social comparison process, this low performance level may become normative and carry over to subsequent sessions. Further, since in laboratory studies using ad hoc groups there may be little intrinsic or extrinsic incentive for a high level of performance, the low producers in the group may be more influential than the high producers (via downward comparison on the part of high producers; Camacho & Paulus, 1995; Paulus & Dzindolet, 1993).

However, under conditions where there are strong intrinsic or extrinsic incentives, upward comparison on the part of low producers may occur. When participants are provided feedback about their performance relative to others, they are motivated to perform at a higher level, due possibly to enhanced feelings of competition (Coskun, 2000; Lount & Phillips, 2007; Michinov & Primois, 2005; Munkes & Diehl, 2003; Paulus, Larey, Putman, Leggett, & Roland, 1996). Similarly, when participants are told at the beginning of brainstorming about a high performance level of other brainstormers, their performance is significantly enhanced (Coskun, 2000; Paulus & Dzindolet, 1993). The importance of social comparison processes was demonstrated in a study in which individuals were exposed to either 8 or 40 ideas from someone who was presumed to be similar to them in creativity or to either 8 or 40 ideas generated by a computer. Those who thought that the ideas came from a similar person were more influenced by the rate of idea exposure than were those who thought that the ideas came from a computer (Dugosh & Paulus, 2005).

In regard to motivational processes, group norms are important. One might expect that if a group had a strong orientation for individuality or uniqueness, the group would be motivated to generate more unique ideas, especially if creative ideas are the goal. Alternatively, a group with a more collective or group harmony orientation might demonstrate enhanced creativity if that is the group goal or norm since members of such groups might be more likely to behave in accord with that norm. Goncalo and Staw (2006) found results consistent with the individualistic prediction in a study manipulating individualistic and collectivistic orientations and whether group members were instructed to generate creative or practical ideas for a problem solving task. Individualistic groups that were instructed to be creative had more ideas and more novel ideas than did collectivistic groups that were instructed to be creative. When groups were instructed to generate practical ideas, there were no significant differences on these measures between the individualistic and collectivistic groups. Thus, an individualistic norm in groups seems to support the expression and sharing of novel ideas because of a reduced concern about what others might think. Moreover, it appears that group norms influence creative behavior especially when one's identity as a member of the group is very salient (Adarves-Yorno, Postmes, & Haslam, 2007).

When groups are involved in creative activities, there is typically an implicit or explicit goal associated with idea generation. This goal may be to come up with a lot of ideas or very creative ideas or both. The group goal has important implications for the group's performance. One of the most important determinants of performance in groups is perceived efficacy (Baer, Oldham, Jacobsohn, & Hollingshead, 2008), and group goals can have a strong influence on this efficacy (Larey & Paulus, 1995). If group goals are set too high, groups may feel reduced efficacy, and this may inhibit their performance (Latham & Locke, 2009). However, it is important for groups to have a challenging goal, and their performance is most enhanced if they had a role in setting this goal (Haslam, Wegge, & Postmes, 2009).

Very little research has been conducted on how groups deal with different goals (Litchfield, 2008). Quantity of ideas is the major goal in brainstorming research. We know that a quantity goal increases the total number of ideas

(Paulus & Dzindolet, 1993) and that the number of good ideas is positively related to the total number of ideas (Diehl & Stroebe, 1987). Yet no study has directly compared the impact of the four subgoals typically employed in brainstorming studies (generate as many ideas as possible, don't criticize others' ideas, say what comes to mind, build on others' ideas). However, one study found that the "don't criticize" rule may not be critical to brainstorming success since encouraging debate and even criticism did not inhibit creativity on a brainstorming task (Nemeth and Ormiston, 2007).

Cognitive Processes

Two cognitive models of group creativity have recently been proposed. These models share some basic assumptions: The idea sharing process requires group members to search their relevant knowledge or memory for relevant ideas. The sharing of these ideas can stimulate group members to think of additional ideas or areas of knowledge. The mutual exchange process can lead to an increase in the number of ideas generated in the group, the number of categories explored, and the novelty of the ideas.

Semantic Network Model Paulus and Brown (Brown & Paulus, 2002; Paulus & Brown, 2003, 2007) have suggested that creativity in idea generating groups occurs to the extent that idea sharing stimulates excitation in group members' semantic networks (networks of related ideas or categories). Ideas from one person may stimulate a similar idea in another person if the two people share similar or overlapping associative networks. This is because related concepts or ideas are likely to activate one another (Collins & Loftus, 1975). Consistent with this perspective, Dugosh and Paulus (2005) found that priming college students with ideas that were fairly common in prior brainstorming sessions with similar students resulted in the generation of more ideas and more unique ideas than priming with uncommon ideas. This presumably occurs because common ideas are more likely to be related to the semantic networks of the student participants. Other evidence comes from a series of experiments that manipulated the relationship of dual words in either distant (e.g., apple–eagle) or close (e.g., apple–grapes) associations and that asked participants to come up with more words from these associations prior to the brainstorming session (Coskun, 2009). Consistent with the associative memory perspective, the participants who worked on close associations generated more unique ideas in the subsequent brainstorming session than did those who worked on distant associations.

An important feature of the semantic network model is the accessibility of the categories of ideas relevant to the brainstorming task. Some categories may be relatively unique and unrelated to more common categories. These unique categories may not be accessed unless there is some external stimulus or reminder to do so. Exposing individuals to unique categories does in fact enhance the number of ideas generated from such categories (Dugosh &

Paulus, 2005; Leggett, 1997; Nijstad, Stroebe, & Lodewijkx, 2002). Another important factor in the impact of shared ideas is the degree to which individuals pay attention to these ideas (Coskun & Yilmaz, 2009; Dugosh, Paulus, Roland, & Yang, 2000). Unless participants attend to the ideas, one would not expect any associative impact. The semantic network model has been formalized as a computational model involving a matrix of probabilities of transitions from one category to another. This model has been able to replicate the findings of a number of brainstorming studies (Brown & Paulus, 1996; 2002; Brown, Tumeo, Larey, & Paulus, 1998; Coskun & Yilmaz, 2009; Paulus et al., 2010).

One of the key predictions of the associative memory model is that individuals are stimulated by exposure to ideas from others. This prediction has been supported in several studies showing that exposing brainstorming individuals to a relatively large number of ideas increases the number of ideas they generate (Dugosh & Paulus, 2005; Dugosh et al., 2000). Moreover, increased exposure to irrelevant ideas or information reduces the number of ideas generated (Dugosh et al., 2000), because this type of material can interfere with semantic associations relevant to the task. For this reason, instructing brainstormers to avoid sharing ideas that are irrelevant to the task enhances idea generation in groups (Putman & Paulus, 2009).

Search for Ideas in Memory Model Nijstad and Stroebe (2006) have developed an associative memory model of group creativity that provides a detailed analysis of the memory search and idea production processes. This model overlaps somewhat with the Paulus and Brown (2003, 2007) semantic network model but focuses on the generation of specific ideas and the importance of "flow of ideas" rather than the category transition process (Brown et al., 1998). According to Nijstad and Stroebe, a consistent flow of ideas is likely when individuals search within a specific category because of the semantic clustering of ideas within the category. When individuals switch categories, they have to begin a new search, and the generation of ideas should be slower because it inevitably takes time to search one's memory for new categories. Nijstad and Stroebe (2006) argue that idea sharing has a positive effect because it reduces the time needed to develop one's own search cues for new categories. When individuals cannot come up with an idea within a certain period of time, this is experienced as a "failure". This can be a signal to the person that he or she has run out of ideas and needs to stop trying to generate more ideas (Nijstad, Stroebe, & Lodewijkx, 2006). Since groups should be able to generate more total ideas than individuals, groups should persist longer. In a study in which interactive groups were allowed to continue brainstorming until they felt it was a good time to stop, groups indeed brainstormed longer than individuals (Nijstad, Stroebe, & Lodewijkx, 1999). Yet, even with the increased time to brainstorm, interactive groups did not exceed the performance of comparable nominal groups. Nijstad et al. (2006) argued that the enhanced experience of "failure" for individual brainstormers is at least partly responsible for positive perceptions of performance in group brainstorming relative to individual brainstorming.

The Role of Cognitive Stimulation The two models discussed above have stimulated a number of studies on the cognitive processes involved in group idea generation and provided a basis for predicting synergistic effects of group idea sharing. One of the basic goals of cognitively oriented research has been to determine whether shared ideas can stimulate additional ideas in groups. That would seem to be an obvious outcome. However, when group members are sharing ideas, they have to take turns—only one person can effectively have the floor at a given time. So it is not possible for group members simply to generate a flow of ideas off the tops of their heads. They can express some of their ideas as they occur, but they also have to coordinate turns with the other group members, listen to their ideas, and possibly build on those ideas. While one is listening to ideas from others, one may forget the ideas that one has "on hold," and the semantic associations related to those ideas may dissipate (Diehl & Stroebe, 1987; Nijstad & Stroebe, 2006; Paulus & Brown, 2003, 2007). In fact, Nijstad, Stroebe, and Lodewijkx (2003) found that a critical factor in people's ability to generate ideas in a given period of time is their ability to express ideas as they occur. This is obviously difficult in face-to-face groups. Another limiting factor of idea generation is that it may lead to fixation on a limited range of topics (Baruah & Paulus, 2009; Larey & Paulus, 1999; Ziegler et al., 2000). In group interaction, it is natural to focus on one topic at a time. So when one person shares an idea on a topic, others may generate ideas in the same category. This may lead to the generation of a large number of ideas within a particular category but may limit the range of categories surveyed (Nijstad & Stroebe, 2006; Rietzschel, Nijstad, & Stroebe, 2007; Santanen, Briggs, & De Vreede, 2004).

An alternative for enhancing cognitive stimulation in groups is to use electronic or writing procedures for exchanging ideas (Dennis & Williams, 2003; Heslin, 2009). These procedures can be designed so that individuals can share ideas as they occur without having to wait their turn to present these ideas. Moreover, when one has a temporary halt in one's idea generation process, one can use that as an opportunity to examine ideas that have been shared by others (e.g., in an electronic format or in a stack of shared ideas or posted notes). These procedures allow one to take advantage of the semantic flow of individual ideation and the stimulating effects of periodic exposure to ideas from others. Studies have found that the production losses typically experienced in groups are not observed when electronic brainstorming or brainwriting procedures are used. In fact, these paradigms are the only ones that have produced evidence of synergy in which interacting groups generate more ideas than do nominal groups (De Rosa, Smith, & Hantula, 2007; Paulus & Yang, 2000).

SYNERGY IN CREATIVE GROUPS

As the work on electronic brainstorming and brainwriting suggests, the search for synergy has been a major focus of the research on group task performance and creativity (Larson, 2009). The basic rationale for bringing groups together for creative projects is that such interactions will lead to more and better ideas. Synergy has been assumed in case studies of unusually creative groups (Farrell, 2001; John-Steiner, 2000; Sawyer, 2007; Sutton & Hargadon, 1996). These case studies provide detailed descriptions of these groups and are useful in pointing out potentially critical factors in their success. However, it is not possible to determine with any certainty which of the many factors was indeed critical. Given the intelligence of the people involved in these groups, they may have come up with great ideas or products no matter what the group process was. Similarly, studies of team innovation have found some factors that influence perception of innovation (Hülsheger et al., 2009; West and Richter, 2008), but they have not compared the performance of innovative teams with the performance of non-team controls to determine the extent to which team interaction enhances innovation.

Conditions Required for Synergy

What are the critical conditions for group synergy? First of all, it is important to overcome the factors related to production loss in groups—social loafing, evaluation apprehension, production blocking, and downward comparison. So group members should be held accountable for their individual contributions to the group (Paulus et al., 1996). This can be accomplished by some system that allows the tracking of individual contributions. Group members should feel free to express ideas as they occur without fear of others' criticisms (Diehl & Stroebe, 1987). The interaction process should allow for unconstrained exchange of ideas as in electronic brainstorming and brainwriting. And since group members may move their performance in the direction of low performing members, there should be some incentive for high levels of performance or some sense of competition (Paulus & Dzindolet, 2008). These various procedures can reduce production losses in groups. Second, to attain synergy it is important that the group interaction process allow for an effective tapping of the cognitive resources of each group member. Therefore, the task needs to be structured so that there can be an effective meshing of individual idea generation and processing of shared ideas. Group members need to able to tap shared ideas when they wish, and they may benefit from incubation sessions after a period of idea exposure. The provision of such a session immediately after a shared brainstorming session allows for tapping additional associations stimulated during the sharing period (Dugosh et al., 2000; Paulus & Yang, 2000), and brief breaks during the sharing process can also provide such a benefit (Paulus, Nakui, Putman, & Brown, 2006). Third, it is important for group members to pay careful attention to the shared ideas (Paulus & Brown, 2007). This may be difficult when one is faced with the multiple tasks of generating ideas, attending to ideas of others, and building on those ideas. Asking participants to remember shared ideas appears to be one way to increase attention and idea generation (Dugosh et al., 2000). Finally, synergy should be most likely when the group has diverse areas of expertise related to the problem. This would increase the range of topics or relevant categories of ideas explored and subsequently the number of ideas generated (Baruah & Paulus, 2009; Coskun, 2005; Nijstad & Stroebe, 2006). However, it is also possible that exposure to many categories will lead to superficial tapping of these categories rather than a deeper exploration of the most relevant categories (Nijstad & Stroebe, 2006). One may be more likely to come up with creative ideas if one is primed to focus on a specific subcategory of a problem (Coskun, Paulus, Brown, & Sherwood, 2000; Rietzschel et al., 2007). However, this can be at the expense of generating ideas in other categories. Since the most creative ideas are likely to occur during an in-depth search of a category, it may be important to balance the range of categories explored with the depth of exploration.

Evidence for Synergy

Using the above approaches, a number of studies have found evidence for synergy in creative groups (De Rosa et al, 2007; Dugosh et al., 2000; Dugosh & Paulus, 2005; Paulus & Yang, 2000). More specifically, they have demonstrated that interactive brainstorming groups can generate more ideas than comparable nominal groups. It is important to note that all of these studies used electronic or writing exchange procedures. Another way to minimize the potential negative effects of group interaction while still gaining stimulation is to brainstorm in pairs. Evidence indicates that pairs of face-to-face brainstormers typically show little if any deficit in performance relative to nominal pairs (Diehl & Stroebe, 1987; Mullen et al., 1999). More importantly, one study with a relatively difficult brainstorming task found that interacting pairs outperformed nominal pairs by about 50% (Wilson, Timmel, & Miller, 2004). So keeping face-to-face groups as small as possible is one way to obtain synergy with such groups.

Interestingly, research on electronic brainstorming has found that the synergistic benefits increase with the size of the group (Dennis & Williams, 2003). The beneficial effects of electronic brainstorming on both the number of ideas generated and their rated novelty is most evident when groups have eight or more members (De Rosa et al., 2007). So far there is not a clear explanation for this effect. It could reflect the stimulating effect of the wide range of ideas and categories that result as groups increase in size. It could also reflect increased motivation in that group members may feel more competitive as groups get larger and they see the accumulation of a large number of ideas. These factors may produce increased idea generation in electronic brainstorming groups where production blocking is not an issue.

DIVERSITY AND CREATIVITY

Group members can vary along a wide variety of personal dimensions, including age, gender, race, personality, values, experience, and expertise. At present there is a strong emphasis on promoting diversity in work and educational settings and an assumption that interaction among diverse group members will be beneficial for social relations. Although some studies have demonstrated such benefits (Pettigrew & Tropp, 2008), others have shown that member diversity is often related to negative social relations, consistent with the literatures suggesting a strong bias in favor of those who are similar to oneself or who belong to one's ingroup (Hogg, 2006). It is also often assumed that diversity in work groups will enhance their performance. This is a reasonable assumption given the increased breadth of perspectives and knowledge in diverse groups. However, systematic reviews have not supported this view. In terms of general group performance, some studies have shown increased performance, some have found reduced performance, and others have found no effect (Bowers, Pharmer, & Salas, 2000; Mannix & Neale, 2005 ; Van Knippenberg & Schippers, 2007; Webber & Donahue, 2001).

Several reviews have examined a broad range of factors that might determine whether there are benefits of diversity in groups (see Moreland, this volume). For example, such benefits may depend on the type of diversity (Bowers et al., 2000; Harrison & Klein, 2007; Mannix & Neale, 2005), with benefits somewhat more likely when the diversity involves differences in deep-level or task-relevant information and when the task is difficult. It seems obvious that groups whose members have diverse knowledge needed for a task are more likely to perform this task effectively than are groups that do not have this knowledge. There is some evidence of this from self-report studies of team creativity (Hülsheger et al., 2009), and a few studies have obtained support using objective performance measures. For example, in several brainstorming studies, ethnic and cultural diversity were related to increased quality or range of ideas (McLeod, Lobel, & Cox, 1996; Nakui, Paulus & Van der Zee, 2008; Watson, Kumar, & Michaelson, 1993). However, thus far there are no compelling studies of the benefits of expertise or knowledge diversity on creativity (Derry, Gernsbacher, & Schunn, 2005; Van Knippenberg & Schippers, 2007).

Part of the problem with knowledge diversity is that people with different areas of expertise may also differ from one another in their values and interests and how they perceive the task (Cronin & Weingart, 2007; Gebert, Boerner, & Kearney, 2006). So a team of interdisciplinary scientists may have a wealth of diverse knowledge to share, but their effective collaboration requires a willingness to learn about each other's areas of expertise and to carefully integrate and align this with one's own. This has been emphasized in the elaboration model of Van Knippenberg and Schippers (2007). In order for diversity to facilitate creativity, group members must be motivated to process information from other members. One factor that facilitates this is having a positive attitude toward diversity (Homan, Van Knippenberg, Van Kleef, & De Dreu, 2007; Mitchel, Nicholas & Boyle, 2009; Nakui et al., 2008). For example, ethnic diversity in groups was related to enhanced novelty of ideas only when group members had positive attitudes toward diverse groups (Nakui et al., 2008). Two other factors that appear to enhance the benefits of diversity for creativity are a generally supportive social context (Mannix & Neale, 2005) and a longer time working together as a team (Watson et al., 1993).

Another key factor in enhancing the benefits of diversity for creativity may be "common ground," or what Mannix and Neal (2005) term "bridging". That is, it may be important for group members to realize that they have common interests and values (Chatman, Polzer, Barsade, & Neale, 1998; Ely & Roberts, 2008). An analysis of successful real -world collaborative groups indicates that they typically have a common vision and set of values (Farrell, 2001). This provides a strong foundation upon which diverse perspectives can be exchanged without breaking up the group. It may be important to allow a diverse group to first develop common interests and values and a sense of cohesion before it begins serious exchange of diverse perspectives (Van der Zee & Paulus, 2009). Having some common *cognitive* ground may also be helpful. As discussed earlier, exposure to relatively common ideas is more likely to stimulate additional unique ideas than is exposure to unique ideas (Dugosh & Paulus, 2005). Moreover, group members who begin brainstorming with a focus on a common set of categories generate more overall ideas than do those who begin with a focus on different categories (Baruah & Paulus, 2009). Also consistent with the common ground perspective is the fact that moderate levels of diversity seem to be most beneficial for information sharing (Dahlin, Weingart, & Hinds, 2005).

The literature on diversity provides additional evidence on how difficult it is to obtain synergistic benefits from group interaction. As with the research on group brainstorming, simply exchanging complementary perspectives in a group does not insure that the group will be particularly creative. Such creative benefits will only be realized when the social, motivational, and task conditions are optimal for careful and motivated processing of shared ideas, even those that might elicit some negative emotional reactions.

IDEA GENERATION VERSUS EXPLOITATION

Most of the research on creative performance in groups has focused on idea generation, or divergent thinking. However, as noted earlier, the creative process in real-world settings often involves several phases, including problem selection, idea generation, idea evaluation, and idea implementation (Parnes, 1975). (The latter two phases are often discussed together as the exploitation phase.) As suggested by Amabile (1996), these phases are likely to be influenced differently by particular processes. For example, a "low evaluative" setting encouraging the generation of a large number of ideas may be good for producing ideas, but exploitation requires selection of the ideas with the greatest potential and then their effective implementation. This may require a "high evaluative" setting characterized by various judgment, decision, and negotiation processes. There is very little research that has examined the idea generation and exploitation phases independently. Most studies on work team innovation use self-report measures that do not clearly distinguish between these two phases. Only a few studies on group creativity have examined different phases of the creative process. Two studies asked participants to brainstorm and then to select their best ideas (Putman & Paulus, 2009; Rietzschel, Nijstad, & Stroebe, 2006). Both of these studies found that the average originality of the selected ideas was no better than the average originality of all the ideas generated by the individuals or groups. There appears to be a bias toward the more common ideas being selected as the best ideas (Putman & Paulus, 2009). Putman and Paulus (2009) had individuals brainstorm as a group or as individuals prior to evaluating their ideas as a group. As usual, nominal groups generated more ideas (and more novel ideas), and they were subsequently able to select more novel ideas from this larger pool in comparison to the interactive groups. However, this benefit for nominal groups did not occur when they evaluated their ideas as individuals in comparison to interactive groups evaluating ideas as a group (Rietzschel et al., 2006)

FACTORS THAT ENHANCE GROUP CREATIVITY

We have highlighted some of the key processes involved in group creativity and discussed a number of factors that enhance group creativity. Among those that reflect the cognitive aspects of the process are being exposed to a large number of ideas, being exposed to diverse ideas, being aware of unique categories of knowledge, having a shared category focus, engaging in solitary brainstorming sessions after group brainstorming, taking brief breaks during brainstorming, and having minimum exposure to irrelevant information. It also seems beneficial to avoid cognitive overload by having participants focus on idea categories in sequence rather than consider them all at once (Coskun et al., 2000) and by structuring electronic brainstorming so that individuals are exposed to only a limited number of new ideas each time they submit an idea (Santanen et al., 2004). There are also a number of social factors that influence the number of ideas generated. More ideas are generated when groups have high standards or goals and are provided feedback about their performance. One interesting finding is that almost all of these effects have a similar positive effect for individual performers and groups (Paulus & Brown, 2003). Only the shared category focus (Baruah & Paulus, 2009) and the aftereffects assessments (Dugosh et al., 2000; Paulus & Yang, 2000) have shown differential benefits for groups.

Training Group Creativity

The various findings we have summarized suggest that there are a number of ways to increase group creativity. And in fact there are many people making a good living facilitating and training teams for creative work. How effective is such training? There is a literature on training creativity, and the presumption is that creativity can be learned (Runco, 2004; Scott, Leritz & Mumford, 2004). Amabile and Mueller's (2007) componential theory of creativity suggests that one should be able to train task-relevant skills and creativity-relevant skills, and there is some evidence that such training or related experience does enhance creativity (Nickerson, 1999). Yet according to the componential model, one also needs intrinsic motivation. Studies of team innovation suggest that intrinsic motivation may be very important to creativity (Carmeli & Spreitzer, 2009), but controlled studies of group creativity have not assessed the role of intrinsic motivation and the possibility of training groups to be so motivated.

Of the few studies that have examined training of creative groups, some have found that facilitators who monitor the group interaction can enhance the performance of interacting brainstorming groups to the point that they perform at a level similar to that of nominal groups (Offner, Kramer, & Winter, 1996; Oxley, Dzindolet, & Paulus, 1996). However, what happens when the facilitator goes away? Have the participants acquired any skills that carry over to subsequent group sessions? This issue was examined in a study in which groups were trained for an hour in various aspects of effective brainstorming (being efficient, attentive, taking advantage of diversity, and practicing brainstorming with feedback) (Baruah & Paulus, 2008). It was found that training enhanced the subsequent performance of the groups on a new brainstorming task (both in terms of number of ideas and their originality). If one hour of training can have such an impact, it is reasonable to assume that more extensive training using the right techniques will have an even more positive impact. One important aspect of training may be direct experience with the task in a group setting (Gino, Todorova, Miron-Spektor, & Argote, 2009; Moreland, Argote, & Krishnan, 1996). Such direct experience appears to increase mutual awareness of who knows what and who is good at what (transactive memory). This can be very useful as the group tries to coordinate the various aspects of the task and the creative process.

Providing a Supportive Context for Creativity

Even though a group may be trained in various skills relevant to the task, it is important to have a supportive context for creativity, whether this can be in short term settings or in organizations. Most of the suggestions for what this context should entail come from the team innovation literature. According to this literature, it is important to have an environment that allows group members to feel comfortable with one another and to feel free to be creative. Among the factors that contribute to a supportive context for creativity are group cohesion, a low degree of relationship conflict, support for innovation, and a feeling of participative safety (i.e., that one does not have to fear the consequences of one's creative actions) (Hülsheger et al., 2009). One reason these factors may enhance creativity is that they increase the positive mood state of the group members. Evidence indicates that such positive moods, especially if they are at least moderately high in activation level (such as feelings of joy, happiness, or positive excitement) enhance divergent thinking (Baas, De Dreu, & Nijstad, 2008; Davis, 2008; Grawitch, Munz, Elliott, & Mathis, 2003).

Groups should also have a positive disposition toward the creative task. They should have a strong vision or clear commitment to their goals, high standards of performance, and effective communication. Groups are not likely to develop these unless they have effective leadership. It appears that the most effective leadership for such groups (whether this is internal or external to the group) is provided by a transformational leader (Eisenbeiss, Van Knippenberg, & Boerner, 2008; Zaccaro, Heinen, & Shuffler, 2009). Such a leader inspires creativity through inducing a shared vision, having high expectations, showing individual consideration and support, and encouraging followers to take innovative approaches (Bass, 1998). A positive disposition toward the creative task not only helps motivate creative behavior, but the consequent success of the group in creative activities may increase individuals' and the group's skills and sense of efficacy (Baer et al., 2008). Efficacy, or the conviction that one is able to accomplish a particular task, is an important factor in a wide range of performance settings, including creative ones (Bandura, 2000; Henderson, 2004).

CREATIVITY IN LABORATORY AND REAL-WORLD GROUPS: SIMILARITIES AND DIFFERENCES

Although much of our review has focused on group creativity in controlled laboratory settings, there has been a growing recognition of the importance of the creative process both in long-term collaborative groups (John-Steiner, 2000; Kanigel, 1986; Sawyer, 2007; Schrage, 1995) and in work teams embedded in organizations (Bennis & Biederman, 1997; Mannix et al., 2009; Paulus, 2000, 2007; Thompson & Choi, 2006). These latter lines of work on collaborative creativity in real-world settings provide an important context for assessing the theoretically oriented research on group creativity that has dominated social psychology. The experimental literature in turn provides a theoretical basis for understanding the creative process in real-world groups and suggests ways to enhance their effectiveness.

Most of the work on innovation by work teams in organizations has been restricted to outsiders' and team members' perceptions of the innovation process and its outcomes (Hülsheger et al., 2009). This work suggests that job relevant diversity, task and goal interdependence, and team size are all positively related to team innovation. Diversity and team size are assumed to have positive effects because they increase the range of information and knowledge available to the team. Task and goal interdependence are assumed to have positive effects because they insure that group members will attend to one another and increase their motivation for the task. These findings are thus consistent with the importance of both cognitive and motivational factors in group creativity. Research on work teams indicates that additional factors associated with innovation include vision (shared goal commitment), participative safety, support for innovation, task orientation, and communication. Again each of these is consistent with research in group creativity demonstrating the importance of goals, low evaluation apprehension, motivational factors, task focus, and effective exchange of ideas (Paulus & Dzindolet, 2008). Team innovation is also facilitated by cohesion. This has not been found to be an important factor in short term settings, perhaps because it is difficult to develop strong cohesion in such settings.

Studies of long-term creative collaboration have been primarily restricted to descriptive analyses of groups (e.g., Farrell, 2001; John-Steiner, 2000). In an extensive analysis of collaborative groups, or circles, of authors, poets, artists, psychoanalysts, and activists, Farrell (2001) noted that much of their critical interaction occurred in dyads. Thus, members of these groups gained much social and intellectual support from a specific partner. Analyses of these interactions were particularly interesting in that they highlighted various stages through which these groups moved, namely formation, rebellion against authority, constructing a new vision, creative work, collective action, separation, and reunion. Of course not all creative groups go through these stages, but research on work teams also suggests that time is important (Mohammed, Hamilton, & Lin, 2009). Collaborative groups typically consist of 3 to 5 members, and they begin to work in pairs in the vision stage. This fits with the notion that effective creative groups should stay relatively small. In the creative work stage, group members alternate between working alone, working in pairs, and meeting as a circle. This meshes nicely with the stimulation/incubation perspective of group interaction in brainstorming environments, which suggests the need for individual reflection time after group interaction. It is important to note that when long-term collaborative groups carry out a collective project, the complexity of the process often yields social conflicts and subsequent separation from the circle. So even in these groups, the negative effects of social conflicts are evident.

CONCLUSIONS

We have reviewed the literature on group creativity from the vantage points of the research on temporary groups in controlled experiments, work teams in organizations, and long-term collaborative groups in real-world settings. The work on teams and long-term collaborative groups has provided a rich set of findings about the factors that influence creativity in these settings. The work on laboratory groups has provided detailed cognitive, social, motivational models of the group creative process and tested the impact of various factors that facilitate and inhibit group creativity. Although these three research traditions represent different contexts and use different methodologies and samples, we have found considerable consistency among their results.

It is clear from research on laboratory groups that face-to-face groups have a difficult time being creative. Practically all of the published studies have found that such groups generate fewer ideas and fewer good ideas than do nominal groups. Since the average rated creativity of the ideas generated by interacting groups and individuals is about the same, it appears that simply collecting ideas generated by individuals may be the best way to come up with a high number of good ideas (Reinig, Briggs, & Nunamaker, 2007). However, it has been found that when groups interact by means of writing or computers, the production loss due to group interaction is not observed, and these groups can in fact exhibit both more creative ideas and more novel ideas than nominal groups. Furthermore, a wide range of conditions can enhance group creativity, similar to the many ways in which team innovation can be enhanced (Paulus, Dzindolet, & Kohn, 2011). For example, when face-to-face brainstorming groups are given extended time to generate ideas, their performance improves relative to nominal groups. From this vantage point, one can see the groups and teams literatures are fairly consistent. In short term settings, groups will likely demonstrate production losses. However, with increased time in the group and extended periods of interaction, groups may become fairly effective. They should become more cohesive, develop transactive memory systems, have more opportunities for deeper processing or elaboration of the shared information, and have multiple opportunities to move between individual and group performance, thereby taking full advantage of individual incubation, or reflection time. Further support for such a congruency perspective comes from the fact that many of the factors that have been found to facilitate group interaction also facilitate team interaction (see also Paulus, Nakui & Putman, 2005). Thus, the positive perceptions of participants and observers of innovation in teams may have some basis in reality.

Of course, full support for this congruency perspective will require additional research both in laboratory and field settings. In the former case, longer-term experimental studies with groups of individuals who work together on meaningful projects are required. These could be done in laboratories by having real-world work groups perform relevant tasks under controlled conditions (e.g., Paulus et al., 1995). This would allow a more precise assessment of the synergistic potential for creative interactions in such groups in comparison to these same individuals performing their tasks in isolation. Alternatively, one could do experimental studies in actual work settings in which manipulations of relevant variables and precise measures of group processes and of performance, and perceptual outcomes are possible. Such studies would enable an examination of consistency between team member performance and perceptions. We do not know of any such studies to date.

An important issue for research on real-world work teams is that many (perhaps most) of their creativity tasks cannot be decomposed to assess nominal group performance. For example, a task that requires high levels of expertise from a chemist, biologist and a mathematician cannot be done by just one of those individuals. This is the major reason for the popularity of multi-disciplinary and interdisciplinary teams in science and engineering. Nonetheless, it would still be of interest to examine this type of situation with a set of tasks varying in the extent to which they are feasible for individuals with differing expertise. For example, a chemist, biologist, and mathematician may all be able to come up individually with creative solutions for a more environmentally sustainable college campus. A number of scholars have noted the difficulties encountered by interdisciplinary teams (Derry et al., 2005) and cross-functional teams (Cronin & Weingart, 2007). One implication of the research on group creativity is that the meetings that take place in real-world teams may not be nearly as productive as the participants assume. By using the insights from group creativity research to make these meetings more effective, we may be able to enhance the innovative potential of these teams.

Although there has been a tremendous growth in research on group creativity over the past 20 years, there is still much to learn about the creative process. Experimental research has provided only a few demonstrations of creative synergy in groups, and most research in work settings has been restricted to verbal reports. There is a need for more research with long-term groups in real-world settings that involves an objective assessment of the creative process. This type of research will be difficult and time consuming, but it is necessary in order to more effectively link the theoretically oriented research from laboratory settings to more realistic groups. Such research can further clarify the importance of such factors as group member diversity, group and intergroup exchange processes, and the other variables outlined in Figure 1. This type of research will also enable us to explore the roles of temporal processes, including turnover, in groups as well as the extent to which the creative process involves the actual combination or integration of shared ideas.

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