Taking a Broad Perspective Before Brainstorming

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Three studies examined the role of prior consideration of categories on a brainstorming task. Participants were asked to generate abstract categories before they brainstormed either in groups or individually in Experiment 1. It was expected that generating categories before ideation would be beneficial. However, it was found that category generation harmed the group ideation process. Prior category generation reduced clustering of ideas within categories for groups, which might have led to a decrease in productivity. The last two experiments examined whether groups would benefit by brainstorming one category at a time because this might increase clustering. It was found that sequential category brainstorming helped increase productivity during the ideation process and increased clustering. These studies demonstrate that a prior categorization phase can facilitate subsequent brainstorming because it enhances subsequent clustering of ideas within categories.

Keywords: group creativity, brainstorming, categorization, task structure

Brainstorming is a popular technique for enhancing the number of ideas individuals and groups can generate (Sutton & Hargadon, 1996). By following the four rules of brainstorming suggested by Osborn (1957), one can enhance both the number of ideas and the number of good ideas (those rated above average in novelty; Meadow, Parnes, & Reese, 1959; Parnes & Meadow, 1959; Paulus, Kohn, & Arditti, 2011). However, brainstorming in face-to-face groups has been found to be less effective than brainstorming alone (Diehl & Stroebe, 1987; Mullen, Johnson, & Salas, 1991). Much research has examined the factors responsible for this production loss in groups and ways in which to enhance group brainstorming (Nijstad & Stroebe, 2006; Paulus & Coskun, 2012). For example, studies have also shown that when groups exchange ideas by means of computer systems or writing, group brainstorming can be more effective than solitary brainstorming (Derosa, Smith, & Hantula, 2007; Paulus & Yang, 2000). In “real world groups” the creative process is likely to involve a number of phases including determination of the problem, discussion of different aspects or categories of the problem, generating ideas about the different aspects of the problem and selecting the best ideas for further discussion and possible implementation (cf., Basadur, Basadur, & Licina, 2012). A few studies have recently examined the selection process after brainstorming (e.g., Putman & Paulus, 2009; Rietzschel, Nijstad, & Stroebe, 2006). However, one issue that has received little empirical attention is the category generation phase of the creative idea generation process. No studies have examined how having participants first determine categories of a problem relates to subsequent brainstorming. This is the focus of the present series of experiments.

There are two models that have focused on the cognitive processes in group brainstorming that are relevant to understanding the role of categories in brainstorming (Nijstad & Stroebe, 2006; Paulus & Brown, 2003, 2007). The
Search for Ideas in Associative Memory (SIAM) and cognitive-social-motivational models highlight the importance of the search of different domains of memory or semantic categories related to an issue. Some categories may be quite salient and easily tapped for search, but others may require some priming from collaborators or a facilitator. Taylor and Greve (2006) have suggested that if participants are knowledgeable about a large number of categories, they have a wider selection of categories to combine.

There is evidence to suggest that priming categories is beneficial. Coskun, Paulus, Brown, and Sherwood (2000) found that presenting more categories to brainstormers enhanced the number of ideas generated. Rietzschel, Nijstad, and Stroebe (2007) found that priming four specific categories with questions led to higher productivity and originality within the primed subcategories but not overall productivity. Nijstad, Stroebe, and Lodewijks (2002) found that presenting ideas from broad range of categories enhanced the range of ideas but not the number of ideas. Presenting ideas from only a couple semantic categories led to generation of more ideas in those specific categories. Based on these three studies, it appears that the effects of priming categories are dependent upon the specific categories. Based on these three studies, it appears that the effects of priming categories are dependent upon the specific categories. 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ilar number of individuals (nominal groups) (Dennis & Williams, 2005; DeRosa et al., 2007; Paulus, Kohn, Arditti, & Korde, 2013). However, for small groups the evidence is a mixed, with some studies showing enhanced performance in groups (Dugosh, Paulus, Roland, & Yang, 2000) whereas others find lower performance in groups (DeRosa et al., 2007; Kohn & Smith, 2011).

The aim of this experiment was to increase the productivity in brainstorming by allowing participants to generate categories before a brainstorming phase. In the categorization conditions, the participants were asked to generate abstract categories in groups of three. These categories were expected to prime the participants and enable them to generate a higher number of ideas in a later brainstorming phase. After generating these abstract categories, the participants all brainstormed on the same topic. This brainstorming phase was done either individually or in groups of three. The categorization phase was expected to increase generation of ideas for both individuals and groups. It was anticipated that individuals might benefit more from prior categorization than groups. Individuals may be better able to focus on one category at a time. With group brainstorming members are likely to be focusing on different categories. The hypotheses for this experiment were:

Hypothesis 1: Participants in categorization conditions should be able to explore categories to a greater extent because of the prior generation of categories or search cues. As a result they should generate more ideas and a greater number of ideas in each category (category depth).

Hypothesis 2: Based on DeRosa et al. (2007) participants who brainstorm individually will generate more ideas across a wider range of categories (variety) than an interactive group.

Hypothesis 3: The prior categorization task may be of greater benefit to individual performers than to groups.

Hypothesis 4: Based on the research by Ward and by Mumford et al. (1994) prior categorization may increase originality of ideas.

Hypothesis 5: Idea clustering will predict the quantity of idea generation in the interactive group conditions.

Method

Participants. In total, 267 undergraduate students participated in the experiment. Fifteen participants were eliminated because they did not follow the instructions. There were 93 men and 159 women in the experiment. The age range of the participants was between 17 and 55, with a mean age of 21.57 years. They were given credits for participating in this experiment as a requirement for their psychology class. There were 21 groups in each condition.

Design and procedure. A 2 (Categorization vs. No Categorization) × 2 (Group vs. Individual) design was used for this experiment. The four conditions were Categorization Group, Categorization Individual, No Categorization Group, and No Categorization Individual. The No Categorization Individual condition required only individual participants, whereas all other conditions required a total of three participants to be present for the experiment. The brainstorming data from three individuals tested separately were later combined to form a nominal group. An EBS procedure was used for this experiment. The group chat feature of AOL Instant Messenger (AIM) was used for the group conditions, as it enabled all three participants to type simultaneously in the same window and view the ideas generated by the other participants. For the individual conditions, the regular instant messaging feature of AIM was used that only allowed conversation between the participant and the experimenter.

The first part of the experiment was the categorization phase. Because of the complexity of the task, participants in the categorization conditions were given a categorization task practice session. This was done individually or in a group, dependent upon their condition. In this 1-min practice session participants were asked to generate categories for the topic “Reform America’s Healthcare System.” They were then given the experimental topic, “List all the possible ways in which the University can be improved” (university problem). Participants in the categorization conditions were asked to generate categories in groups of three for 5 min. They were asked not to provide each other with
any feedback during this time. Participants in the no-categorization conditions were given a packet of mazes (as a filler task) for the first 5 min of the experiment. They were told to rate each maze according to its difficulty level after completion. The filler task was done individually.

The second part of the experiment consisted of a 20-min brainstorming session. Participants in the group conditions completed this phase in groups of three, whereas participants in the individual conditions completed this phase individually. All participants were instructed to generate specific ideas in response to the university problem. Participants in the categorization conditions were given a list of the categories that they had generated in the first part of the experiment. They were told,

Your experimenter will give you a list of categories that you and the other participants just generated in the first phase of the experiment. You are welcome to use these categories to help you to think of specific ideas to the topic; however, you are not limited to generating ideas only in these categories.

They were also instructed not to provide each other with any comments or feedback. They were provided with a postexperiment questionnaire after the brainstorming session to collect demographic information.

**Dependent variables.** The dependent variables measured in this experiment were the number of ideas generated, the variety of ideas, the category depth, originality, and the clustering of ideas. Each idea generated by the participants was coded for the category to which they belonged. Two coders independently coded the ideas for the specific categories. The primary coder coded each idea that was generated by the participants in all conditions. The secondary coder coded 25% of the ideas within each condition. Interrater reliability was $\kappa = .85$ ($p < .001$). The variety of ideas was calculated by summing the total number of categories explored during the brainstorming phase. Category depth was calculated by dividing the number of ideas generated by the variety of ideas. Individual clustering was also assessed at the group level to determine how often participants repeated ideas in the same category. Two raters independently rated all the ideas on a scale of 1 (being a very common idea) to 5 (being a very original and unique idea) for originality for half of the participants. The interrater reliability was Cronbach’s $\alpha = .77$.

Individual clustering was calculated using the formula for the adjusted ratio of clustering (ARC) developed by Roenker, Thompson, and Brown (1971). The number of category repetitions was examined at the individual level to calculate ARC. In other words, we examined the number of ideas a participant generated within a category before moving on to the next one (irrespective of the categories that his peers were exploring). This measure was examined only for the interactive group conditions because this measure is not meaningful for nominal groups.

**Results**

To assess Hypotheses 1, 2, and 3, a series of $2 \times 2$ analysis of variances (ANOVAs) were conducted. The result of a 2 (Categorization manipulation: Categorization vs. No Categorization) $\times$ 2 (Brainstorming Setting: Individual vs. Group) ANOVA for quantity of ideas revealed a main effect for brainstorming setting, $F(1, 80) = 14.06, MSE = 489.08, p < .001, \eta^2 = .15$. Participants in the individual conditions ($M = 82.29, SE = 3.41$) generated more ideas than those in the group conditions ($M = 64.19, SE = 3.42$); $d = 0.78$. In addition, there was a significant interaction effect, $F(1, 80) = 9.85, MSE = 489.08, p = .002, \eta^2 = .11$. Post hoc analyses revealed that the No Categorization Group and No Categorization Individual conditions generated approximately the same number of ideas (see Table 1 for means and SDs). However, the Categorization Individual condition generated significantly more ideas than the Categorization Group condition; $d = 1.37$. In addition, the No Categorization Group condition generated more ideas than the Categorization Group condition ($d = 1.30$), but there were no significant differences between the two individual conditions.

A similar $2 \times 2$ ANOVA was done for brainstorming variety. There was a significant main effect for brainstorming setting, $F(1, 80) = 7.55, MSE = 7.95, p = .007, \eta^2 = .09$. Participants in the individual conditions ($M = 21.91, SE = .44$) generated a greater variety of ideas than those in the group conditions ($M = 20.21, SE = .44$); $d = 0.57$. Furthermore, there was a significant interac-
Table 1
Experiment 1 Quantity, Variety, Category Depth, and Clustering of Brainstorming Ideas by Condition

<table>
<thead>
<tr>
<th>Condition</th>
<th>Quantity (SD)</th>
<th>Variety (SD)</th>
<th>Category depth (SD)</th>
<th>Clustering (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Categorization Individual</td>
<td>75.10 (17.41)</td>
<td>21.67 (2.08)</td>
<td>3.45 (.67)</td>
<td></td>
</tr>
<tr>
<td>Categorization Individual</td>
<td>88.43 (27.85)</td>
<td>21.33 (2.58)</td>
<td>3.40 (.85)</td>
<td></td>
</tr>
<tr>
<td>No Categorization Group</td>
<td>72.90 (21.22)</td>
<td>22.24 (2.64)</td>
<td>3.91 (.93)</td>
<td>.15 (.06)</td>
</tr>
<tr>
<td>Categorization Group</td>
<td>54.67 (21.12)</td>
<td>18.81 (3.44)</td>
<td>2.85 (.84)</td>
<td>.06 (.08)</td>
</tr>
</tbody>
</table>

Note. There were 21 groups in each of the four conditions.

tion, $F(1, 80) = 7.13$, $MSE = 7.95$, $p = .009$, $\eta^2 = .08$. Post hoc analyses showed that the participants in the No Categorization Group and No Categorization Individual conditions explored approximately the same number of categories. However, the groups in the Categorization Individual condition explored significantly more categories than those in the Categorization Group condition; $d = .83$. Similarly, the participants in the No Categorization Group condition explored more categories than those in the Categorization Group condition; $d = 1.12$.

Another $2 \times 2$ ANOVA assessed the effects for category depth. There was a significant main effect for brainstorming setting, $F(1, 80) = 10.70$, $MSE = .68$, $p = .002$, $\eta^2 = .12$. Participants in the individual conditions ($M = 3.72$, $SE = .13$) exhibited more category depth than those in the group conditions ($M = 3.13$, $SE = .13$); $d = 0.69$. Furthermore, there was a significant interaction, $F(1, 80) = 6.53$, $MSE = .68$, $p = .013$, $\eta^2 = .08$. The post hoc analyses revealed that the participants in the No Categorization Group and No Categorization Individual conditions had approximately the same category depth. However, the participants in the Categorization Individual condition had a significantly greater category depth than those in the Categorization Group condition; $d = .65$. In addition, the participants in the No Categorization Group condition had more category depth than those in the Categorization Group condition; $d = 1.20$.

To assess Hypothesis 4, a $2 \times 2$ ANOVA evaluated the average originality of ideas. There were no main effects for the categorization manipulation ($F < .16$), brainstorming setting ($F < .78$), or their interaction ($F < .01$).

To assess Hypothesis 5, an independent $t$ test on individual clustering revealed that there was more clustering in the No Categorization Group condition than in the Categorization Group condition, $t(40) = 4.12$, $p < .001$ (see Table 1 for means and SDs). A regression analysis showed that individual clustering significantly predicted brainstorming quantity, $B = 90.87$, $t(40) = 2.31$, $p = .026$, $sr^2 = .118$ for these two conditions.

Discussion

The participants in the individual conditions displayed a greater quantity and variety of ideas as well as more category depth when compared with those in the group conditions. This outcome supported the hypothesis (Hypothesis 2) that participants who brainstorm individually should generate more ideas than the participants in the group condition. Contrary to Hypothesis 4 prior categorization did not increase originality of ideas. As expected (Hypothesis 3), participants in the individual conditions benefited more from categorization than those in the group conditions—more ideas, more variety, and more category depth. However, unexpectedly this increase in productivity for the Categorization Individual condition compared with No Categorization Individual condition did not reach significance. Furthermore, post hoc analyses showed that productivity in the groups was actually impaired by the categorization task. The participants in the Categorization Group condition showed a decrease in the number of ideas, the variety of ideas, and their category depth compared with the No Categorization Group condition. When brainstorming in an EBS group, participants may experience more distraction because of the varied and unexpected ideas presented by other participants (Dennis & Williams, 2005). Because the participants in the Categorization Group condition might have been brainstorming ideas from a different primed category than the category their peers submitted, they might have experienced even more distraction. This distraction
provides for multiple competing search cues (those from the category list and those from their peers). This could increase the amount of category switching and decrease productivity. Consistent with Hypothesis 5, individual clustering predicted the quantity of ideas for groups in the second phase of the experiment. The fact that clustering was significantly greater in the No Categorization Group condition than in the Categorization Group condition supports the explanation that participants in the Categorization Group condition suffered from being distracted by multiple search cues or strategies.

**Experiment 2**

Experiment 2 was designed to assess the possibility that asking participants to brainstorm on only one category at a time would increase clustering and productivity in the brainstorming session. Although groups are aware of the existence of many categories, they might concentrate only on some of the dominant ones (Larey & Paulus, 1999). Therefore, providing participants with one category at a time might help them focus on all of the individual categories and therefore generate more ideas in these categories. Additionally, this should reduce the number of search cue switches and the costs associated with this switching (Nijstad & Stroebe, 2006). This systematic focus should lead to enhanced idea generation because of an increase in category depth. Furthermore, the sequential process should reduce the potential distracting effect of multiple search cues in the group conditions.

Coskun et al. (2000) and Dennis, Valacich, Connolly, and Wynne (1996) found that groups generate more ideas when brainstorming one category at a time than when brainstorming on all categories simultaneously. Coskun et al. (2000) found that when participants were presented with categories sequentially, they would focus their ideas on the specific category being presented to them. This led them to generate ideas more or less equally in all of the categories provided to them. Furthermore, providing participants 10 categories led them to generate more ideas than providing them with only two categories in the sequential task, with time allotted the same in both conditions. Coskun and Yilmaz (2009) also found that the participants in a sequential condition generated more ideas in a brainstorming task than did the participants in the nonsequential condition. Because the participants were cued with categories every 5 min, the sequential participants steadily generated ideas throughout the 30 min of the brainstorming task. These findings suggest that providing participants with different categories in short time intervals should help them generate more ideas.

In Experiment 1, we did not observe a predicted benefit of categorization in terms of increasing the originality of ideas, perhaps because participants did not brainstorm ideas one category at a time. Previous studies (Hong & Milgram, 2010; Milgram, Moran, Sawyers, & Fu, 1987) found that very typical ideas come early during ideation and very original ideas come later. This may be enhanced when participants focus on one category at a time. Thus, in this study we examined the originality of ideas as a function of time and output order.

Therefore, Experiment 2 included a Categorization Sequential Group condition. Participants in this condition generated categories in the first phase of the experiment, but instead of receiving the entire category list at the beginning of the second phase, the participants were provided with the individual categories sequentially. Specifically, they were given one category every 2 min of the brainstorming session for a total of 10 categories during the brainstorming phase. Groups were only provided 10 of their categories so as to increase the likelihood that domains were more exhaustively probed as well as to reduce the costs associated with category switching. The No Categorization Group condition and a modified version of the Categorization Group condition from Experiment 1 were also included in Experiment 2. It was predicted that:

_Hypothesis 1:_ Participants in the Categorization Sequential condition should generate more ideas and display more category depth in the brainstorming phase compared with the participants in the other two conditions.

_Hypothesis 2:_ Participants in the Categorization Sequential condition should display a lower variety of ideas compared with those in the other conditions because they will concentrate more on the categories provided to them and less on other categories.
Hypothesis 3: The amount of clustering in the Categorization Sequential condition should be greater than that in the other two conditions, resulting in the generation of more ideas.

Hypothesis 4: Idea clustering will predict idea generation.

Hypothesis 5: Originality of ideas will increase with output order (later ideas more original). For the Categorization Sequential condition, there will be a temporal effect in which originality will increase the longer participants spend within each category.

Method

Participants. In total, 108 undergraduate students participated in Experiment 2. These participants are different from the participants in Experiment 1. They received credit for their psychology course. In total, 24 participants’ data had to be eliminated because they did not show up in groups of three and could not be run as an intact group. Three other participants had to be eliminated because they did not follow the instructions provided to them. Therefore, the data provided by 84 participants were used in the data analyses. There were 58 women and 26 men. The age range of the participants was from 16 to 38, with a mean age of 19.9 years. There were 10 groups in No Categorization and Sequential conditions and 9 groups in the Categorization condition.

Design and procedure. The experiment consisted of three group conditions—No Categorization, Categorization, and Categorization Sequential. All conditions consisted of interactive groups of three and involved the university problem. The No Categorization condition was the same as in Experiment 1. The participants in the Categorization Sequential condition first practiced the categorization phase by generating categories to a practice topic (“Reform America’s Healthcare System”) for 1 min. They then generated categories to the actual topic (“Ways to improve the University”) for 5 min. Participants next participated in a 3-min brainstorming session using the practice topic. Finally, participants brainstormed on the actual topic. During the brainstorming phase, the experimenter provided the groups with one category every 2 min. These categories were randomly selected from the original list (every group generated at least 10 categories—three categories were selected from two of the group members and four from the third member). This set of 10 randomly selected categories was provided in the AIM group chat window so that all three group members could view it. Participants were instructed that, “The experimenter will provide you with a different category every two minutes. Please try to generate ideas in that category. However, feel free to generate ideas in any other categories that you can think of.” The Categorization condition was modified to match the Categorization Sequential condition. Rather than providing the participants with a list of all categories that they had previously generated, each group member was provided with a list of 10 randomly selected categories from the original list. In addition, a 3-min practice session was added before the brainstorming phase in which the participants brainstormed on the topic “Reform America’s Healthcare System.”

Dependent variables. The dependent variables in this experiment were the number of ideas generated, the variety of ideas, the category depth, the clustering of ideas, and originality. Each idea generated by the participants was coded for the category to which they belonged as well as the originality of the idea. Similar to Experiment 1, the primary coder evaluated each idea that was generated by the participants in all conditions. The secondary coder coded 25% of the ideas within each condition. Interrater reliability for category was found to be $\kappa = .80$ ($p < .001$). Interrater reliability for originality, as measured by Cronbach’s $\alpha$ was .86.

Results

To assess Hypotheses 1, 2, and 3, a series of ANOVAs examined differences in quantity, variety, and clustering. A one-way ANOVA for the total quantity of ideas revealed a significant difference among the conditions, $F(2, 25) = 3.97, MSE = 562.72, p = .032, \eta^2 = .24$. Post hoc analyses indicated that the participants in the Categorization Sequential condition generated significantly more ideas than those in the Categorization condition, $p = .030, d = 1.24$ (see Table 2 for means and SDs). An ANOVA
for the differences among the conditions for variety revealed a significant difference in variety, \(F(2, 25) = 12.32, MSE = 7.71, p < .001, \eta^2 = .50\). The participants in the No Categorization \((p < .001, d = 2.03)\) and Categorization \((p = .004, d = 1.70)\) conditions displayed a wider variety than those in the Categorization Sequential condition. An ANOVA to assess the difference in category depth displayed by the participants in the three conditions was also significant, \(F(2, 25) = 15.15, MSE = 1.68, p < .001, \eta^2 = .55\). It revealed that the participants in the Categorization Sequential condition had more category depth than the participants in the Categorization \((p < .001, d = 2.07)\) and the No Categorization \((p = .001, d = 1.80)\) conditions.

An ANOVA also revealed significant clustering differences among the conditions, \(F(2, 25) = 51.91, MSE = .012, p < .001, \eta^2 = .81\). The participants in the Categorization Sequential condition clustered more to their own ideas than those in the Categorization \((p < .001, d = 3.73)\) and the No Categorization \((p < .001, d = 3.57)\) conditions. Supporting Hypothesis 4, there was a positive correlation between clustering and quantity, \(r(26) = .57, p = .002\).

An ANOVA found no significant differences between the three conditions on the average originality of their ideas, \(F(2, 25) = 0.56, MSE = .04, p = .58\). To test Hypothesis 5 and examine if the order in which an idea is generated from a category affects the originality of an idea, each idea was assigned an output order (first idea receives a “1”; second idea receives a “2”; etc.). A linear regression analyzed how the output order and condition predicted the originality of each idea. Terms for model included: output order (centered), Categorization (coded as 1 for categorization condition, 0 for the other conditions), Categorization Sequential (coded as 1 for categorization sequential condition, 0 for the other conditions), interaction of Categorization and output order, and the interaction of Categorization Sequential and output order. Because of dummy coding, variables were entered in three blocks, with dummy-coded condition variables added in Block 2 and dummy-coded interaction terms added in Block 3. The full model explained a significant amount of originality variance; \(R^2 = .092, F(5, 2541) = 51.57, MSE = 1.255, p < .001\) (see Table 3 for predictors). The interaction between output order and condition (two terms) significantly increased the variance explained by the model, \(\Delta R^2 = .008, F(2, 2541) = 11.31, p < .001\). The interaction (illustrated in Figure 1) shows that for all conditions, originality increases with output order, but that it increases the least for the Categorization Sequential condition.

The unique procedure of the Categorization Sequential condition allowed us to conduct additional temporal analyses of how participants generated ideas within each primed category. Each primed category (2 min block) was divided into four time quadrants \([Q1: 0–30 \text{ s}; Q2: 31–60 \text{ s}; Q3: 61–90 \text{ s}; \text{and Q4: 91–120 s}]\). Only the ideas that matched the primed category were analyzed. A 4 (time quadrant) repeated measures ANOVA found no differences between the quadrants for quantity, \(F(3, 297) = 0.95, p = .42\).

### Table 2

<table>
<thead>
<tr>
<th>Condition</th>
<th>Quantity (SD)</th>
<th>Variety (SD)</th>
<th>Category depth (SD)</th>
<th>Clustering (SD)</th>
<th>Average originality (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Categorization Sequential Group</td>
<td>101.70 (29.06)</td>
<td>16.20 (3.01)</td>
<td>6.38 (1.88)</td>
<td>.54 (.15)</td>
<td>2.83 (0.27)</td>
</tr>
<tr>
<td>No Categorization Group</td>
<td>83.33 (21.22)</td>
<td>22.22 (2.91)</td>
<td>3.76 (0.83)</td>
<td>.10 (.08)</td>
<td>2.93 (0.21)</td>
</tr>
<tr>
<td>Categorization Group</td>
<td>71.33 (18.93)</td>
<td>20.78 (2.33)</td>
<td>3.41 (0.77)</td>
<td>.11 (.05)</td>
<td>2.83 (0.11)</td>
</tr>
</tbody>
</table>

*Note.* There were 10 Categorization Sequential groups, 9 No Categorization groups, and 9 Categorization groups.

### Table 3

<table>
<thead>
<tr>
<th>Predictors</th>
<th>B</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>2.923**</td>
<td>.042</td>
</tr>
<tr>
<td>Output order</td>
<td>.109**</td>
<td>.014</td>
</tr>
<tr>
<td>Categorization</td>
<td>.095</td>
<td>.066</td>
</tr>
<tr>
<td>Sequential categorization</td>
<td>-.335**</td>
<td>.055</td>
</tr>
<tr>
<td>Categorization × Output Order</td>
<td>.057</td>
<td>.023</td>
</tr>
<tr>
<td>Sequential Categorization × Output Order</td>
<td>-.033</td>
<td>.016</td>
</tr>
</tbody>
</table>

*Note.* Output order was centered at the mean.

\* \(p < .05\). \** \(p < .01\).
repeated measures ANOVA revealed a significant effect of time for average originality, $F(3, 234) = 33.15, \text{MSE} = 0.38, p < .001, \eta^2 = .30$. Average originality for Q1 was significantly lower than Q2 ($p < .001, d = .87$), Q3 ($p < .001, d = .17$), and Q4 ($p < .001, d = 1.11$). Average originality for Q2 was significantly lower than Q3; $p = .02, d = .38$ (see Figure 1 for an illustration of these two analyses).

Discussion

Participants in the Categorization Sequential condition generated significantly more ideas than those in the Categorization condition (52% more ideas) but not significantly more than those in the No Categorization condition (only 28% more ideas). Thus, Hypothesis 1 was only partially supported, as it was expected that the participants in the Categorization Sequential condition would generate significantly more ideas than those in both of the other conditions. As predicted the participants in the Categorization Sequential condition also displayed significantly more category depth than those in the other two conditions (Figure 2).

Supporting Hypothesis 2, participants in the Categorization Sequential condition displayed a lower variety of ideas than those in the other two conditions. These participants were only presented with 10 of the categories that they had previously generated. They might have allotted more attention to these categories, leading to a decrease in the variety of ideas. As a trade-off, however, the category depth was increased in the Categorization Sequential condition, probably because these participants were focused on the presented categories and were not distracted by other categories, consistent with the findings of Rietzschel et al. (2007). Because all three participants within each session were generating ideas in the same category, they may have experienced less distraction (i.e., fewer competing search cues). In the other two conditions, different participants were generating ideas in different categories, which might have served as a distraction (Barua & Paulus, 2011). Presenting categories sequentially may have eliminated this distraction and increased idea generation. In support of Hypothesis 3, the participants in the Categorization Sequential condition clustered more than the participants in the other two conditions, and consistent with Hypothesis 4 clustering predicted number of ideas generated.

Supporting Hypothesis 5, originality did increase with output order for all conditions. This finding supports earlier research (Hong & Milgram, 2010; Milgram et al., 1987) that showed one is likely to find the most original ideas later in a session. Interestingly this output order effect was weakest for the Categorization Sequential condition. The Categorization Sequential procedure was successful in significantly increasing the number of ideas, but not the aver-
age originality of ideas. However, ideas generated later within each category time period were more original. Thus, the sequential condition does have the potential to lead to the generation of more novel ideas.

**Experiment 3**

It has been suggested that priming by categories can lead to cognitive stimulation. This might lead participants to be more productive because they are better able to retrieve information from their knowledge. However, priming can either be done by instructing participants to generate categories or by providing them with a list of previously compiled categories. Previous findings indicate that when individuals are exposed to the ideas of other participants, they generate more ideas (Dugosh et al., 2000). Furthermore, when they are primed with ideas in the categories that are generated by other participants, they are cognitively stimulated and generate more ideas (Leggett, 1997).

In contrast to the present series of experiments, previous research on sequential brainstorming did not have participants generate categories on their own (Coskun et al., 2000; Coskun & Yilmaz, 2009; Dennis et al., 1996). Because they received categories that they might not have otherwise explored, they had the benefit of using their self-generated cues as well as additional cues or categories. Theoretically, this should enable them to have more ideas as well as a greater variety of ideas. Experiments 1 and 2 have concentrated on priming participants by helping them generate their own cues (create categories) before brainstorming. Although this might be beneficial, it may be even more beneficial to provide additional categories that the participants might not have considered. Previous research has not distinguished between these two different strategies of priming in brainstorming.

Experiment 3 included all three conditions from Experiment 2 and two yoked conditions to distinguish between the two different strategies. In the yoked conditions, the participants were provided with the categories that were generated by a different group. The following hypotheses were assessed:

**Hypothesis 1:** The participants in the sequential conditions should generate more ideas, have greater category depth, lower variety, and have more clustering during the brainstorming phase than the participants in the nonsequential conditions.

*Figure 2.* Quantity and average originality of ideas brainstormed during each primed block in the Sequential Categorization condition.
Hypothesis 2: The participants in the yoked conditions should have more ideas, more variety, and greater category depth than the participants in the other conditions because they have the additional benefit of being primed with categories they might have otherwise not explored.

Hypothesis 3: The participants in the Yoked Sequential condition should have the most ideas and the greatest category depth because they should have the benefits of brainstorming sequentially as well as being primed with categories they might have otherwise not explored.

Hypothesis 4: Idea clustering should predict the quantity of ideas generated.

Method

Participants. In total, 252 undergraduate students participated in the experiment. They received credits for their participation, which was required for their psychology course. In total, 27 participants were eliminated because they did not follow the experiment instructions provided to them. Therefore, the data provided by 225 participants were used in the data analyses. There were 151 women and 72 men. The age of the participants ranged from 16 to 47 years, with a mean age of 20.3 years.

Design and procedure. A 2 (Categorization vs. Yoked) × 2 (Sequential vs. Nonsequential) design was used for Experiment 3. Furthermore, a No Categorization condition was added as a control. All conditions required three participants per group because all conditions used interactive group brainstorming. The No Categorization, Categorization, and Categorization Sequential conditions were identical to those of Experiment 2.

In the yoked conditions, a list of categories was displayed for the participants using the AIM group chat feature on their screens for 5 min. These categories had been previously generated by groups of participants in the categorization conditions. These categories were displayed to the participants in the yoked conditions at approximately the same time as the participants in the categorization conditions. The group members were informed that a previous group of undergraduate students generated this category list for the university problem. The brainstorming phase for the Yoked Nonsequential and Yoked Sequential conditions was similar to the second phase of the Categorization Nonsequential and the Categorization Sequential conditions, respectively. Participants in the Yoked Nonsequential condition were provided with a list of 10 random categories and brainstormed for 20 min without interruption. The participants in the Yoked Sequential condition were provided with one category every 2 min on their screen while they were brainstorming. All participants were given a postexperimental questionnaire at the end of the experiment to collect demographic information.

Dependent variables. The dependent variables in this experiment were the number of ideas, variety of ideas, category depth, and individual clustering. As in Experiments 1 and 2, each idea generated by the participants was coded for the category to which they belonged. The primary and secondary coders used the same coding methods as the previous studies. The primary coder evaluated each idea that was generated by the participants in all conditions and the secondary coder coded 25% of the ideas within each condition. Interrater reliability was found to be $\kappa = .88 (p < .001)$.

Results

A series of $2 \times 2$ ANOVAs were run to test Hypotheses 1, 2, and 3. A 2 (Categorization condition: Categorization vs. Yoked) × 2 (Brainstorming condition: Sequential vs. Nonsequential) ANOVA for quantity of ideas revealed a marginal main effect for brainstorming condition; $F(1, 56) = 3.04, MSE = 1002.86, p = .087, \eta^2 = .05$. Groups in the sequential conditions ($M = 89.27, SE = 5.79$) generated marginally more ideas than those in the nonsequential conditions ($M = 75.00, SE = 5.79$); $d = 0.45$. There was no significant effect of categorization condition or a significant interaction; $Fs < 1.15$.

A $2 \times 2$ ANOVA for brainstorming variety yielded a significant main effect for brainstorming condition, $F(1, 56) = 36.55, MSE = 7.24, p < .001, \eta^2 = .40$. Groups in the nonsequential conditions ($M = 19.76, SE = .49$) generated a greater variety of ideas than those in the sequential conditions ($M = 15.57, SE = .49$); $d = 1.57$. There was no significant effect of catego-
rization condition or a significant interaction; $F$'s $< 1.35$.

A 2 x 2 ANOVA for category depth revealed a significant main effect for brainstorming condition, $F(1, 56) = 22.37$, $MSE = 2.69$, $p < .001$, $\eta^2 = .29$. Groups in the sequential conditions ($M = 5.77$, $SE = .30$) exhibited more category depth than those in the nonsequential conditions ($M = 3.76$, $SE = .30$); $d = 1.20$. Furthermore, there was a marginally significant interaction, $F(1, 56) = 3.37$, $MSE = 2.69$, $p = .0671$, $\eta^2 = .06$. The post hoc analyses showed that the Categorization Nonsequential condition had a slightly lower category depth ($M = 3.55$, $SE = .42$) than the Yoked Nonsequential condition ($M = 3.97$, $SE = .42$); $d = .35$. However, the Categorization Sequential condition ($M = 6.33$, $SE = .42$) displayed significantly more category depth than the Yoked Sequential condition ($M = 5.20$, $SE = .42$); $d = .57$. There was not a significant effect of categorization condition; $F < .75$.

A 2 x 2 ANOVA for individual clustering found a significant main effect for brainstorming condition, $F(1, 56) = 162.78$, $MSE = .01$, $p < .001$, $\eta^2 = .74$. As predicted, groups in the sequential conditions ($M = .47$, $SE = .02$) exhibited more clustering than those in the nonsequential conditions ($M = .13$, $SE = .02$); $d = 3.31$. There was no significant effect of categorization setting or a significant interaction; $F$'s $< 1.10$. Supporting Hypothesis 4, a regression analysis showed that individual clustering significantly predicted brainstorming quantity, $B = 58.42$, $t(73) = 3.29$, $p = .002$, $sr^2 = .13$ for all the conditions.

One-way ANOVAs were conducted to examine the differences between the No Categorization condition and the other conditions. A one-way ANOVA for the total quantity of ideas did not reveal a significant difference among the conditions, $F(4, 70) = 1.57$, $MSE = 1049.51$, $p = .193$, $\eta^2 = .08$. However, post hoc analyses showed that the participants in the Categorization Sequential condition generated significantly ($p = .029$) more ideas than those in the No Categorization condition; $d = .71$. There was a significant difference in brainstorming variety, $F(4, 70) = 10.97$, $MSE = 7.86$, $p < .001$, $\eta^2 = .39$. The participants in the Categorization Sequential and Yoked Sequential conditions displayed a lower variety of ideas than those in the No Categorization, Categorization Nonsequential, and Yoked Categorization conditions; $ds > 1.15$. The ANOVA for category depth was also significant, $F(4, 70) = 10.13$, $MSE = 2.42$, $p < .001$, $\eta^2 = .37$. It revealed that the participants in the Categorization Sequential condition had more category depth than the participants in the remaining four conditions; $ds$ ranged from .57 to 1.61. Furthermore, participants in the Yoked Sequential condition displayed more category depth than the participants in the No Categorization, Categorization Nonsequential, and Yoked Categorization conditions; $ds$ ranged from .90 to 1.51 (Table 4).

**Discussion**

Consistent with our predictions and Experiment 2, sequential presentation of categories affected idea generation. Participants in the sequential conditions had a marginally greater brainstorming quantity and significantly less variety than the participants in the nonsequential conditions. As a result, participants in the sequential conditions had significantly greater category depth. This combined with the finding that sequential conditions had more clustering supports our hypothesis that using one category at a time (sequential) leads to a more exhaustive

<table>
<thead>
<tr>
<th>Condition</th>
<th>Quantity (SD)</th>
<th>Variety (SD)</th>
<th>Category Depth (SD)</th>
<th>Clustering (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Categorization Nonsequential</td>
<td>71.53 (24.19)</td>
<td>20.00 (2.00)</td>
<td>3.55 (1.04)</td>
<td>.12 (.08)</td>
</tr>
<tr>
<td>Categorization Sequential</td>
<td>94.47 (38.55)</td>
<td>15.00 (2.75)</td>
<td>6.33 (2.44)</td>
<td>.49 (.14)</td>
</tr>
<tr>
<td>Yoked Nonsequential</td>
<td>78.47 (31.66)</td>
<td>19.53 (2.45)</td>
<td>3.97 (1.33)</td>
<td>.13 (.08)</td>
</tr>
<tr>
<td>Yoked Sequential</td>
<td>84.07 (30.63)</td>
<td>16.13 (3.38)</td>
<td>5.20 (1.40)</td>
<td>.45 (.10)</td>
</tr>
<tr>
<td>No Categorization</td>
<td>68.13 (35.16)</td>
<td>20.07 (3.22)</td>
<td>3.27 (1.14)</td>
<td>.10 (.09)</td>
</tr>
</tbody>
</table>

*Note.* There were 15 groups in each of the five conditions.
search of each cue. As a result, groups are more likely to generate more ideas (quantity) while sacrificing breadth of ideas (variety). However, contrary to our predictions, we did not find any additional benefit of presenting categories generated by others (yoked categories). We had anticipated that these yoked categories might have additional stimulation value. Apparently, the source of the category is not as important as whether the categories are presented all at once or one at a time. Our results are consistent with previous studies that demonstrated a benefit of presenting participants with sequential categories (Coskun et al., 2000; Dennis et al., 1996). The categories in the Coskun et al. (2000) study were random high frequency ones that were not generated by the participants themselves. In the Dennis et al. (1996) experiments participants were presented with questions or category names that were deemed most relevant. Our findings indicate that the benefit of sequential category presentation is not limited to the presentation of such high frequency categories but can be obtained by any self- or other-generated categories. However, because category depth in the Yoked Sequential condition was less than the Categorization Sequential condition, it is possible that the participants in the yoked condition were simply not as motivated to fully explore these domains because it might not have been personally relevant to them.

The amount of clustering predicted the quantity of ideas in accordance with Experiments 1 and 2, supporting Hypothesis 4. The amount of clustering does predict the quantity of ideas brainstormed. The sequential conditions exhibited significantly more clustering than the yoked conditions, and as a result, the sequential conditions brainstormed (marginally significant) more ideas.

In summary, it appears that having participants start at an abstract level (categorization) can boost brainstorming productivity when they use these categories in a nonrandom way. Going through self- or other-generated cues, one-at-a-time, allows groups to probe long-term memory to search for ideas without getting distracted with other cues. This leads to greater category depth and as a result, a greater number of ideas. If groups were given more time to exhaust each category cue and/or allowed to generate ideas to each of their categories (instead of just 10), we might observe an even greater benefit of sequential brainstorming to one’s self-generated categories. However, in a follow-up experiment we found that providing participants 10 of the categories or all of the categories they had generated during the idea generation phase does not make a difference in the number of ideas they generated in the relatively short time period provided in this experiment. It appears that during this time period they are only able to access a limited number of categories. In a longer session, providing more categories may be beneficial, especially if they are presented sequentially.

Conclusions

Collectively, the experiments have demonstrated a method to enhance brainstorming. Having individuals first generate abstract categories (Experiment 1) led to a 21% increase in the number of ideas. Having groups first generate abstract categories and then use these categories one at a time leads to an increase in the number of ideas compared with when the groups do not engage in the abstraction process at all (Experiment 2: 28%; Experiment 3: 39%). The intent of brainstorming is to generate as many ideas as possible so that there is an increased chance of finding a potential good solution(s) (Osborn, 1957). Therefore, it is the authors’ recommendation that individual and group brainstorming sessions first start by generating abstract domains of ideas. There is some suggestion in the literature that prior consideration of broader issues before idea generation may increase originality of ideas (e.g., Mumford et al., 1994; Ward & Kolomyts, 2010). However, we did not find any benefit of prior categorization for average originality of ideas in Experiments 1 and 2. The reason for the lack of effect on originality in this type of research is that the brainstorming task focuses on generating ideas without regard to quality. The tasks used in the Ward studies and by Mumford et al. (1994) did not have such an emphasis. It would be of interest to examine this issue more systematically with a range of creativity tasks and instructions.

In addition to suggesting recommendations for enhancing brainstorming, our studies provide general support for the cognitive models of brainstorming (Nijstad & Stroebe, 2006; Paulus & Brown, 2003, 2007). The SIAM model (Ni-
jstad & Stroebe, 2006) states that an effortful process in working memory leads to the assembly of a search cue. Ideas are generated by probing long-term memory with these search cues. Thus, this model and others (e.g., Brown, Tumeo, Larey, & Paulus, 1998) predict that more clustering of semantically related ideas should lead to more ideas. Our results support these predictions in two ways. First, our analyses demonstrate that clustering (as measured by ARC) significantly predicts the number of ideas generated. Second, we showed that category switching harms productivity (Experiment 1) whereas focusing on a single search cue at a time boosts productivity (Experiments 2 and 3). Furthermore, as participants spend more time in a category, they generated more original ideas (Experiment 3). Collectively, the data from these studies as well as prior studies demonstrate the benefit of a priori generating search cues and the importance of exhausting a search cue before moving on to the next search cue.

References


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