THE ROLE OF ABSTRACTION IN CREATIVE IDEA GENERATION

by

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ABSTRACT

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IDEA GENERATION

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The present study examined the role of categories during a brainstorming task. Participants were asked to generate abstract categories before they brainstormed either in groups or individually in Study 1. It was expected that generating categories would be beneficial before ideation. However, it was found that category generation harmed the group ideation process. It was also found that they were not clustering as much to their ideas, which might have led to a decrease in productivity. Study 2 aimed to examine whether groups would benefit by brainstorming sequentially because of high clustering. It was found that sequential brainstorming helped increase productivity during the ideation process and increased clustering. Study 3 aimed to differentiate between self-generated categories (abstraction conditions) and categories that were generated by other participants (yoked conditions). It was predicted that the categories generated by other participants should be more beneficial because it would cognitively stimulate the participants to generate more ideas. Furthermore, it was also predicted that sequential brainstorming would be beneficial for both abstraction condition as well as yoked condition. We did find a benefit of sequential brainstorming, but failed to see an increase in productivity for the

yoked conditions. However, this might have been due to the quality of the categories that were presented to the yoked conditions. Because these categories were generated by other participants, they might have not tapped into their semantic structure.

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CHAPTER 1

INTRODUCTION

Productivity and creativity are important factors when generating novel and innovative ideas. The brainstorming technique helps participants generate many ideas in order to produce novel and innovative solutions. Participants are encouraged to use prior knowledge to generate ideas in response to a brainstorming topic. Furthermore, knowledge of different categories of a topic can function as a cue to help participants generate a unique set of ideas. For example, if participants are given the brainstorming topic of "Reform America's Healthcare System," the different categories could be "medicine," "emergency room," and "doctors." The purpose of this research is to examine the role of exposure to categories of ideas prior to generating exemplars of ideas on a topic on the outcome measure of quantity and variety of ideas. For example, Ward (1994) asked participants to generate a novel exemplar based on existing category information and found that participants combined the categories that were already present in their memory to generate imaginary drawings of unique species of aliens. For instance, if they were told that the atmosphere the aliens lived in had islands with molten lava between them, participants would design the alien species to have wings and feathers. This demonstrated that participants use certain categories that are already in their knowledge to generate novel ideas/exemplars.

Furthermore, being able to exploit different domains of a topic ensures higher productivity on a given task. When participants are able to generate several ideas in one category of a topic, they are able to generate more ideas. In another study, Ward (2008) asked participants to develop a new sport and write a description of it. They were then asked to write down

everything that came to their mind when they developed the new sport. They were also asked how knowledgeable they were about different sports. Ward found that individuals who take abstract approaches (e.g. something that requires a ball) had more novel ideas compared to the participants who based their ideas on a concrete sport (e.g. basketball). His findings suggest that exploring the different abstract categories stored within one's knowledge might help participants later generate more original ideas.

Because participants use categories that already exist in their knowledge to generate novel ideas, they can be cognitively primed with categories before the brainstorming task to stimulate them and enhance their productivity. When the participants in one study were primed with subcategories of a brainstorming topic prior to a brainstorming task, they were to found to have higher productivity and originality within the primed subcategories (Rietzschel, Nijstad & Stroebe, 2007). These findings indicate that if participants are exposed to certain categories before they are asked to generate ideas for the same topic, they are likely to be more productive and creative. This outcome is presumably due to the cognitive stimulation they receive from the categories. Furthermore, if categories help participants generate more creative ideas, the presence of a large number of categories should help them to generate even more ideas. 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. The combination of a wide variety of categories should further help them in generating more ideas.

Different participants might be knowledgeable about different aspects of a brainstorming topic. Therefore, brainstorming in a group might expose them to a wide variety of categories. This experience should enable participants of different backgrounds and expertise to generate

novel ideas collaboratively. When participants are exposed to a wide range of categories, they are more likely to generate more novel ideas than when they are only exposed to a few categories (Nijstad, Stroebe & Lodewijkx, 2002). Thus group members should be cognitively primed with a large variety of categories and therefore generate a wide variety of ideas during a subsequent idea generation phase, in comparison to individual brainstormers.

The ideas generated by other group members can also operate as cues that trigger the information stored in one's memory (Nijstad & Stroebe, 2006). This process enables the individual to combine the ideas presented by their group members with the ideas present in their own knowledge store and generate more novel ideas. The result should be increased productivity of both the individual participants. Another factor that might make group idea generation more effective is social matching (Camacho & Paulus, 1995). When participants are present in a group with members who have a high level of performance, they might generate more ideas in order to match the performance levels of the other group members. Therefore, group brainstorming might have some extra benefits compared to individual brainstorming.

However, there are some other factors that might impede group brainstorming. Social loafing has been identified as a factor that might decrease productivity during group idea generation (Dennis et al. 2005). If various participants are working together, there might be a participant who does not generate a high quantity of ideas when the other group members are already doing so. This might lower overall the productivity of group idea generation. Evaluation apprehension in groups may also reduce the generation of ideas (Camacho & Paulus, 1995). Participants may be afraid of being judged negatively by their peers and therefore might limit the

generation of ideas. Some of these negative effects can be eliminated by the method of electronic (i.e. computer-based) brainstorming (EBS).

EBS has been an effective method used in idea generation tasks in which individuals brainstorm through an electronic medium rather than in face-to -ace (FTF) communication. Previous research has shown that EBS groups are more productive and have a higher sense of satisfaction when compared to FTF groups (DeRosa, Smith & Hantula, 2007). Several participants can communicate electronically at the same time in EBS, whereas FTF requires spoken communication in which each participant must wait until the current speaker is done talking to contribute his/her ideas. This often leads to a limitation- production blocking (Diehl & Stroebe, 1987). The reduced production blocking in EBS appears to be a major factor in the enhanced performance relative to FTF groups (Gallupe, Basstianutti & Cooper, 1991).

Dennis and Williams (2005) suggest that the benefits of electronic brainstorming increase when the group size increases. In support of this claim, they cite evidence that individual brainstorming can be more beneficial for participants than brainstorming in a group with eight or less members (Dennis & Williams). However, when the group size increases and becomes larger than eight, groups tend to outperform groups of randomly paired individuals (nominal groups). Nominal groups are formed by combining the ideas of three different individuals who worked alone in the brainstorming task. Although ideas generated by other participants should cognitively stimulate group members and lead to more idea generation, this has typically not been the case for small groups. It is not clear why small groups experience a productivity loss. It is possible that different participants are generating ideas in different categories, which might be a distraction to the remaining group members (Baruah & Paulus, 2011). Clustering one's ideas in

the same category might eliminate this distraction by other members in that group. Participants might generate several ideas in one category before they move to the next one. For instance, if participants are given the topic of "sports," they might generate several ideas on the category "baseball" before generating ideas in a different category.

Nijstad and Stroebe (2006) suggest that participants will continue to generate ideas in a category until they can no longer think of any ideas in that category. When they reach this stage, they will stop generating ideas in that category and start generating ideas in a new category. This clustering within the same category of ideas can lead to a higher number of ideas generated because they are able to follow their train of thoughts and are not distracted by other categories. However, another experiment using a recall task found that groups showed lower clustering compared to individuals (Basden, Basden, Bryner & Thomas, 1997). Therefore, low clustering in groups might lead group members to generate fewer ideas. On the other hand, Baruah and Paulus (2010) found that providing groups three categories, compared to one, increased clustering as well as the quantity of ideas generated. Therefore generating several categories might help groups cluster more of their ideas and increase the number of ideas generated during the brainstorming task.

CHAPTER 2

STUDY 1

The present study aimed to increase the productivity in brainstorming by allowing participants to generate categories for the topic “Ways in Which to Improve UTA” prior to a brainstorming phase. In the abstraction conditions, the participants were asked to generate abstract categories in groups of three. These categories are expected to prime the participants and enable them to generate a higher quantity of ideas at a later phase. After they were primed by these abstract categories, the participants all brainstormed on the same topic. This brainstorming phase was done either individually or in groups of three. The abstraction phase was expected to increase generation of ideas in line with findings of Baruah & Paulus (2010). They found that participants cluster more if they share their categories with two other participants and were simultaneously exposed to three categories, compared to when they did not share these categories and were only exposed to one. In line with previous research (e.g. Dennis & Williams, 2005), participants in the individual conditions should be more productive in the brainstorming phase. The hypotheses for this study were:

H1: Participants who brainstorm individually will generate more ideas and will have more variety and category depth.

H2: The abstraction task should benefit both groups and individuals. Therefore participants in an abstraction condition should generate more ideas and exhibit more variety and more category depth than the participants in a no-abstraction condition.

H3: Participants in an abstraction group condition should exhibit more clustering than the participants in a no abstraction group condition.

H4: The amount of clustering should predict the number of ideas generated. Participants who cluster more should generate more ideas.

2.1 Method

2.1.1 Participants

A total of 267 undergraduate students participated in the experiment. 15 participants were eliminated because they did not follow the instructions. There were 93 men and 159 women in the study. The age range of the participants was between 17 and 55, with the mean age being 21.57 years old. They were given credits for participating in this study as a requirement for their psychology class. There were 21 groups in each condition.

2.1.2 Design and Procedure

A 2 (Abstraction vs. No Abstraction) X 2 (Group vs. Individual) design was used for this experiment. The four conditions were Abstraction Group, Abstraction Individual, No Abstraction Group and No Abstraction Individual. The No Abstraction 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 Electronic Brainstorming (EBS) procedure was used for this experiment. The group chat feature of AOL Instant Messenger (AIM) was used for the group conditions, as it enables various users to chat simultaneously in the same window. This allowed all three participants to type simultaneously in the same window and view the ideas

generated by one another. For the individual conditions, the regular Instant Messaging feature of AIM was used which only allows conversation between the participant and the experimenter.

The first part of the experiment was the abstraction phase. The participants were given a one-minute practice session in which they were asked to generate categories in the topic "Reform America's Healthcare System." They were then given the experimental topic, "List all the possible ways in which UTA can be improved," (UTA problem). Participants in the abstraction conditions were asked to generate categories in groups of three for five minutes. They were asked to not provide each other with any feedback during this time (Appendix A). Participants in the no-abstraction conditions were given a packet of mazes (as a filler task) for the first five minutes of the experiment. They were told to rate each maze according to its difficulty level after completion.

The second part of the experiment consisted of a 20-minute 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 UTA problem (see Appendix A). Participants in the abstraction conditions were given a list of the categories that they had generated in the first part of the experiment. They were asked to use the list to think of ideas. However, they were told not to limit their ideas to the list provided to them and were encouraged to generate ideas in other categories as well. They were also instructed not to provide each other with any comments or feedback. They were provided with a post-experiment questionnaire after the brainstorming session (see Appendix B).

2.1.3 Dependent Variables

The dependent variables measured in this experiment were the number of ideas generated, the variety of ideas (i.e. total categories explored during the brainstorming phase), and the category depth. Category depth was defined as the average number of ideas the groups generated for each category. Individual clustering was also assessed at the group level to determine how often participants repeated ideas in the same category. Individual clustering was calculated based on 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 (see Appendix C for details).

2.2 Results

The result of a 2 (Abstraction setting: Abstraction vs. No Abstraction) X 2 (Brainstorming setting: Individual vs. Group) ANOVA for quantity of ideas revealed a main effect for brainstorming setting, $F(1, 80) = 13.74$, $MSE = 493.92$, $p < .001$, $\eta^2 = .15$. Groups in the individual conditions ($M = 81.76$, $SE = 3.43$) generated more ideas than those in the group conditions ($M = 63.79$, $SE = 3.43$). In addition, there was a significant interaction effect, $F(1, 80) = 10.56$, $MSE = 493.92$, $p = .002$, $\eta^2 = .12$. Post-hoc analyses revealed that the No Abstraction Group and No Abstraction Individual conditions generated approximately the same number of ideas. However, the Abstraction Individual condition generated significantly more ideas than the Abstraction Group condition. In addition, the No Abstraction Group condition generated more ideas than the Abstraction Group condition but there were no significant differences between the two Individual conditions (see Table 1 for means and SD).

A similar 2 X 2 ANOVA was done for brainstorming variety. There was a significant main effect for brainstorming setting, $F(1, 80) = 9.97$, $MSE = 7.45$, $p = .002$, $\eta^2 = .11$. Groups in the individual conditions ($M = 21.95$, $SE = .42$) generated greater variety of ideas than those in the group conditions ($M = 20.07$, $SE = .42$). Furthermore, there was a significant interaction, $F(1, 80) = 6.75$, $MSE = 7.45$, $p = .011$, $\eta^2 = .08$. Post-hoc analyses showed that the groups in the No Abstraction Group and No Abstraction Individual conditions explored approximately the same number of categories. However, the groups in the Abstraction Individual condition explored significantly more categories than those in the Abstraction Group condition. Similarly, the groups in the No Abstraction Group condition explored more categories than those in the Abstraction Group condition (see Table 1 for means and SD).

Another 2 X 2 ANOVA was calculated for category depth. There was a significant main effect for brainstorming setting, $F(1, 80) = 9.37$, $MSE = .69$, $p = .003$, $\eta^2 = .11$. Groups in the individual conditions ($M = 3.68$, $SE = .13$) exhibited more category depth than those in the group conditions ($M = 3.13$, $SE = .13$). Furthermore, there was a significant interaction, $F(1, 80) = 7.91$, $MSE = .69$, $p = .011$, $\eta^2 = .09$. The post hoc- analyses showed that the groups in the No Abstraction Group and No Abstraction Individual conditions had approximately same category depth. However, the groups in the Abstraction Individual condition displayed significantly more category depth than those in the Abstraction Group condition. Also, the groups in the No Abstraction Group condition had more category depth than those in the Abstraction Group condition (see Table 1 for means and SD).

An independent *t*-test on individual clustering revealed a significant difference between the No Abstraction Group condition ($M = .15$, $SD = .07$) and the Abstraction Group condition (*M*

= .07, *SD* = .08) conditions, $t(40) = 3.80$, $p < .001$. Furthermore, a regression analysis showed that individual clustering significantly predicted brainstorming quantity, $B = 128.60$, $t(40) = 3.52$, $p = .001$, $sr^2 = .236$ for these two conditions.

Table 1. Quantity, Variety and Category Depth of Brainstorming Ideas by Condition

	Quantity (*SD*)	Variety (*SD*)	Category Depth *(SD)*
No Abstraction Individual	75.10 *(17.41)*	21.67 (*2.08*)	3.45 *(.67)*
Abstraction Individual	88.43 *(27.85)*	21.33 (*2.58*)	3.40 *(.85)*
No Abstraction Group	72.90 *(21.22)*	22.24 (*2.64*)	3.91 *(.93)*
Abstraction Group	54.67 *(21.12)*	18.81 (*3.44*)	2.85 *(.84)*

2.3 Discussion

The participants in the individual conditions displayed a greater quantity and variety of ideas as well as more category depth when compared to those in the group conditions. This outcome supported the hypothesis that participants who brainstorm individually should generate more ideas than the participants in the group condition. However, the abstraction task did not benefit the participants as hypothesized. There was no increase in productivity for the groups in the Abstraction Individual conditions. Furthermore, post-hoc analyses showed that productivity in the Abstraction Group condition was actually impaired by the abstraction task. The participants in this condition showed a decrease in the number of ideas, the variety of ideas, and their category depth. 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 Abstraction Group condition might have been brainstorming in different primed categories when they saw these varied and unexpected ideas, they might have experienced even more distraction.

Contrary to expectations, the No Abstraction Group displayed more individual clustering than Abstraction Group. However, consistent with the hypothesis, individual clustering predicted the quantity of ideas in the second phase of the experiment. Therefore, the lack of individual clustering might be another factor hindering the performance of the participants in the Abstraction Group condition. Disruption of their individual search cues might have led to less clustering and the generation of fewer ideas. Therefore, a procedure that helps individuals and groups cluster to one category at a time might decrease distraction, increase clustering, and enhance performance.

CHAPTER 3

STUDY 2

Study 2 was designed to assess the possibility that higher clustering would increase productivity in the brainstorming session. In order to produce higher clustering, the sequential brainstorming method was used in which participants were asked to brainstorm sequentially on one category at a time. In a study by Coskun (1996), groups were found to generate a more ideas when brainstorming sequentially. 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. This systematic focus should lead to enhanced idea generation because of an increase in category depth.

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. Coskun and Yilmaz (2009) also found that the participants in their sequential condition generated more ideas in a brainstorming task than did the participants in the non-sequential condition, who experienced productivity loss in the later phase of the brainstorming task. However, because the participants were cued with categories every five minutes, the sequential participants steadily generated ideas throughout the

30 minutes of the brainstorming task. These findings suggest that providing participants with different categories in short time intervals should help them to generate more ideas.

Study 2 therefore includes a Sequential Abstraction Group condition. Participants in this condition generated categories in the first phase of the experiment, but instead of receiving the category list at the beginning of the second phase, the participants were provided with the categories sequentially. Specifically, they were given one category in every two minutes of the brainstorming session for a total of 10 categories during the brainstorming phase. The No Abstraction Group condition and a modified version of the Abstraction group condition from Study 1 were also included in Study 2. It was predicted that:

H1: Participants who are provided categories sequentially should generate more ideas and display more category depth in the brainstorming phase compared to the participants in the other two conditions.

H2: Participants who are provided categories sequentially should display a lower variety of ideas compared to those in the other conditions because they will concentrate more on the categories provided to them and less on other categories.

H3: The amount of clustering should predict the total number of ideas generated. Participants who cluster more should generate more ideas.

H4: The amount of clustering in the sequential condition should be greater than that in the other two conditions, resulting in the generation of more ideas.

3.1 Method

3.1.1 Participants

A total of 108 undergraduate students participated in Study 2. They received credits for their participation, which was required for their psychology course. A total of 24 participants 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 the mean age being 19.9 years old. There were ten groups in No Abstraction and Sequential conditions and nine groups in the Abstraction condition.

3.1.2 Design and Procedure

The study consisted of three conditions-- No Abstraction, Abstraction, and Sequential Abstraction. All conditions consisted of groups of three. The No Abstraction condition was same as in Study 1. The Abstraction condition was modified to match the Sequential Abstraction condition. The participants were provided with a randomized list of ten categories from those they had generated in the first phase of the experiment. In addition, a three-minute practice session was added before the brainstorming phase in which the participants brainstormed on the topic “Reform America’s Healthcare System.”

The participants in the Sequential Abstraction condition were also asked to generate categories in the first phase of the experiment. They then participated in a three-minute practice session before starting the second phase of the experiment. In the second phase, the experimenter provided the groups with one category in every 2 minutes of the brainstorming session. This

information was provided in the AIM group chat window so that all three group members could view it. They were asked to use these categories to generate ideas, but were instructed not to limit their ideas to the categories provided to them. In fact, they were encouraged to generate ideas in other categories. The participants in all three conditions were given a recall task after the brainstorming phase and were asked to recall five ideas that were submitted by their partners. This task was used to determine how much attention the participants had paid to each others' ideas. All participants were then given a post-experimental questionnaire at the end of the experiment (see Appendix B).

3.1.3 Dependent Variables

The same dependent variables were measured in this study as Study 1-- number of ideas, variety of ideas, category depth, and individual clustering.

3.2 Results

A one-way ANOVA for the total quantity of ideas revealed a significant difference among the conditions, $F(2,21) = 3.72$, $MSE = 624.27$, $p = .041$, $\eta^2 = .262$. Post-hoc analyses revealed that the participants in the Sequential Abstraction condition generated significantly more ideas than those in the Abstraction condition. A second ANOVA was used to analyze the differences among the conditions for the measure brainstorming variety. The results revealed a significant difference in brainstorming variety, $F(2,21) = 9.82$, $MSE = 166.36$, $p = .001$, $\eta^2 = .483$. The participants in the No Abstraction and Abstraction conditions displayed a greater variety than those in the Sequential Abstraction condition. A third ANOVA was used to assess the difference in category depth displayed by the participants in the three conditions. This result was also significant, $F(2,21) = 12.37$, $MSE = 40.25$, $p < .001$, $\eta^2 = .541$. It revealed that the

participants in the Sequential condition had more category depth than the participants in the Abstraction condition and the No Abstraction condition (see Table 2 for means and SD).

A fourth ANOVA revealed significant clustering differences among the conditions, $F(2,21) = 37.68$, $MSE = .012$, $p < .001$, $\eta^2 = .782$. The participants in the Sequential condition clustered more to their own ideas than those in the Abstraction and the No Abstraction conditions. Individual clustering predicted the quantity of ideas in the brainstorming phase, $B = 77.92$, $t(22) = 3.83$, $p = .001$, $sr^2 = .399$.

Table 2. Quantity, Variety, Category Depth and Clustering of Brainstorming Ideas by Condition

	Quantity (*SD*)	Variety (*SD*)	Category Depth *(SD)*	Clustering (*SD)*
Sequential Abstraction Group	103.13 *(32.62)*	16.25 (3.15)	6.47 *(2.16)*	.69 *(.18)*
No Abstraction Group	84.00 *(21.12)*	22.13 (*2.85*)	3.80 *(.80)*	.14 *(.06)*
Abstraction Group	69.13 *(19.05)*	21.00 (*2.39*)	3.24 *(.67)*	.19 *(.08)*

3.3 Discussion

Participants in the Sequential Abstraction condition generated significantly more ideas than those in the Abstraction condition but not significantly more than those in the No Abstraction condition. Thus hypothesis 1 was only partially supported, as it was expected that the participants in the Sequential Abstraction condition would generate significantly more ideas than those in the two other conditions. The participants in the sequential abstraction condition also displayed significantly more category depth than those in the other two conditions, which was in accordance with the hypothesis.

As predicted, participants in the Sequential condition displayed a lower variety of ideas than those in the other two conditions. These participants were only presented with 10 categories that they had previously generated. They might have paid 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 sequential condition, probably because the participants were focused on the presented categories and were not distracted by other categories. Because all three participants within each session were generating ideas in the same category, they may have experienced less distraction. In the other two conditions, different participants were generating ideas in different categories, which might have served as a distraction (Baruah & Paulus, 2011). Presenting categories sequentially may have eliminated this distraction and increased idea generation. In support of hypothesis 3, the participants in the Sequential condition clustered more than the participants in the other two conditions. Furthermore, consistent with hypothesis 4 and the findings of Study 1, clustering predicted the number of ideas generated.

CHAPTER 4

STUDY 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, Paulus, Roland & Yang, 2000). Furthermore, when they are primed with ideas within the categories that are generated by other participants, they are cognitively stimulated and generate more ideas (Leggett, 1997). Leggett (1997) provided participants ideas that were generated by others that were either high frequency or low frequency. High frequency ideas were defined as the ideas that were generated by different participants and were not novel, whereas low frequency ideas were novel and were not generated by many participants. She found that participants who received exemplars from low frequency categories generated more ideas. Because the low frequency exemplars are rarely explored by participants, providing participants with exemplars within those categories might enable them to generate ideas that they might not have explored otherwise.

In previous research on sequential brainstorming, participants did not generate the categories on their own (Coskun 1996; Coskun et al., 2000; Coskun & Yilmaz, 2009). Because they received categories that they might not have otherwise explored, they have the additional benefit of being primed with novel categories. Therefore, the ideas generated by them will

include the categories that are retrieved from their own knowledge as well as from other participants' knowledge. This should enable them to have more ideas as well as a greater variety of ideas. Studies 1 and 2 have concentrated on priming participants by helping them start at the abstract category level 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 procedures of priming in brainstorming.

Study 3 included all three conditions from Study 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. This should have primed participants with novel categories that they might not have considered previously. In the second phase of the experiment, participants in the yoked condition were provided with a list of 10 random categories and brainstormed for 20 minutes without interruption. The participants in the Sequential Yoked condition were provided with one category every two minutes on their screen while they were brainstorming. The following hypotheses were proposed:

H1: The participants in the sequential conditions should generate more ideas, greater category depth and more clustering during the brainstorming phase than the participants in the non-sequential conditions.

H2: The participants in the sequential conditions should display a lower variety of ideas compared to the participants in the non-sequential conditions, because they will concentrate more on the categories provided to them and less on other categories.

H3: The participants in the yoked conditions should have more ideas, with more variety and greater category depth than the participants in the other conditions, because they have the additional benefit of being primed with novel categories.

H4: The participants in the Yoked Sequential Group should have the most ideas and the greatest category depth because they should have the benefits of brainstorming sequentially as well as being primed by novel categories that they might not have explored otherwise.

H5: The amount of clustering should predict the total number of ideas generated. Participants who cluster more should generate more ideas.

4.1 Method

4.1.1 Participants

A total of 252 undergraduate students participated in the experiment. They received credits for their participation, which was required for their psychology course. A total of 27 participants had to be 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 old, with the mean age being 20.3 years old.

Table 3. Descriptives for Race of participants

Race	*N (Total = 225)*
White/Anglo American	61
Black/African American	38
Native American	2
Latino/Hispanic	62
Asian	43
Other/Multi-Cultural	18
Missing	2

4.1.2 Design and Procedure

A 2 (Abstraction vs. Yoked) X 2 (Sequential v. Non-Sequential) design was used for Study 3. Furthermore, a No Abstraction condition was added as a control. All conditions required three participants per group, as the participants in all conditions all participated in group brainstorming.

The No Abstraction, Abstraction and Sequential Abstraction conditions were identical to those of Study 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 minutes. These categories had been previously generated by groups of participants in the abstraction conditions. These categories were displayed according to their time stamp so that participants in the yoked conditions saw the categories approximately at the same time as the participants in the abstraction conditions. The group members had been informed about the UTA problem before they were shown this list. They had also been informed that another group of undergraduate students had previously generated this list. The second phase for the Yoked Group and Sequential Yoked Group conditions were similar to the second phase of the Abstraction Group and the Sequential Abstraction Group conditions respectively. As in Study 2, the participants were also given the recall task after completing of the second phase of the experiment. The recall task was modified for Study 3. Specifically, the participants were asked to list as many ideas as they could recall that were submitted by their partners. Finally all participants were given a post-experiment questionnaire to be completed after the recall task (see Appendix B).

4.1.3 Dependent Variables

The same dependent variables were measured in this study as Study 1 and 2-- the number of ideas, variety of ideas, category depth, and individual clustering.

4.2 Results

A 2 (Abstraction setting: Abstraction vs. Yoked) X 2 (Brainstorming setting: Sequential vs. Non-Sequential) ANOVA for quantity of ideas revealed a marginal main effect for brainstorming setting, $F(1, 56) = 3.06$, $MSE = 1008.44$, $p < .086$, $\eta^2 = .052$. Groups in the sequential conditions ($M = 89.13$, $SE = 5.80$) generated marginally more ideas than those in the non-sequential conditions ($M = 74.8$, $SE = 5.80$).

A similar 2 X 2 ANOVA was completed for brainstorming variety. There was a significant main effect for brainstorming setting, $F(1, 56) = 33.92$, $MSE = 7.31$, $p < .001$, $\eta^2 = .377$. Groups in the non-sequential conditions ($M = 19.57$, $SE = .49$) generated greater variety of ideas than those in the sequential conditions ($M = 15.50$, $SE = .49$).

Another 2 X 2 ANOVA was calculated for category depth. There was a significant main effect for brainstorming setting, $F(1, 56) = 22.31$, $MSE = 2.67$, $p < .001$, $\eta^2 = .29$. Groups in the sequential conditions ($M = 5.78$, $SE = .30$) exhibited more category depth than those in the non-sequential conditions ($M = 3.78$, $SE = .30$). Furthermore, there was a marginally significant interaction, $F(1, 56) = 3.45$, $MSE = 2.67$, $p = .068$, $\eta^2 = .06$. The post hoc- analyses showed that the Abstraction Group condition had a slightly lower category depth ($M = 3.75$, $SE = .42$) than the Yoked Abstraction condition ($M = 3.99$, $SE = .42$). However, the Sequential Abstraction condition ($M = 6.35$, $SE = .42$) displayed significantly more category depth than the Sequential Yoked condition ($M = 5.2$, $SE = .42$).

A fourth 2 X 2 ANOVA for individual clustering found a significant main effect for brainstorming setting, $F(1, 56) = 163.35$, $MSE = .01$, $p < .001$, $\eta^2 = .75$. As predicted, groups in the sequential conditions ($M = .47$, $SE = .02$) exhibited more clustering than those in the non-sequential conditions ($M = .13$, $SE = .02$). Furthermore, a regression analysis showed that individual clustering significantly predicted brainstorming quantity, $B = 58.67$, $t(73) = 3.30$, $p = .002$, $sr^2 = .13$ for all the conditions.

One-way ANOVAs were conducted to examine the differences between the no abstraction condition and the other conditions. A one-way ANOVA for the total quantity of ideas did not reveal a significant difference among the conditions. However, post-hoc analyses showed that the participants in the Sequential Abstraction condition generated significantly more ideas than those in the No Abstraction condition. There was also a significant difference in brainstorming variety, $F(4,70) = 10.14$, $MSE = 7.91$, $p < .001$, $\eta^2 = .367$. The participants in the Sequential Abstraction and Sequential Yoked conditions displayed a lower variety of ideas than those in the No Abstraction, Abstraction and Yoked Abstraction conditions. The ANOVA for category depth was also significant, $F(4, 70) = 10.13$, $MSE = 4.20$, $p < .001$, $\eta^2 = .367$. It revealed that the participants in the Sequential condition had more category depth than the participants in the remaining four conditions. Furthermore, participants in the Yoked Sequential condition displayed more category depth than the participants in the No Abstraction, Abstraction and Yoked Abstraction conditions. There were no significant differences in the recall score among the participants among the five conditions, $F(4, 70) = 1.066$, $MSE = 10.42$, $p = .380$, $\eta^2 = .057$ (see Table 4 for means and SD).

Table 4. Quantity, Variety, Category Depth and Clustering of Brainstorming Ideas by Condition

	Quantity (*SD*)	Variety (*SD*)	Category Depth *(SD)*	Clustering (*SD*)	Recall (*SD*)
Abstraction Group	71.33 *(24.31)*	19.80 (3.21)	3.57 *(1.14)*	3.45 *(.67)*	10.26 *(2.88)*
Sequential Group	*94.33 (38.62)*	14.93 (*2.79*)	6.35 *(2.44)*	3.40 *(.85)*	10.82 *(3.10)*
Yoked Abstraction Group	78.27 *(31.77)*	19.33 (*2.41*)	3.99 *(1.32)*	3.91 *(.93)*	12.01 *(2.93)*
Sequential Yoked Group	83.93 *(30.68)*	16.07 (*3.31*)	5.20 *(1.40)*	2.85 *(.84)*	12.04 *(3.38)*
No Abstraction Group	54.67 *(21.12)*	19.80 (2.18)	3.57 *(1.40)*	2.85 *(.84)*	12.16 *(3.77)*

4.3 Discussion

Participants in the Sequential conditions displayed a significantly greater category depth and clustering than the participants in the Non-Sequential conditions. However, contrary to my hypothesis, the effect for quantity of ideas was only marginally significant. The participants in the Sequential conditions had a marginally greater brainstorming quantity than the participants in the Non-sequential conditions. Therefore, hypothesis 1 was only partially supported. Participants in the Sequential conditions also displayed significantly less variety than the participants in the Non-sequential conditions. This result supported the second hypothesis.

The third hypothesis was not supported because there were no main effects for the yoked conditions. However, it was also predicted that the participants in the Sequential Yoked should generate the most ideas and category depths in comparison to the other four conditions. Participants in the Sequential Yoked condition did have more category depth than those in the No Abstraction, Abstraction and Yoked Abstraction conditions, but the participants in the

Sequential Abstraction conditions had more category depth than those in the Sequential Yoked condition. Furthermore, there were no differences in the quantity of ideas among the participants in the Sequential Yoked condition and any other conditions. Therefore, hypothesis 4 was not supported.

The amount of clustering predicted the quantity of ideas in accordance with Study 1 and Study 2, supporting our prediction. Because the sequential conditions have significantly more clustering than the yoked conditions and clustering predicts the quantity of ideas, the participants in the sequential conditions should have generated significantly greater ideas. However, this was not the case. The one-way ANOVA for quantity showed that the participants in the Sequential Abstraction generated significantly more ideas than the participants in the No Abstraction condition. Nevertheless, the power might have been reduced due to the high variance in the means. If the variance is reduced, we might see more significant differences among the other conditions. A one-way ANCOVA with recall as the covariate was used for this purpose. I found a significant difference among the conditions for quantity. Furthermore, post-hoc analyses revealed that the participants in the Sequential Abstraction condition generated significantly more ideas than those in the No Abstraction, Abstraction, andYoked Abstraction conditions. The one-way ANOVA also revealed that the participants in the Sequential Abstraction condition displayed more category depth than the participants in other four conditions. This was contrary to my prediction because I had assumed that Sequential Yoked condition would fare the best. Thus, when individuals generate their own categories, they may be more personally relevant and allow for more in-depth exploration.

Previous studies found that sequentially providing participants with categories sequentially increased their brainstorming productivity (Coskun 1996; Coskun et al., 2000; Coskun & Yilmaz, 2009). These were random high frequency categories that were not generated by the participants themselves. I also found that participants in the Sequential conditions generated marginally more ideas than the participants in the Non-sequential conditions. They also had significantly higher category depth and clustering. Moreover, the post-hoc analyses revealed significant improvements in the productivity of participants in the Sequential Yoked condition. This finding suggests that the main effects for sequential conditions may have been driven by the Sequential Abstraction condition. Therefore, the present findings do not directly support previous findings. However, these discrepancies in results might have been due to the quality of categories in the other studies. The categories that the other studies used were clearer and also had other sub-categories. For instance, some of the categories that Coskun (1996) provided to the participants were “parking,” “classes” and “activities.” The category “parking” can contain several sub-categories such as “towing” and “tickets.” This structure enabled the participants to generate several ideas within that category because it reflected the semantic structure of the population. The categories that I provided in the present study were not always that broad. Some of the categories that I provided were “smaller classes” and “school colors.” Because these categories are not that broad, participants in the yoked conditions might not have found them very beneficial. Though this was the case for the participants in the Yoked conditions, the participants in the Sequential Abstraction condition still benefitted from these categories. This might have accured because they had generated these categories themselves and therefore, found them more meaningful. We can study this in the future by providing participants

with broader categories. Instead of selecting the 10 categories randomly, we can select the 10 broadest categories from the list and present those to the participants. We can also have another condition in which we provide the participants with these "lesser" categories that are not as broad. This type of design might give us a clearer understanding on how the quality of the categories can influence the brainstorming process.

I found no benefit of the abstraction phase in Study 1 without asking the participants to brainstorm sequentially on different categories. Ward (2008) had found that starting at an abstract level would lead to an increased productivity when he asked participants to develop a new sport. However, when I instructed participants in groups to start at an abstract level, their productivity did not increase in the brainstorming phase. This might have been due to distraction by the categories as well as their partners' ideas. In accord with the results of Baruah & Paulus (2011), I found that the different participants generated ideas in different categories, which in turn led to distraction. Providing the participants with the categories sequentially seems to have removed this distraction by helping them cluster more in one category at a time. Therefore, I did find a positive effect of Abstraction as well as Sequential brainstorming. However, I found that the two processes had to be combined to obtain a significant increase in productivity.

This outcome implies that in order to make group brainstorming efficient, we should combine these procedures. If a small group of individuals are generating ideas, they should generate categories for the ideas for the first few minutes. After they have generated some categories, they should explore these categories one by one in order to obtain greatest productivity. The quality of categories generated by these participants should not be important, because they should be personally relevant to them. However, if these individuals in a group are

not going to generate their own categories, the quality of these categories might be important. The results of previous studies (Coskun 1996; Coskun et al., 2000; Coskun & Yilmaz, 2009) indicate that providing high quality categories when brainstorming to these categories sequentially increases productivity. However, my study revealed that lower quality categories do not lead to the same result. Therefore, if individuals in a group are not going to generate their own categories before brainstorming, they should be provided with high quality categories with several subcategories in order to increase productivity.

The one-way ANOVA also revealed that there were no differences between the Abstraction and No Abstraction conditions. However, in Study 1 I found that performance in the No Abstraction condition was significantly better than in the Abstraction condition. This difference in results might have occurred because of the differences in the methodology of Study 2 and Study 3. The participants in the Abstraction condition were only provided with a list of ten random categories in these studies compared to the unlimited number of categories in Study 1. This might have decreased distraction in the brainstorming phase in the Abstraction condition, leading to higher productivity. Participants in Studies 2 and 3 were also given a three-minute practice session before the brainstorming phase. It is possible that practice session might reduce the negative effects of the abstraction phase. Future studies should examine the role of these factors in the effects of abstraction.

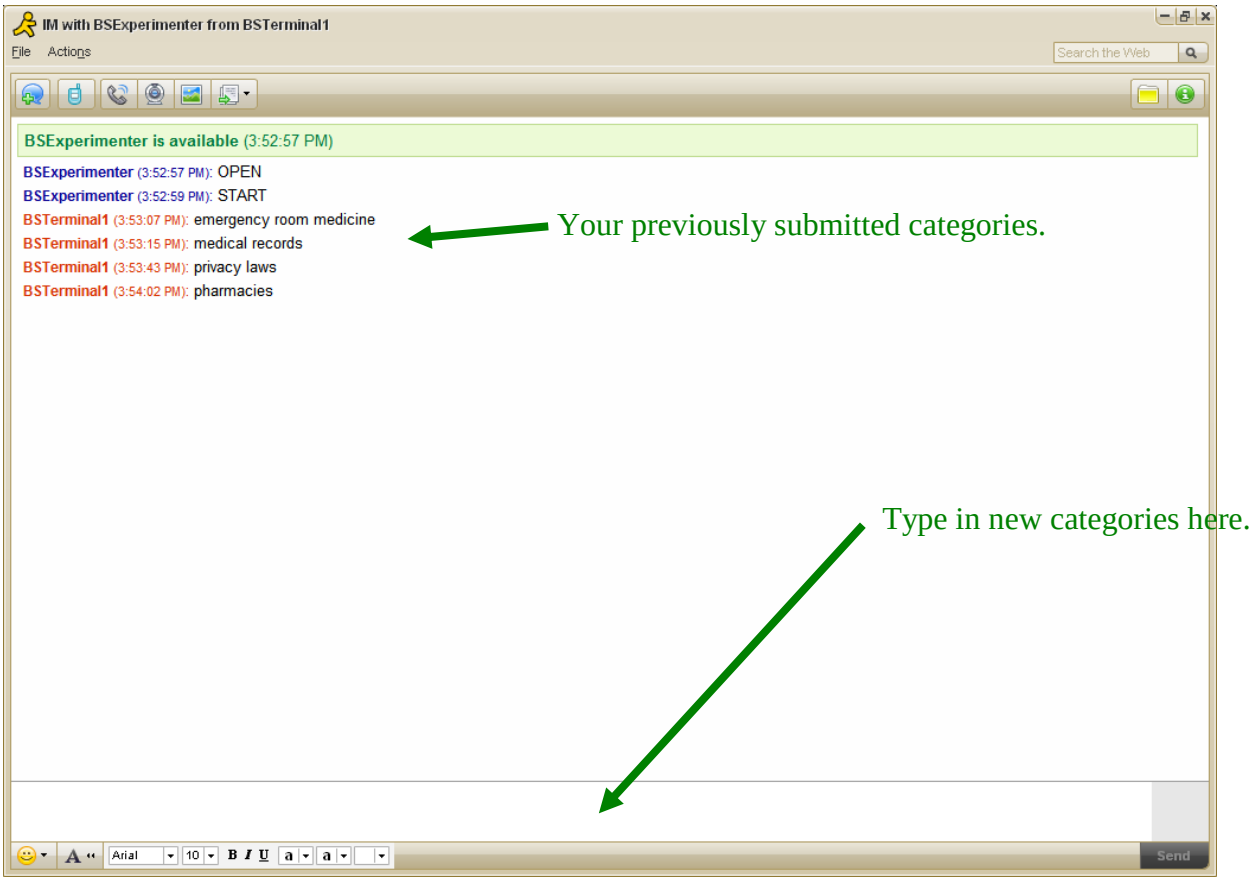
APPENDIX A

EXPERIMENTAL INSTRUCTIONS

Abstraction Instruction (Individuals)

You are about to participate in an experiment examining idea generation. In a minute you will be given a topic. Your job is to list as many **categories or types** of ideas as possible for this topic. Categories are not specific ideas, but rather general domains or classes of ideas. For example, if you were given the topic of "Reform America's health care system," you could come up with the categories: *emergency room*, *pharmacy*, *medical records*, etc. We do not want you to submit specific ideas to this topic (e.g., "Limit Medicare's benefits to doctor's visits for patients older than the age of 75"); we want you to submit categories (e.g., "Medicare"). You will submit your categories by typing the idea into the program (AOL Instant Messenger – "AIM") and then pressing enter. Do not worry about perfect spelling or grammar.

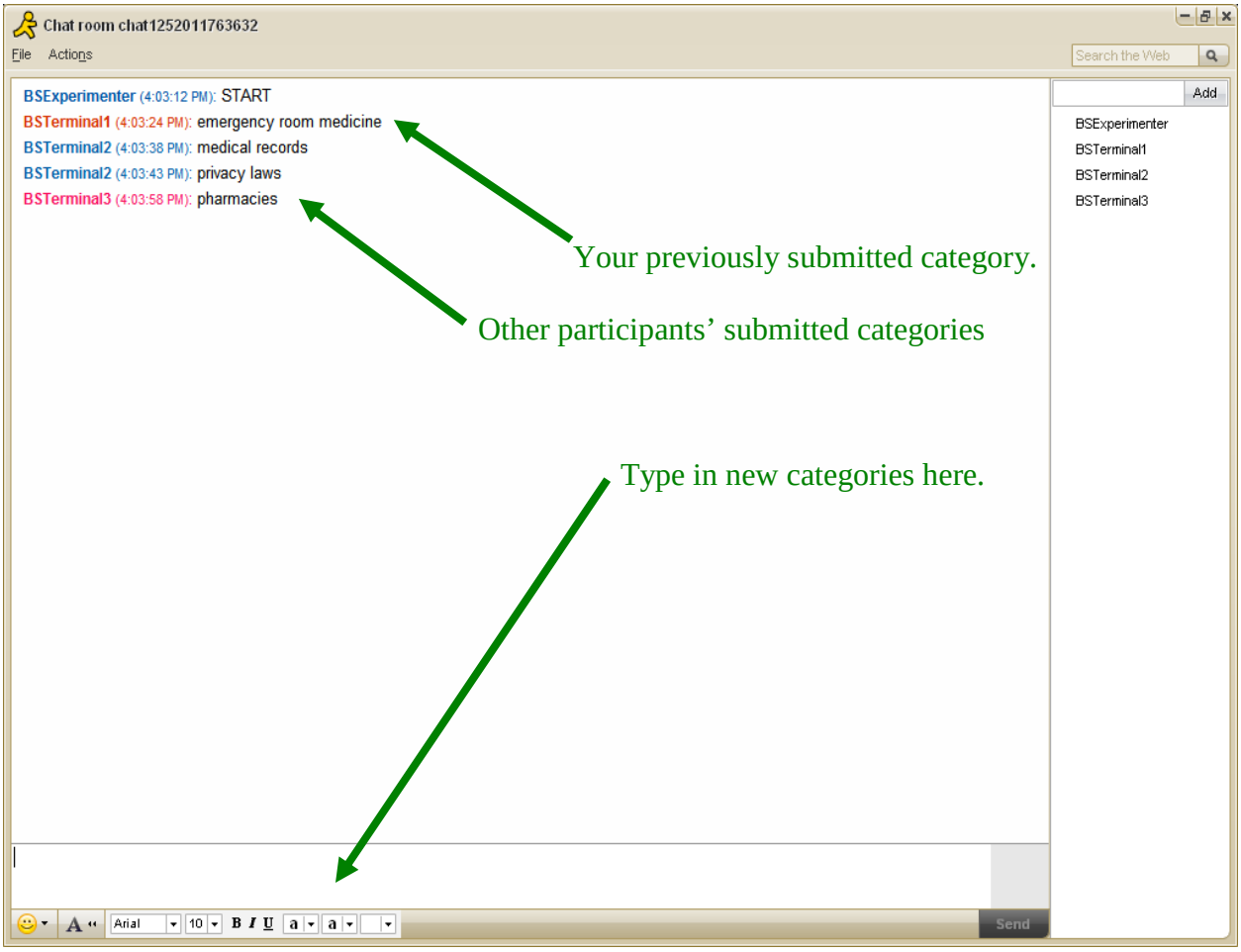
For each category you submit, it will be sent to the Experimenter's computer. However, the Experimenter will not communicate with you via AIM, except telling you to "Start" and "Stop." Here is a diagram of how to type in categories. Please ask your Experimenter if you have any questions regarding how to type in and submit categories.



Abstraction Instruction (Groups)

You are about to participate in an experiment examining idea generation. In a minute you will be given a topic. Your job is to work with your fellow group members to list as many **categories or types** of ideas as possible for this topic. Categories are not specific ideas, but rather general domains or classes of ideas. For example, if you were given the topic of "Reform America's health care system," you could come up with the categories: *emergency room*, *pharmacy*, *medical records*, etc. We do not want you to submit specific ideas to this topic (e.g., "Limit Medicare's benefits to doctor's visits for patients older than the age of 75"); we want you to submit categories (e.g., "Medicare"). You will submit your categories by typing the idea into the program (AOL Instant Messenger – "AIM") and then pressing enter. Do not worry about perfect spelling or grammar.

For each category you submit, it will be sent to the other group members' computers and the Experimenter's computer. Please do not engage in conversation with your fellow group members over AIM – only submit categories. The other participants will not know who submitted each idea as you have each been assigned a random ID. The Experimenter will not communicate with you via AIM, except telling you to "Start" and "Stop." Here is a diagram of how to type in categories.

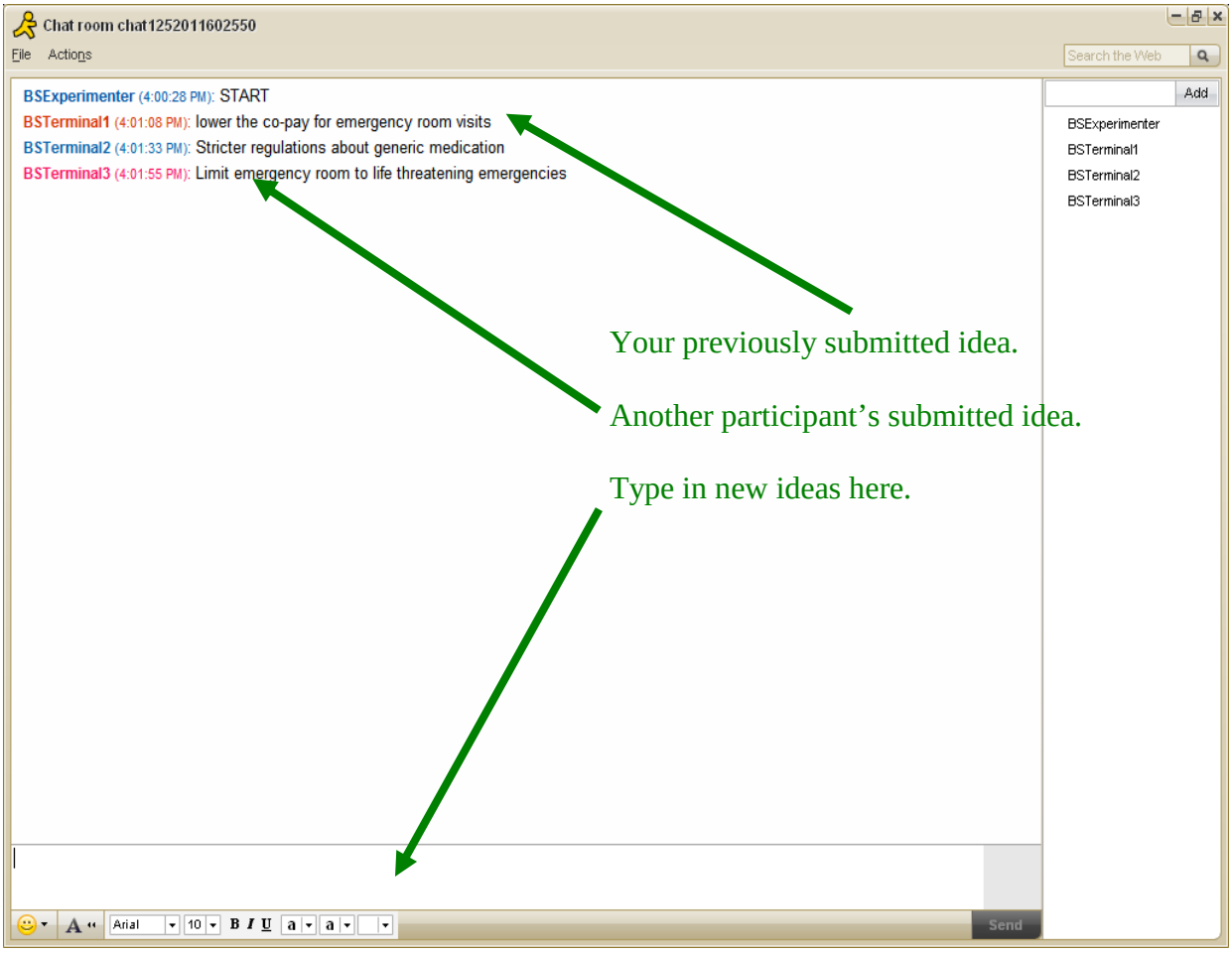


Brainstorming Instructions (No Abstraction Group)

You are about to participate in an experiment examining idea generation. In a minute you will be given a topic. Your job is to list as many ideas as possible for this topic. These ideas can be as short as a few words. You will submit your ideas by typing the idea into the program (AOL Instant Messenger – "AIM") and then pressing enter. Do not worry about perfect spelling or grammar.

You will be working with two other participants on this idea generation task. For each idea you submit, it will be sent to the other participants as well as the Experimenter's computer. However, the Experimenter will not communicate with you via AIM except telling you to "Start" and "Stop." The other participants will not know who submitted each idea as you have each been assigned a random ID.

Here is a diagram of how to type in ideas.

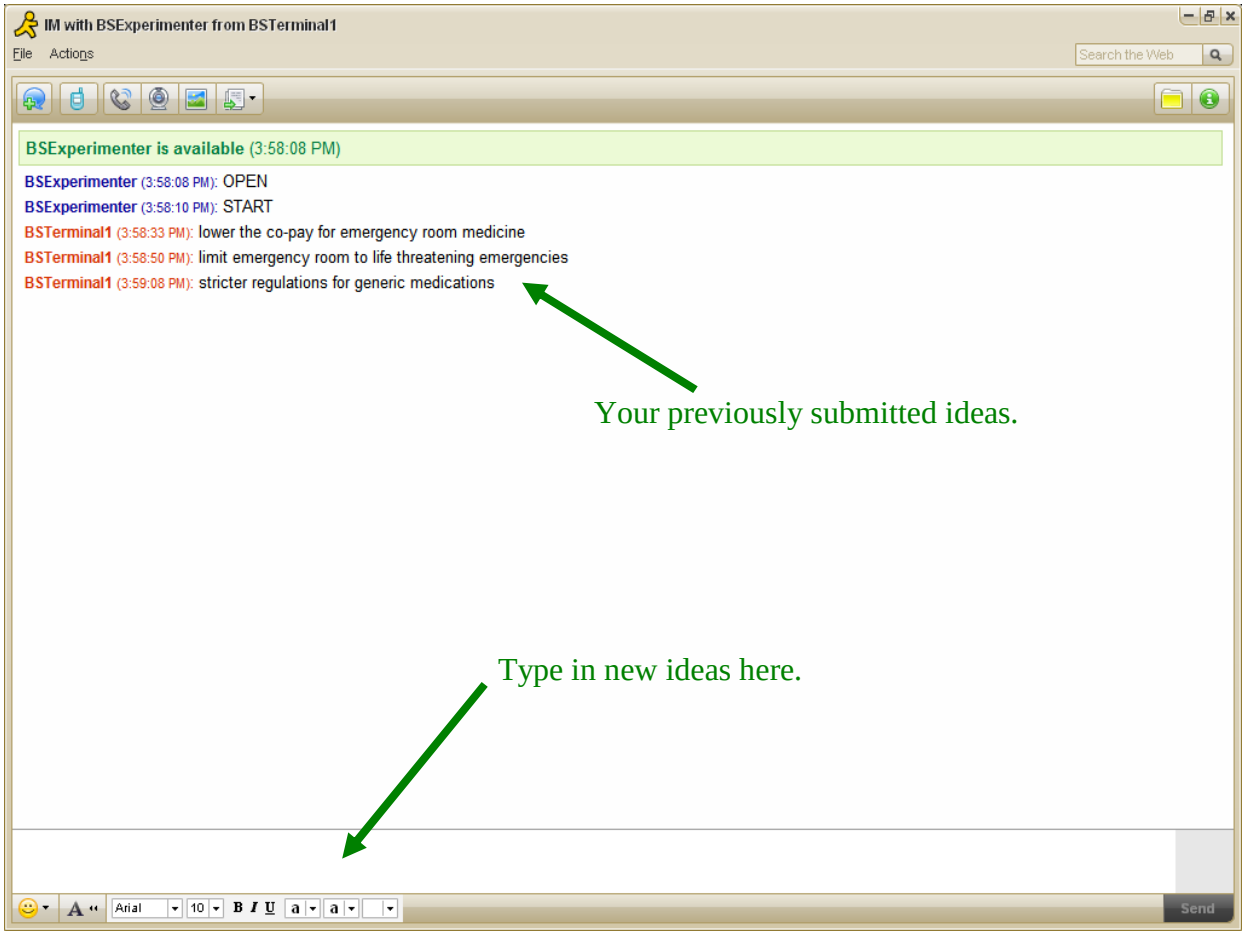


Brainstorming Instructions (No Abstraction Individual)

You are about to participate in an experiment examining idea generation. In a minute you will be given a topic. Your job is to list as many ideas as possible for this topic. These ideas can be as short as a few words. You will submit your ideas by typing the idea into the program (AOL Instant Messenger – "AIM") and then pressing enter. Do not worry about perfect spelling or grammar.

For each idea you submit, it will be sent to the Experimenter's computer. However, the Experimenter will not communicate with you via AIM except telling you to "Start" and "Stop."

Here is a diagram of how to type in ideas:

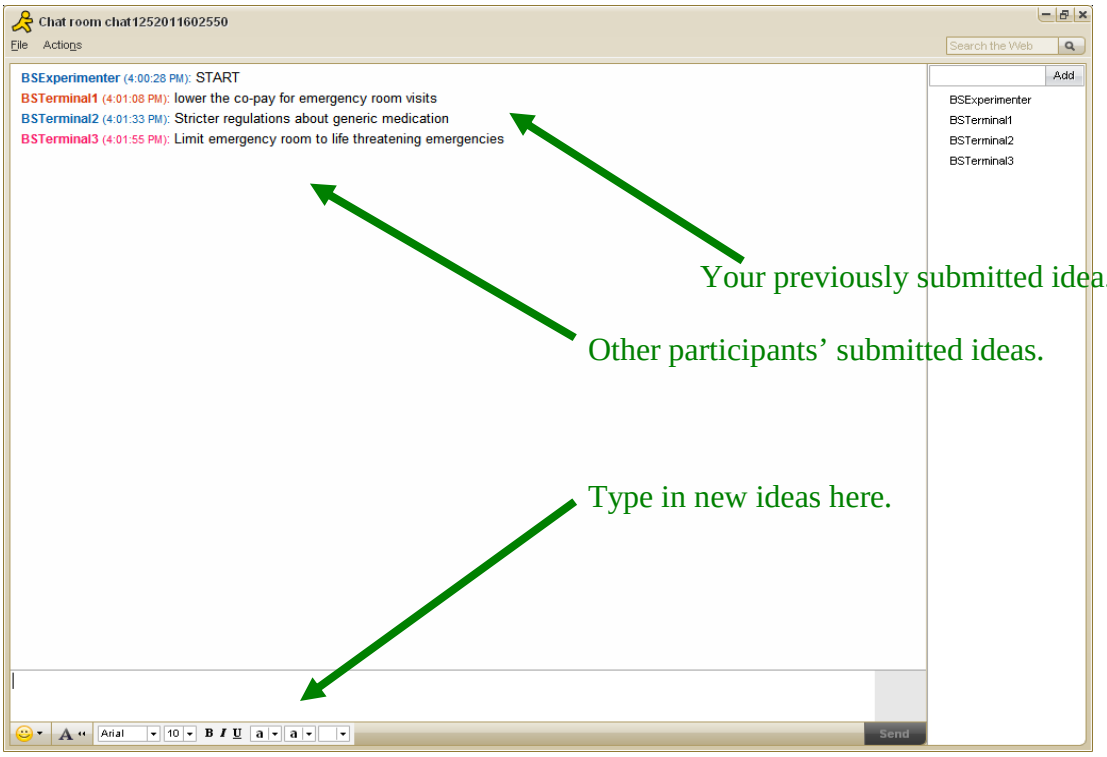


Brainstorming Instructions (Abstraction Group)

For the next part of the experiment, you will be asked to generate ideas to the same brainstorming topic (*Ways in which to improve UTA*). However, this time, we want you to list specific **ideas** on which to improve UTA, not categories of ideas. In a minute 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. Your job is to list as many ideas as possible for this topic. These ideas can be as short as a few words. You will submit your ideas by typing the idea into the AIM program and then pressing enter. Do not worry about perfect spelling or grammar.

For example, if you earlier were given the topic of "Reform America's health care system" and one of the categories you generated was *emergency room medicine*, you could generate the ideas: "Lower the co-pay for emergency room visits", "Limit emergency room to life threatening emergencies", and "Stricter regulations for generic medication" even though you did not earlier generate a category about generic medication.

You will be working with two other participants on this idea generation task. For each idea you submit, it will be sent to the other participants as well as the Experimenter's computer. However, the Experimenter will not communicate with you via AIM, except telling you to "Start" and "Stop." The other participants will not know who submitted each idea as you have each been assigned a random ID.
Here is a diagram of how to type in ideas.

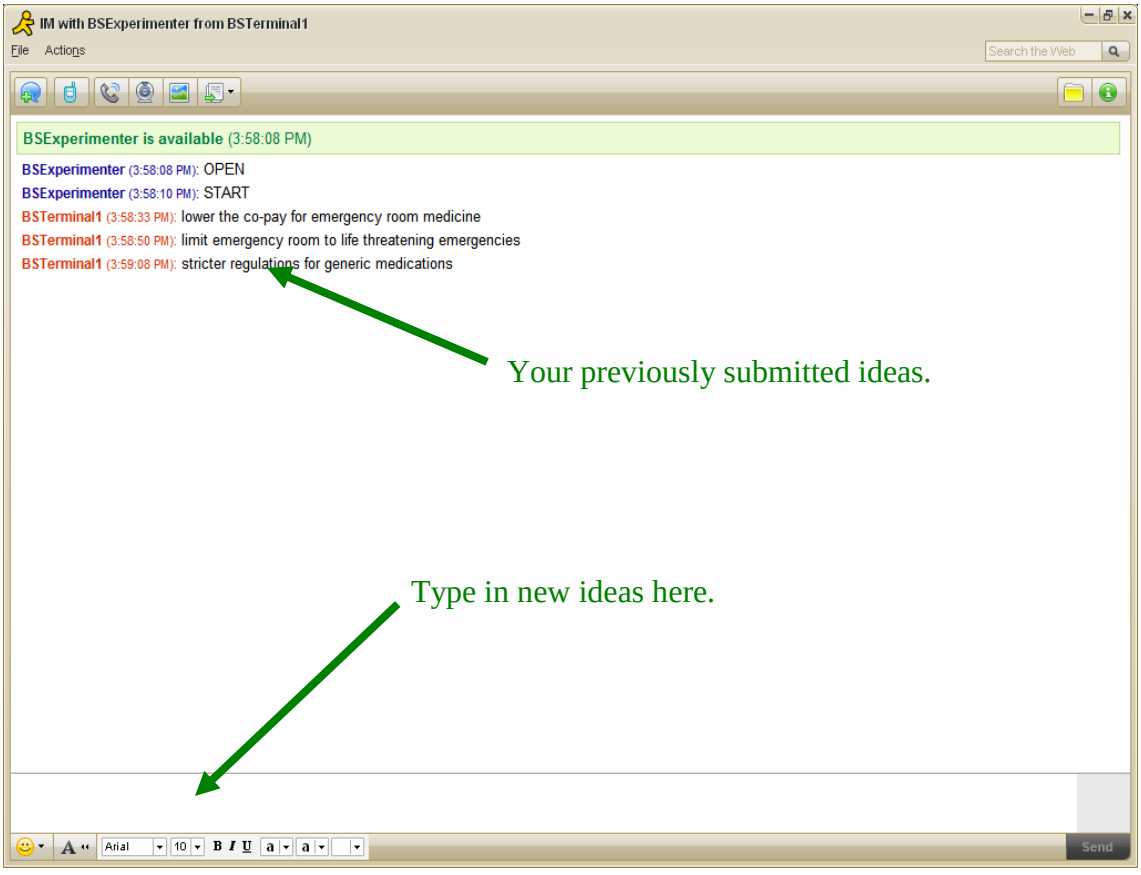


Brainstorming Instructions (Abstraction Individual)

For the next part of the experiment, you will be asked to generate ideas to the same brainstorming topic (*Ways in which to improve UTA*). However, this time, we want you to list specific **ideas** on which to improve UTA, not categories of ideas. In a minute your experimenter will give you a list of categories that your group 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. Your job is to list as many ideas as possible for this topic. These ideas can be as short as a few words. You will submit your ideas by typing the idea into the AIM program and then pressing enter. Do not worry about perfect spelling or grammar.

For example, if you earlier were given the topic of "Reform America's health care system" and one of the categories you generated was *emergency room medicine*, you could generate the ideas: "Lower the co-pay for emergency room visits", "Limit emergency room to life threatening emergencies", and "Stricter regulations for generic medication" even though you did not earlier generate a category about generic medication.

For each idea you submit, it will be sent to the Experimenter's computer. However, the Experimenter will not communicate with you via AIM, except telling you to "Start" and "Stop." Here is a diagram of how to type in ideas.

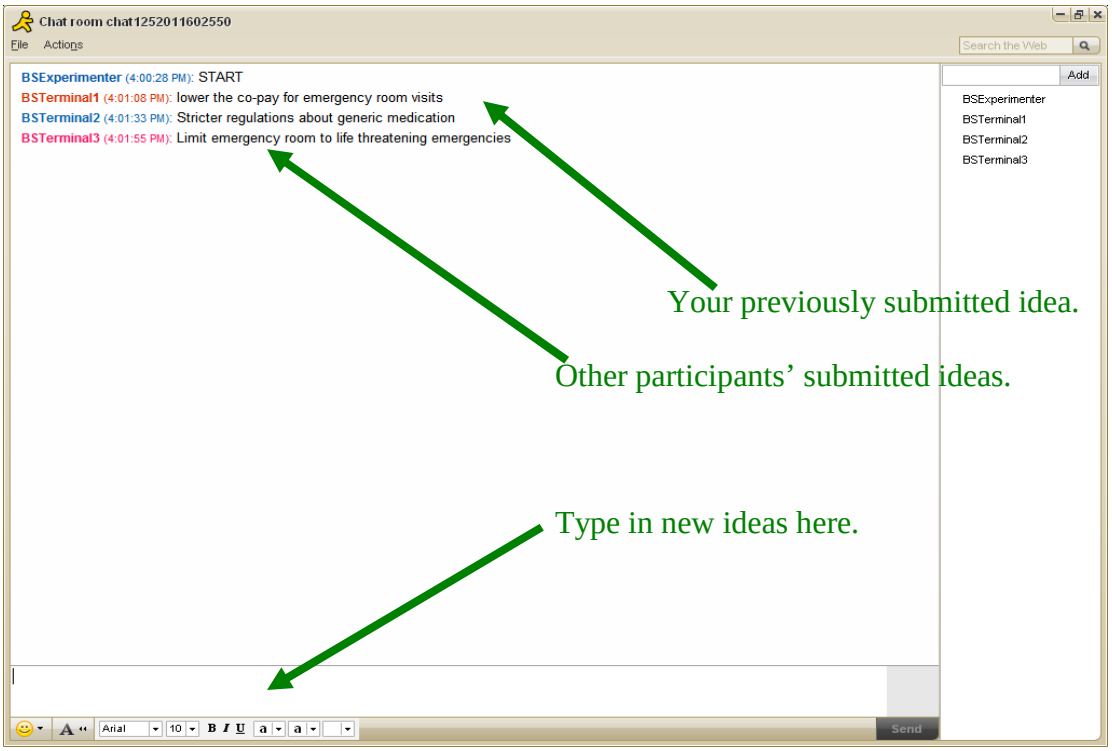


Brainstorming Instructions (Sequential Group)

For the next part of the experiment, you will be asked to generate ideas to the same brainstorming topic (*Ways to improve UTA*). However, this time, we want you to list specific **ideas** on which to improve UTA, not categories of ideas. Your job is to list as many ideas as possible for this topic. These ideas can be as short as a few words. You will submit your ideas by typing the idea into the AIM program and then pressing enter. Do not worry about perfect spelling or grammar.

You will be working with two other participants on this idea generation task. You will be able to see each others' ideas, however do not communicate with one another and continue generating ideas. 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. For example, if you earlier were given the topic of "Reform America's health care system" and the category provided to you by the experimenter is *emergency room*, you could generate the ideas "Lower the co-pay for emergency room visits" and "Limit emergency room to life threatening emergencies". You can also come up with ideas that are based on a different category that is not provided by the experimenter. For example, you can say "Stricter regulations for generic medication" even though the experimenter did not provide you with the category *generic medication*.

For each idea you submit, it will be sent to the other participants as well as the Experimenter's computer. However, the Experimenter will not communicate with you via AIM, except telling you to "Start" and "Stop." Here is a diagram of how to type in ideas.

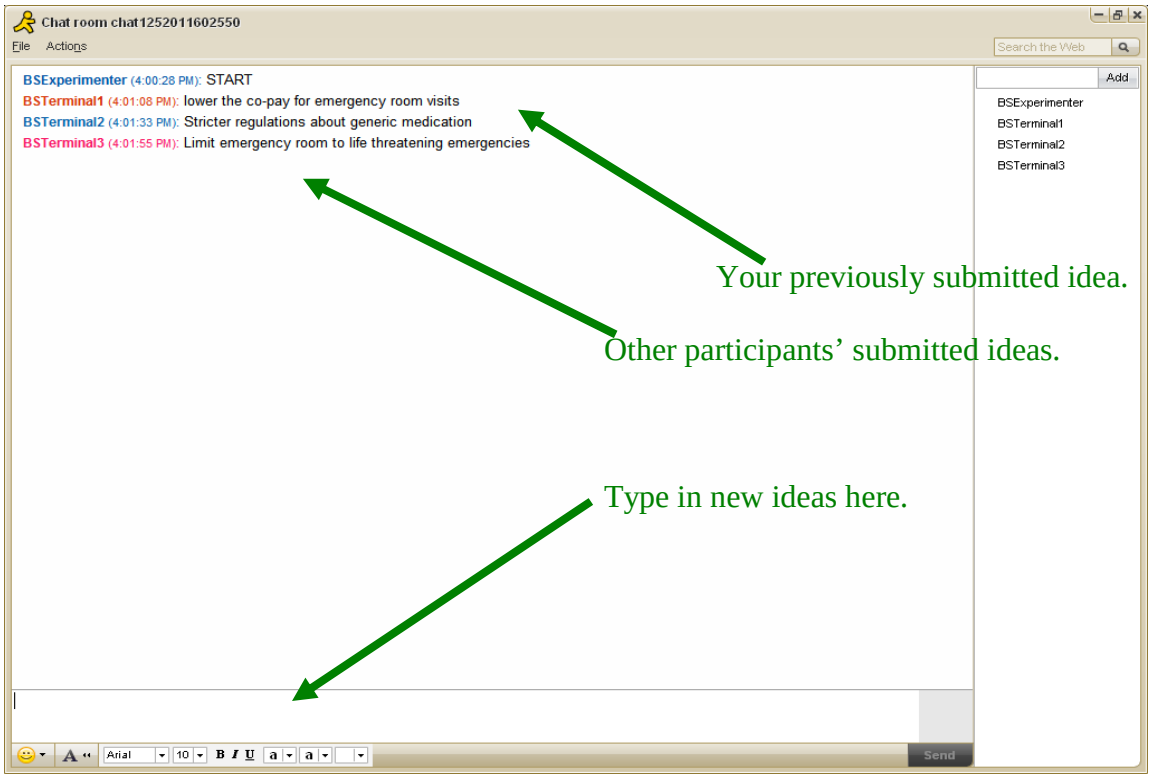


Brainstorming Instructions (Yoked)

For the next part of the experiment, you will be asked to generate ideas to the same brainstorming topic (*Ways in which to improve UTA*). However, this time, we want you to list specific **ideas** on which to improve UTA, not categories of ideas. In a minute your experimenter will give you a list of categories that were generated by three other participants earlier this semester. 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. Your job is to list as many ideas as possible for this topic. These ideas can be as short as a few words. You will submit your ideas by typing the idea into the AIM program and then pressing enter. Do not worry about perfect spelling or grammar.

For example, if you earlier were given the topic of "Reform America's health care system" and one of the categories you generated was *emergency room medicine*, you could generate the ideas: "Lower the co-pay for emergency room visits", "Limit emergency room to life threatening emergencies", and "Stricter regulations for generic medication" even though you did not earlier generate a category about generic medication.

You will be working with two other participants on this idea generation task. For each idea you submit, it will be sent to the other participants as well as the Experimenter's computer. However, the Experimenter will not communicate with you via AIM, except telling you to "Start" and "Stop." The other participants will not know who submitted each idea as you have each been assigned a random ID.
Here is a diagram of how to type in ideas.

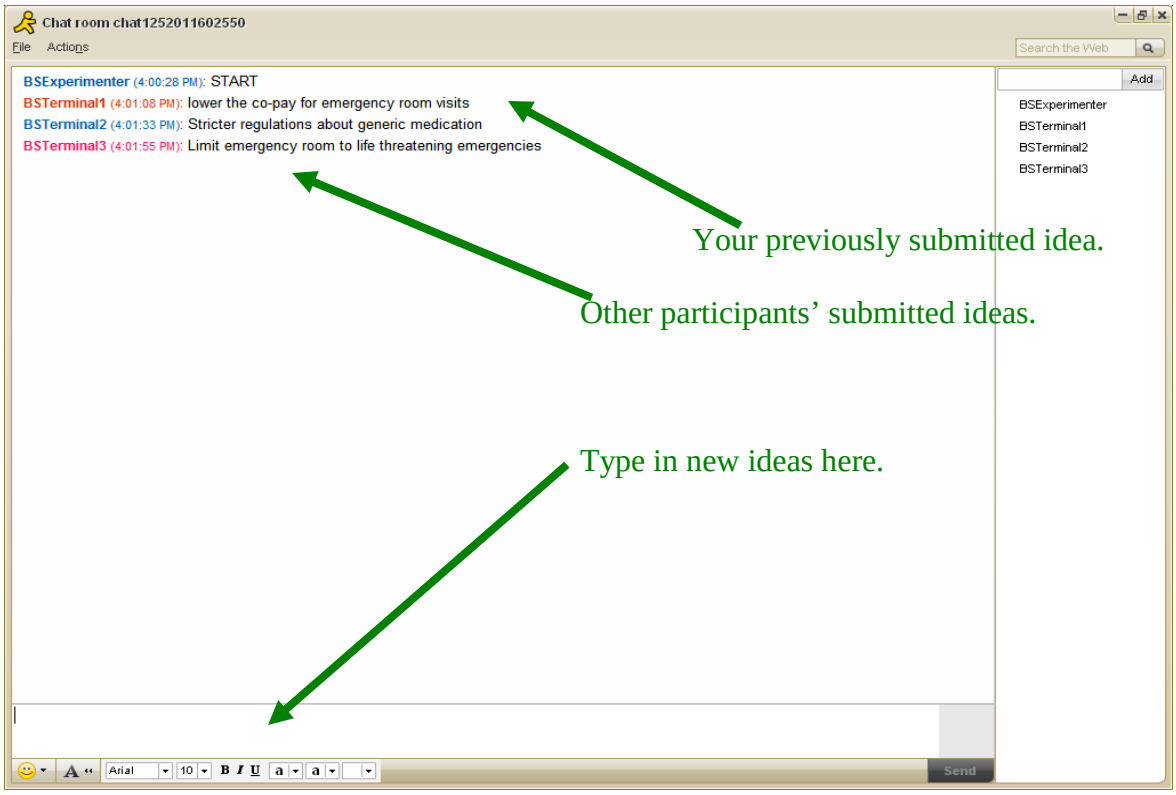


Brainstorming Instructions (Yoked Sequential)

For the next part of the experiment, you will be asked to generate ideas to the same brainstorming topic (*Ways in which to improve UTA*). However, we want you to list specific **ideas** on which to improve UTA, not categories of ideas. Your job is to list as many ideas as possible for this topic. These ideas can be as short as a few words. You will submit your ideas by typing the idea into the AIM program and then pressing enter. Do not worry about perfect spelling or grammar.

You will be working with two other participants on this idea generation task. You will be able to see each others' ideas, however do not communicate with one another and continue generating ideas. 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. For example, if you earlier were given the topic of "Reform America's health care system" and the category provided to you by the experimenter is *emergency room*, you could generate the ideas "Lower the co-pay for emergency room visits" and "Limit emergency room to life threatening emergencies". You can also come up with ideas that are based on a different category that is not provided by the experimenter. For example, you can say "Stricter regulations for generic medication" even though the experimenter did not provide you with the category *generic medication*.

For each idea you submit, it will be sent to the other participants as well as the Experimenter's computer. However, the Experimenter will not communicate with you via AIM, except telling you to "Start" and "Stop." Here is a diagram of how to type in ideas.



Additional Brainstorming Instruction (All Conditions)

When listing ideas to the brainstorming topic, there are some things we want you to keep in mind:

1) **Criticism is ruled out**. Adverse judgment of ideas must be withheld. Say everything you think of.

2) **Freewheeling is welcome**. The wilder the idea the better. It is easier to tame down than to think up. Do not be afraid to say anything that comes to mind. The further out the idea the better. This will stimulate more and better ideas.

3) **Quantity is wanted**. The greater the number of ideas the more likelihood of good ideas. Come up with as many as you can.

4) **Stay focused on the task**. Concentrate on the problem at hand and avoid engaging in irrelevant thought processes and discussions.
   i. Do not tell stories. We are only interested in your ideas. Do not tell stories about your experiences.
   ii. Do not explain ideas. Do not expand ideas on why you think something is good or bad. Simply state your idea and continue with next ideas.

APPENDIX B

QUESTIONNAIRES

(No Abstraction Conditions: Study 1)

Please indicate your responses to the following questions:

1) Generating many ideas to the UTA brainstorming topic was easy.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

2) Generating a wide variety/range of ideas to the UTA topic was easy.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

Questionnaire (Abstraction Conditions: Study 1)

Please indicate your responses to the following questions:

1) Generating many ideas to the UTA brainstorming topic was easy.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

2) Generating a wide variety/range of ideas to the UTA topic was easy.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

3) Generating categories first helped me to brainstorm more ideas later.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

4) Generating categories first helped me to brainstorm a wide variety/range of ideas later.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

Questionnaire (Sequential Group: Study 2 and 3)

Please indicate your responses to the following questions:

1) Generating many ideas to the UTA brainstorming topic was easy.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

2) Generating a wide variety/range of ideas to the UTA topic was easy.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

3) Generating categories first helped me to brainstorm more ideas later.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

4) Generating categories first helped me to brainstorm a wide variety/range of ideas later.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

5) To what extent did you pay attention to your partners' ideas?

1	2	3	4	5	6	7
not at all						*A lot*

6) To what extent did you focus on the ideas of your partners' in generating your own ideas?

1	2	3	4	5	6	7
not at all						*A lot*

7) To what extent did you generate ideas in the category provided by the experimenter?

1	2	3	4	5	6	7
not at all						*A lot*

8) It was easy generating several ideas on the category provided by the experimenter before moving on to the next one.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

Questionnaire (No Abstraction Group: Study 2 and 3)

Please indicate your responses to the following questions:

1) Generating many ideas to the UTA brainstorming topic was easy.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

2) Generating a wide variety/range of ideas to the UTA topic was easy.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

3) To what extent did you pay attention to your partners' ideas?

1	2	3	4	5	6	7
not at all						*A lot*

4) To what extent did you focus on the ideas of your partners' in generating your own ideas?

1	2	3	4	5	6	7
not at all						*A lot*

Questionnaire (Abstraction Group: Study 2 and 3)

Please indicate your responses to the following questions:

1) Generating many ideas to the UTA brainstorming topic was easy.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

2) Generating a wide variety/range of ideas to the UTA topic was easy.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

3) Generating categories first helped me to brainstorm more ideas later.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

4) Generating categories first helped me to brainstorm a wide variety/range of ideas later.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

5) To what extent did you pay attention to your partners' ideas?

1	2	3	4	5	6	7
not at all						*A lot*

6) To what extent did you focus on the ideas of your partners' in generating your own ideas?

1	2	3	4	5	6	7
not at all						*A lot*

7) To what extent did you generate ideas in one category before moving to the next category?

1	2	3	4	5	6	7
not at all						*A lot*

8) It was easy generating several ideas on the same category before moving on to the next one.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

Questionnaire (Yoked Group)

Please indicate your responses to the following questions:

1) Generating many ideas to the UTA brainstorming topic was easy.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

2) Generating a wide variety/range of ideas to the UTA topic was easy.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

3) Receiving a list of categories first helped me to brainstorm more ideas later.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

4) Receiving a list of categories first helped me to brainstorm a wide variety/range of ideas later.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

5) To what extent did you pay attention to your partners' ideas?

1	2	3	4	5	6	7
not at all						*A lot*

6) To what extent did you focus on the ideas of your partners' in generating your own ideas?

1	2	3	4	5	6	7
not at all						*A lot*

7) To what extent did you generate ideas in one category before moving to the next category?

1	2	3	4	5	6	7
not at all						*A lot*

8) It was easy generating several ideas on the same category before moving on to the next one.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

Questionnaire (Sequential Yoked)

Please indicate your responses to the following questions:

1) Generating many ideas to the UTA brainstorming topic was easy.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

2) Generating a wide variety/range of ideas to the UTA topic was easy.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

3) Receiving categories first helped me to brainstorm more ideas later.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

4) Receiving categories first helped me to brainstorm a wide variety/range of ideas later.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

5) To what extent did you pay attention to your partners' ideas?

1	2	3	4	5	6	7
not at all						*A lot*

6) To what extent did you focus on the ideas of your partners' in generating your own ideas?

1	2	3	4	5	6	7
not at all						*A lot*

7) To what extent did you generate ideas in the category provided by the experimenter?

1	2	3	4	5	6	7
not at all						*A lot*

8) It was easy generating several ideas on the category provided by the experimenter before moving on to the next one.

1	2	3	4	5	6	7
strongly disagree			*neither agree nor disagree*			*strongly agree*

APPENDIX C

ARC CALCULATION

ARC Calculation

$$ARC = \frac{R - E(R)}{maxR - E(R)}$$

$$E(R) = \frac{\sum (n_i)^2}{N - 1}$$

R = Number of observed category repetitions

E(R) = Expected number of category repetition due to chance

MaxR = Maximum number of category repetitions (N-K)

N = Total number of ideas generated

K = Number of categories surveyed

n_i = Number of ideas in category *i*

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BIOGRAPHICAL INFORMATION

The author is currently pursuing a Master's degree in Health Psychology and was a GRA for Dr. Paul B. Paulus for 2 years. She is currently researching group brainstorming and how different techniques can be applied to eradicate the productivity block that groups generally experience. She has a Bachelors of Arts degree in Psychology from the University of Texas at Arlington. She has been working on several different projects with Dr. Paul B. Paulus such as the studies that have been mentioned in this paper as well as other studies related to electronic brainstorming.