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The Effectiveness of Electronic Brainstorming In an Industrial Setting

An experiment was conducted comparing the effectiveness of individual versus group electronic brainstorming in order to address real world "wickedly difficult" challenges. While industrial reliance on electronic communications has become ubiquitous, empirical and theoretical understanding of the bounds of its effectiveness have been limited. Previous research using short-term, laboratory experiments have engaged small groups of students in answering questions irrelevant to an industrial setting. The current experiment extended current findings to larger groups of real-world employees addressing organization-relevant challenges over the course of four days. The data demonstrated that individuals performed at least as well as groups in producing quantity of ideas. However, when judged with respect to quality along three dimensions (originality, feasibility, and effectiveness), the individuals significantly ($p<0.05$) outperformed the group working together. The theoretical and applied implications of this finding are discussed.

INTRODUCTION

In today's highly dynamic and competitive world, it is essential that organizations generate novel ideas of high quality to develop or maintain their competitive advantages. Historically, one method of idea generation has been verbal brainstorming, a process where groups of individuals, typically in the same room, work to create and exchange ideas. Popular opinion holds that verbal brainstorming yields more (and better) ideas than the same number of individuals working alone would produce (Furnham, 2000; Guerin, 1986; Osborn, 1957). However, verbal brainstorming has been found to result in certain undesirable consequences (such as evaluation apprehension, production blocking and social loafing) when compared to individual, or nominal, brainstorming (Kerr & Tindale, 2004). To address some of these limitations, electronic brainstorming (EBS) has been proposed as an alternative. An EBS session consists of individuals interacting and exchanging ideas via a computer. While EBS has been shown superior to verbal brainstorming, the research comparing EBS to nominal brainstorming has produced rather mixed results with some research finding EBS superior to nominal groups (e.g., Paulus & Yang, 2000), some researchers finding nominal groups superior to EBS (e.g., Barki & Pinsonneault, 2001) and others finding no difference between the two groups (e.g., DeRosa, Smith & Hantula, 2007).

To date most of the research in this area has been performed in laboratory settings with college students brainstorming about industrially irrelevant topics, leaving generalizability to industrial applications unclear. There are several key differences that must be addressed in order to apply the existing research to an industrial setting. First, groups in typical industrial settings grapple with "wickedly difficult" problems and may be more inclined to assess the quality of ideas, rather than the quantity of ideas as is typical in the current literature. Second, most research has studied three- to four-person student groups, rather than larger work teams that leverage diverse skill and knowledge bases. Third, the current literature's brainstorming topics are not as meaningful to students as a "wicked" problem might be to a vested employee. Fourth, it is unclear how typical workplace scheduling demands might affect the outcome as results from short, one-time brainstorming sessions may not generalize to real-world situations where groups of individuals brainstorm over a period of time.

An experiment to investigate these issues was conducted at Sandia National Laboratories (SNL) in the summer of 2007. Specifically, this experiment explored the effectiveness of EBS within the industrial setting of a modern, national research laboratory. Over the course of four days, employees

and contractors at SNL voluntarily enrolled and contributed ideas in the web-based brainstorming experiment. The participants were randomly assigned to either group or nominal brainstorming conditions and were asked to work on a "wicked" problem proposed by SNL President Tom Hunter (termed "The Hunter Question"). Both the quantity and quality of ideas were assessed.

METHOD

Participants

Participants included 147 employees and contractors at SNL. Of those who signed up to participate, 69 employees actually contributed ideas. Thus, only these participants were included in analyses. All were volunteers.

Materials

The experiment took place on a website that was created and managed by the experimenters. The participants electronically signed the informed consent and electronically completed the demographic and satisfaction questionnaires.

Procedure

Participants were primarily recruited through an advertisement in the Sandia Daily News (an internal news source emailed daily to SNL employees) soliciting participants for the study at both SNL in Albuquerque, New Mexico and Livermore, California. In order to further increase recruitment, the experimenters also sent personal recruitment emails to SNL employees they knew requesting that they participate in the study. In addition, a link to information regarding the study was placed on the SNL intranet Homepage. All of the recruitment messages informed the employees that a study interested in electronic brainstorming was being conducted and would consist of brainstorming (either alone or in a group) via a website at least once a day for four days. Once the employees expressed interest in participating in the study, they were directed to a website which described the study in detail and informed the participants of what the experiment would entail. The website contained an informed consent that the participants were to read and (electronically) sign if they consented to participate. In addition, the participants created an anonymous userid and password to use for the duration of the experiment. Once they had signed the informed consent and created a userid and password, the participants filled out a demographic questionnaire. Finally, the participants were directed to a website in which they could submit ideas to the topic in question.

The participants were randomly divided into one of two groups: EBS or nominal brainstorming. All participants brainstormed ideas regarding the Hunter Question.

When the participants logged onto the website, the Hunter Question was displayed at the top of the screen and they were asked to input their ideas. Those in the nominal condition worked by themselves and did not see the ideas of other participants. Those in the EBS condition brainstormed with others and were able to see and build off of the ideas of the other members in the group. The responses in the EBS condition were all anonymous (i.e., it was not known who contributed what idea because all responses were tied solely to the anonymous userid that the participant generated). There were two reasons for this. The first reason was that anonymity in group brainstorming sessions has been known to reduce evaluation apprehension (e.g., Cooper, Gallupe, Pollard & Cadbsy, 1998). Second, by presenting the participants with the performance on their peers (because the participants were able to view which userid came up with which idea) they might be less likely to engage in social loafing (Karau & Williams, 1993; Roy, Gauvin & Limayem, 1996)

Participants in the EBS conditions were asked to adhere to the rules of brainstorming per Osborn (1957). In addition, the participants were told that abusive language and name calling would not be tolerated, and those who did not follow the rules would be locked out of the experiment.

At the end of the experiment, the participants were asked to fill out a Satisfaction Questionnaire (modeled after Dennis & Valacich, 1993). The questionnaire asked them several questions regarding their satisfaction with the experiment, along with their motivation and interest in the task.

RESULTS

In order to assess the effectiveness of the brainstorming sessions, we assessed the quantity and quality of the ideas provided. The quantity of unique ideas generated were summed for each group (the ideas for those in the nominal group were pooled and then compared to the EBS group) and we performed a repeated measures analysis of variance (ANOVA) on the number of ideas expressed on each of the days by research group membership (nominal or group). There was a significant effect for the number of ideas expressed on each day (Wilks' lambda, F (3, 65) = 2.784, p = .048, η_p^2 = .114) in which there was a larger number of ideas put forward on day one compared to the following three days. However, we found no significant difference in the number of ideas between the group and nominal conditions. In fact, absolute values favored the nominal condition (mean = 6.26, SD = 12.85) over the group condition (mean = 4.66, SD = 9.21).

In addition to quantity measures, responses were also examined for quality. In order to do this analysis, responses were summarized into general concepts representing each participant's answer to the Hunter question so as to minimize redundancy within each participant's individual entries. Responses unrelated to the question, like those addressing the website design, were not considered. Following the example of Barki and Pinsonneault (2001), the quality of ideas was scored according to originality, feasibility, and effectiveness. In this scoring scheme, *originality* referred to the extent to which the idea was novel, or out of the ordinary, *feasibility* referred to the extent to which the idea was precise and the ease with which it could be implemented, given the current context (including available financial resources, infrastructure, time required, legal issues, etc.), and *effectiveness* referred to the extent to which the idea helped to solve the given problem. Two raters were chosen due to their background and experience in operations management and industrial/organizational psychology. The raters independently scored the ideas on these qualities on a seven point Likert Scale with one corresponding to low evidence for the component and seven corresponding to high evidence for the component. The ratings were then averaged for each idea. Because we were interested in the most meaningful ideas, we evaluated maximum ratings rather than average ratings. Thus, if a participant received ratings of 3, 4, and 5 for a particular day, the maximum rating of 5 was used as that participant's dependent value. T-tests were conducted to independently evaluate originality, feasibility, and effectiveness. We found significant differences for all t-tests such that the nominal condition outperformed the group condition for originality (t = 3.69, p < .001), feasibility (t = 2.39, p = .02) and effectiveness (t = 2.65, p = .01).

We also compared the groups' responses to questions on the Satisfaction Questionnaire using a t-test. While we did not obtain a significant difference between the two groups (likely due to the small number of respondents), we did obtain the overall trend that has been established in the previous literature; that is, that the participants in the EBS group were generally more satisfied, motivated and interested in the brainstorming task than were those in the nominal condition (see Dennis & Valacich, 1993; Gallupe, Bastianutti & Cooper, 1991; Valacich, Dennis & Connolly, 1994).

DISCUSSION

Our primary empirical finding demonstrates that (at least for this interface design) nominal brainstorming is superior to group brainstorming. Although this superiority cannot be seen in the number of ideas generated by the groups, it can be seen in the quality of ideas. The quality of the ideas in the nominal condition was significantly better across all three quality ratings, including originality, feasibility, and effectiveness. Although these results are preliminary, they are potentially interesting for two reasons that will be discussed in turn. First, they demonstrate that employees may effectively use computer-mediated nominal brainstorming as a cost effective means to work on wickedly difficult problems. Second, they are a novel empirical finding suggesting that electronic group effectiveness may be mediated by group size.

The finding that individuals are more successful than groups in computer-mediated brainstorming suggests a time- and cost-savings potential for companies. Generally, when electronic group

brainstorming is compared to verbal brainstorming, it is touted as having the advantages of shorter meetings, increased participation by remote team members, better documentation via electronic recording, improved access to the meeting records and, importantly, cash savings (Furnham, 2000). When there is no longer the mandate that these electronic communications occur concurrently, these advantages would seem to be even greater. One might assume that participants in a nominal condition would require less time to contribute ideas as compared to those in a group condition where they would (ideally) read the other postings before giving their ideas. However, at least some of the submissions suggested that they were prepared offline and pasted into the web site forms. Thus an evaluation of the time savings in this experiment is not addressed. However, nominal brainstorming does allow for increased participation due to greater scheduling flexibility.

In sum, our data demonstrate that within the current industrial setting, nominal brainstorming was at least as effective as group brainstorming. This study is one of the first to our knowledge to empirically examine brainstorming within an industrial setting. Additionally, the current experiment is the first to extend brainstorming groups beyond the typical 3- or 4-person groups (occasionally 12-person) to large, 30-person groups. It is also the first to examine how a longer duration of 4 days affects results.

While our results demonstrate that nominal brainstorming is more effective than group brainstorming (at least in the quality of ideas), more research will be necessary in order to fully circumscribe the generalizability of this finding to other questions, interfaces, and industrial settings. Future research may compare different computer-mediated technologies, interfaces, and experimental manipulations. For example, a more wiki-like interface might allow users to build off of other people's ideas more easily than the interface used for the current experiment and, thus, outperform a nominal group. Another potential mitigation for large group brainstorming might also include having some kind of facilitator. As one of our participants suggested, "In a real world brainstorm it seems like there should be at least one person in charge with the ability to bring up additional points and keep the ideas flowing when they slow down as they did after the first 2 days here."

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