A FIELD EXPERIMENT ON THE EFFECT OF TASK DECOMPOSITION ON THE QUALITY OF DECISIONS IN A GROUP SUPPORT ENVIRONMENT

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ABSTRACT
The use of Group Support Systems has been researched repeatedly using many task-type. For brainstorming tasks the process support of the system have been restricted to ensuring member anonymity and allowing the simultaneous entry of ideas. Little work has been done investigating other process improvements for idea-generating groups. In this paper is investigated the effect on idea quality and quantity of decomposing a brainstorming task with a South African setting. Using Team Expert Choice, an Analytic Hierarchy Process (AHP) based group support system. An experiment was conducted with two groups. It was hypothesized that task decomposition will generate more and better quality ideas. The findings show that task decomposition resulted in 40% more ideas than no decomposition; the effect on decision quality is statistically significant only when decision quality is measured as the number of good ideas.

Keywords: Group Support Systems, AHP, Decision making, Brainstorming.

INTRODUCTION

The moderators influencing the effect of Group Support Systems (GSS) use can be grouped into five categories: the group task, the GSS tool technology, the composition of the group, the size of the group and the effect of facilitation in the group process (Fjermestad and Hiltz ,1998-1999; Dennis and Wixom, 2001-2002). Apart from these and other meta-level studies of GSS most of the experimental research published in the literature has focused on one category of factors. The first of the above categories has already been widely researched but it is still important because of its relationship to the broader open field of problem solving. Some researchers have investigated task type, task complexity, degree of task rationality or clarity and task externalizability. Problem exploration has not however been given sufficient attention both in research and in practice by problem-solving groups, thereby increasing the "likelihood that they (groups) will solve the wrong problem or choose an inappropriate or low quality solution" (Huber, 1984). In spite of some techniques aiming to alleviate this danger (see Rosenhead, 1989), the statement by Huber still seems to be valid today.

The paper deals with the impact of task structuring on the effectiveness of a group using GSS. The latter is a component of a broader definition of the performance of a group using GSS, involving three major factors: (1) effectiveness as defined by decision quality and number of ideas generated, (2) efficiency as defined by the time to complete the task, and (3) participants' satisfaction with the process or outcomes (Benbasat and Lim,1993; Dennis and Wixom, 2001).

A group's task can be defined as the behavior requirements for accomplishing stated goals, via some process, using given information (Zigurs and Buckland, 1998). The same authors propose a theory of task-technology fit based on concepts of task complexity and GSS characteristics. Zigurs and Buckland (1998) and Campbell (1988) distinguish five types of tasks: simple tasks, problem tasks, decision taks, judgment tasks, and fuzzy tasks. Another often quoted classification of tasks is the task circumplex suggested by McGrath (1984), containing four categories. Two of them have been commonly used in GSS research: generation tasks and decision making tasks (Dennis and Wixom, 2001-2002). According to the same authors, generation tasks are additive tasks, in that the outputs of individual participants are combined to form the team output. Members need not select among ideas nor come to a consensus on a shared understanding. Decision making tasks in contrast require participants to develop a shared understanding of criteria and alternatives and reach a consensus on which alternative is best. Fjermestad and Hiltz (1998-1999) found that GSS provide a greater proportion of positive effects to negative effects for idea generation across a wide array of outcome variables. Hence this research will consider task structuring in a generation task, involving brainstorming.

The idea that interacting brainstorming groups tend to produce larger numbers of ideas has been traditionally well received. This idea is premised on the perception that within groups, members hear other people's ideas, ideas they would not have otherwise thought of themselves. They then build on these ideas generating more ideas. As a result, brainstorming groups are expected to be more productive than individuals working alone or as a collective of non-interacting individuals. In principle, brainstorming (Osborn, 1957) requires members to initially state as many ideas as possible; this includes improving on or merging previously stated ideas. The most important dynamic at this stage is the suspension of all judgment (Gallupe et al. 1991) *vis a vis* the goodness of the generated ideas.

The inherent nature of the brainstorming activity is opportune for generating *mis-hits.* This is particularly true during the phase requiring the suspension of judgment (evaluation of generated ideas). How do we then enhance the productivity of brainstorming groups, that is, reduce *mis-hits* and simultaneously adhere to the principle of suspended judgment? This is an important problem for brainstorming groups and one justification for this research.

Dennis et al (1996) and Dennis et al (1999) explore the relationship between task structuring and problem solving effectiveness within an electronic brainstorming environment. To the best of the authors' knowledge, task structuring has only been in those two papers. Another justification for this paper was the suggestion by Dennis and Wixom (2001-2002) that the next step for GSS researchers trying to extend the common body of knowledge and for practitioners seeking to apply research appropriately is to look deeper than the overall effects of GSS use. This paper seeks to empirically test the propositions expounded in Dennis et al (1996) and Dennis et al (1999) using a different type of problem, technology and within a different socio-cultural environment and to enhance the understanding of the role of task structuring for brainstorming groups.

The contribution of this paper is that it presents results testing the effects of task-decomposition in a culturally and technologically different setting from that used by Dennis et al. (1996) and Dennis et al. (1999). We use Team Expert Choice^{R}, an Analytic Hierarchy Process (AHP) based GSS which has not been used before in the GSS published research to the best of the knowledge of the author. The exploratory experiment involved post-graduate Information Systems students from a non-American university. The significance of this study's results is the empirical testing of existing theory under a substantially different set of initial conditions from those of previously published research. In addition some conclusions about the appropriateness of the indicators for idea quality, as published in the literature, were formulated in the process of interpretation of our results. These can be used for improvement of the practical use of GSS. Finally our results lead to a new theoretical proposition about the effect of decomposed task formulation on the holistic perception of the problem as subcategories of the task are explored in sequence. Though the latter needs further empirical proof, it seems that it can be a plausible line of further research for the improvement of GSS practice when the problems require a holistic solution.

The approach taken here is as follows: theoretical and prior research informing this study is outlined, an exploratory empirical investigation is conducted with an experimental and a control group of postgraduate students from the University of Natal, South Africa. Two theoretical propositions are formulated and tested. A third proposition is suggested as a result of our investigation and a conclusion about the relevance and the comparisons of our results with previously published ones is presented. The rest of the paper consists of a section containing a brief overview of previous GSS research informing this study, followed by a section showing the design of the experiment, the results and their interpretation, followed by the conclusion on the research, including its limitations to our study and possible directions for future work.

THEORETICAL ISSUES INFORMING THIS GSS RESEARCH

Problem structuring and the cognitive phenomena related to the individual decision maker

Group brainstorming is influenced by both cognitive phenomena and social or group phenomena (Nagasundaram and Dennis, 1993). Social phenomena have dominated research even though cognitive factors are important (Dennis et al. 1996). The theory on human cognitive phenomena suggests that when presented with an all-encompassing problem, individuals will produce a set of related ideas focusing on only a small set of problem subcategories (see Dennis et al.(1996); Anderson (1987)).

The **cognitive phenomena** are related to the production rules that control cognitive behavior through the specification of cognition steps that produce ideas when activated. These rules are activated automatically by input stimuli without human conscious control (Dennis, et al., 1996). So for instance, for any given stimulus, there are several rules that can be activated, but the rules that are more closely related to the stimuli (and to each other) are most likely to be activated. These closely related rules are likely to lead to the production of closely related ideas. Thus, each individual is likely to produce a set of closely related ideas (Dennis et al., 1996; Anderson, 1987). To that extent, individuals presented with an all-encompassing problem would tend to focus only on a small fraction of the potential solution space while believing themselves to have produced a comprehensive set of solutions (Dennis et al., 1996; Connolly et al., 1993, Gettys et al., 1987). They explore a few related sub-categories in depth rather than contemplate a broader range of sub-categories of the overall problem. "The result is that individual problem solving often misses key solution opportunities because of this narrow focus" (Dennis et al. 1996: 269).

Problem structuring, the activity of identifying the relevant variables in a problem situation and the important relationships among those variables (Pitz et al., 1980) is seen as closely related to "act generation" which is the process of generating actions that might solve ill-defined decision problems. Because problem structuring occurs in the early stages of problem solving, it has considerable effects on the direction and fruition of the succeeding stages (Mintzberg et al., 1976). Although there are many examples that show that incorrectly defined problems can lead to problem solving ineffectiveness and significant monetary losses (Jennings and Wattam, 1994), decision makers as well as analysts seldom use problem-structuring strategies (Bell, 1982). There are various problem structuring techniques: *expansionist* and *reductionist* (Volkema, 1983), *divergent* and *convergent* heuristics (Abualsamh et al., 1990), *soft (alternative) Operations Research* (Rosenhead, 1989). Studies have shown that divergent approaches to problem structuring are most effective (Jennings and Wattam, 1994) whereas convergent approaches to problem structuring are most efficient (Maier, 1970; Abualsamh et al., 1990) and are associated with the straight-line application of standard knowledge.

An individual's ability to structure a problem is largely dependent on and limited by his or her cognitive abilities. Since solutions are based on individual conceptualization, the ability to solve problems depends on how well the problem structure is conceptualized (Loy, 1991). If the conceptualization of the problem structure is wrong or incomplete the decision maker will fail to solve the right problem (Loy, 1991). There is a need to develop problem-structuring tools given our understanding of the mental abilities and processes involved in human problem solving to support problem representation and problem formulation processes.

Problem structuring techniques that attempt to change the individual's focus on the problem, either by decomposing it into subcategories or expanding it into a higher level problem are possible structuring solutions (Volkema, 1983 and Dennis et al., 1996). Volkema (1983) presents some evidence that problem decomposition can improve the number of solutions identified. Breaking a problem into a set of subcategories, which are in turn considered separately, encourages individuals to devote their attention to the entire set of categories more evenly thereby improving performance (Pitz et al., 1980; Dennis et al., 1996; Dennis et al., 1999). According to Samson (1988) even a moderate amount of decomposition should lead to better performance.

Problem structuring and the nature of the task

It is intuitively appealing that the nature of the task will have some effect on structuring efforts; and that some cognitive skills and personalized decision styles would be better matched to certain kinds of tasks while other skills more appropriate for different types of tasks (Keen and Scott-Morton, 1978). One open question is what are the cognitive abilities that a computer-based solution should seek to enhance when supporting generative tasks? Another challenging question is about the appropriateness of the traditional measures of the effectiveness of an electronic brainstorming support system?

As mentioned earlier the effectiveness of GSS usage can be defined by decision quality or the number of ideas generated (Dennis and Wixom, 2001-2002). According to the same authors the primary measure of performance to be used is influenced by the fact whether the task is of idea generation or decision making type. The former focuses primarily on the number of ideas produced per some period of time, while the latter primarily focuses on decision quality and time. This statement is somewhat contradictory to the findings of Hwang (1998) but she is not inferring about the primary measure of performance associated with a given task type. According to Hwang's work, also a meta-analysis of GSS literature, there are two variables that GSS can affect in generative tasks: *decision quality* and *decision time* (Hwang, 1998). The number of ideas generated is not mentioned by her. However, the effects of GSS on *participation* and *member satisfaction* are still unclear (Hwang, 1998). Therefore, formulating hypotheses about the effects of GSS involving the latter variables was considered not appropriate for the purposes of this study. It was decided to adhere to the more widely accepted measures of effectiveness in GSS usage, involving the number of ideas generated and their quality following Dennis et al. (1996) and Dennis et al. (1999), which are valid as a whole for both generative and decision making tasks.

Problem structuring and group phenomena

Groups tend to suffer from cognitive inertia, a phenomenon that is similar to individual cognitive limitation. As groups interact, they may consciously or unconsciously adopt behavioral norms or structures. These norms can constrain behavior (Giddens, 1984). One of the norms typically observed in groups is not "changing the subject" (Lamm and Trommsdorff, 1973). Members may think of subject unrelated ideas but it becomes socially undesirable to contribute these ideas to the discussion. This behavior has been identified within electronic brainstorming groups too and is associated with the generation of fewer ideas (Dennis and Valacich, 1994; Dennis et al., 1996) and a focus on a limited line of thought or single subcategory of a task.

Groups are partly formed to provide a diversity of approaches to problem solving thus contending with the potential narrowness of any one individual's perception and cognitive limitations. However, group cognitive inertia can in turn restrict the group effect. Effective problem structuring in a group environment must employ methods that are effective for both the individual as well as the group. Problem decomposition recommends itself for these purposes (Dennis et al., 1996).

There are risks associated with using task structuring. Dennis et al. (1999) found that the subjects in the single intact-question treatment were more likely to produce ideas that fell outside of the three pre-defined main categories, relevant to their problem. They conclude that one risk of problem structuring is that the decomposition of the task may not completely cover the problem space; it may miss important subcategories (Dennis et al., 1999). A second risk is that it may be more difficult to create good, holistic solutions without considering all subcategories of the task simultaneously. For instance, the ideas developed when focusing on one subcategory may violate constraints imposed by the requirements of another subcategory thus compromising the overall usefulness of the solution (Campbell, 1988; Dennis et al., 1999). These two risks are important in validating the effectiveness of problem decomposition. They need to be investigated by further research, which is another justification for this research. The next section presents the outcomes of an exploratory experiment whose parameters were influenced by the research reviewed here.

Summary of prior research on factors affecting brainstorming

Prior research supports three factors that affect interacting brainstorming groups: *cognitive factors*,*social factors* and *time effects*. Research on the three factors suggests that presenting a group with a single intact problem question should produce fewer ideas than presenting a group with a series of questions, with each question focusing on one subcategory of the total problem (Dennis et al., 1996; Dennis et al., 1999). In the first instance, *cognitive factors* are believed to encourage individuals to focus only on a few subcategories of the problem, thereby overlooking other factors. Secondly, *social factors* within the group are believed to encourage group members to work on the same area of the problem rather than explore the problem from multiple angles all at the same time. Research on *time effects* suggests that when presented with a series of shorter time intervals (as opposed to one single large time interval) individuals may perceive the time constraints. The perception of time constraints would cause the group to work faster.

THE EXPERIMENT AND DISCUSSION OF THE RESULTS

The control group was presented the problem as a single, all-encompassing problem. The treatment group was given the same problem broken in two distinct categories. In addition, the second group was given fixed and shorter time slots to generate ideas for each category of the problem to ensure that the total amount of time spent solving the problem was the same for both groups. The design of the experiment was based on the papers by Dennis et al. (1996) and Dennis et al. (1999).

Hypothesis formulation

Dennis et al. (1996) found that problem structuring had no effect on the subjects' satisfaction or perceived effectiveness. The investigation by Dennis et al. (1999) explored in addition the effect of problem structuring on the time necessary to accomplish the task and found no significant time effects. For these reasons and for the purpose of simplifying the experiment in this research we did not consider the efficiency as defined by the time to complete the task and the participants' satisfaction as dimensions of performance in GSS usage. Dennis et al. (1999) conclude that the contribution to performance is due to task structure and not time structure.

We postulate that task decomposition will result in a larger quantity of ideas. Further we postulate that task decomposition should also result in a higher quality of ideas.

Stated formally, two propositions are made:

Proposition 1: The decomposed-task formulation will stimulate groups to produce more unique ideas than the intact- task formulation.

Proposition 2: *The decomposed-task formulation will stimulate groups to produce ideas of higher quality than the intact-task formulation.*

As mentioned in the introduction, this research is different from the one by Dennis et al. (1996) and Dennis et al (1999) in terms of the technology used and the cultural background of the participants. It can be stated that similarity in the conclusions from the above papers and this research would mean that these two factors have no influence on the impact of task structuring on the effectiveness of the GSS usage.

Profile of the subjects

The subjects were from the Information Systems (IS) Honors class at the University of Natal Pietermaritzburg, South Africa, which is a postgraduate degree needed as a prerequisite to a Masters degree in South Africa. They participated in the experiments as part of the requirements of their Decision Support Systems module. The group was familiar with Systems Analysis and Design issues and IS Methodologies to the extent that these were covered both in their undergraduate years and at Honours level. Nonetheless the task was simplified on purpose to ensure that no memorized knowledge was required to answer the question (Haines and Amabile, 1988). All the participants were familiar with the Team Expert Choice GSS environment.

The group

The group was divided into two groups of six members each. The division was random. The group size in this study is comparable to the typical group sizes studied in GSS research (e.g. see Fjermestad and Hiltz, 1998-1999).

The role of the facilitator

The author acted as a facilitator for both sessions. The facilitator's role was limited to explaining the task, clarifying the objective of the sessions, explaining the principles of brainstorming and how the Team Expert Choice brainstorming module works. She was responsible for administering the process in terms of time and responding to any procedural questions. The facilitator did not arbitrate on idea disagreements between group members..

A description of the technology

The experiment was run on a client-server environment and Team Expert Choice as the Electronic Brainstorming (EBS) application software. Each group member was assigned an individual desktop PC, connected to the Local Area Network (LAN). The facilitator used a separate PC to administer and manage the group process. A group screen was not necessary and therefore was not used. The software manages and delivers a "group view" to each PC when required.

Team Expert Choice fully supports *anonymity*, and the parallel entry of ideas by participants. Subjects were made aware of these features. Both sets of subjects also understood that ideas could be attributed to their originators although the participants were not given the rights to do so (only the facilitator possessed this right). Team Expert Choice also supports the generation of ideas by category. This feature was used for the decomposed task. The latter as well as the voting and multi criteria decision making capabilities of Team Expert Choice make it comparable as a whole to level 2 GSS technology. Level 1 support includes two components: parallelism and anonymity, while level 2 tools provide also information analysis tools (Dennis and Wixom, 2001-2002). According to the same authors, Group Systems.Com software includes level 2 tools. It can be concluded that apart from the AHP features of Team Expert Choice, its other parameters are comparable to those in Group Systems.Com software, used by Dennis et al. (1996) and Dennis et al (1999).

The Task.

The experimental task was extracted from a Systems Analysis and Design textbook case study (O' Brien, 1992). We heeded Haines and Amabile's (1988) suggestion that for the purpose of designing *creativity experimentation tasks* the experimenter should decrease the potential for response bias by using tasks requiring no specific (added) knowledge or training.

The subjects were requested to raise ideas which would relate to the design a system that would support the business imperatives facing a fictitious retail company (Fields Cookies). The retail company, described as a medium sized chain of biscuit stores, which employs managers whose *commitment* levels to customer service concerns are high but whose *compliance* with business, financial and administrative procedures are weak. The case purports that the company employed the current team of store managers at a time when customer service was critical to the survival of the company. The case study also points out that it was mainly through sheer personality traits that the managers were able to craft high commitment to customer service. Compliance with procedures has progressively weakened with their tenure. The company therefore seeks to implement a system to support compliance to the financial and administrative procedures and provide support for commitment to customer-service. The imperative is to maximize the balance between the *compliance-commitment* dichotomy of its store managers' abilities given procedural objectives and constraints.

In this experiment, the control group was presented with a single, intact problem question. The subjects were required to consider the facts of the business and identify the requisite support system features. The task was deliberately presented so that the functional areas of a business entity were outlined explicitly so participants did not have to remember this information. The all-encompassing, intact question was phrased as follows:

> *"What characteristics and components should the Fields Cookies business system have to support and enhance managers' **commitment** to customer service; plus support and enforce **compliance** to sound business practices in the administrative-financial aspects of running the business?"*

The intact question and the decomposed questions were formulated so that they were consistent in terms of writing style and scope. Thus, the decomposition was constructed into two subcategories, as shown below:

i. *"What characteristics and components should the Fields Cookies business system have to support and enhance managers' **commitment** to customer service?"*

ii. *"What characteristics and components should the Fields Cookies business system have to support and enforce compliance to sound business practices in the administrative-financial aspects of running the business?"*

Treatment

Both groups were given fifteen minutes to read, understand the task and clarify any questions with the facilitator regarding what the task entailed and what was expected of the group.

The control group was given 40 minutes to generate idea solutions using Team Expert Choice. The forty-minute session was split into two sessions. In the first 20 minutes, the members of the group were instructed to anonymously enter their ideas into the system without any verbal communication and without "posting" their ideas to the central database representing group memory. During this period, verbal communication was limited to clarifying individuals' understanding of the task, where this was still required. At this initial stage, no single group member was aware of what the other group members' ideas were. All individual ideas were saved onto the individual client PC's.

At the end of the first 20 minutes group members were requested to "post" their individual ideas to the central database to be immediately visible to all. Members could then discuss the contributions of other members and enter more ideas arising from the discussion and or the group database. At this stage, subjects "posted" their entries immediately upon entering them. This part of the session also lasted 20 minutes.

The treatment group was given 20 minutes to fully explore each question. Each 20-minute session was divided into two sessions of ten minutes each. The participants were instructed to silently brainstorm for the first 10 minutes of the session (on just the one question).

Similarly, once the first ten minutes had lapsed, members "posted" their ideas to the group database and the session was opened for participants to view or add to other group members' contributions on that single question. The interactive session took ten minutes thus completing the required twenty minutes for the first subcategory. The second subcategory question was then introduced and treated in the same way as the first. This group was not allowed to review the first subcategory while brainstorming on the second subcategory.

Measures of performance

Two dependent variables, the *number of unique ideas* and the *quality of ideas* were defined. The generated ideas were grouped by subcategory: support for commitment and support for compliance activities.

A transcript of the generated ideas from both treatment groups was given to an expert judge, who was blind to the treatment of the groups. The expert judge eliminated all redundant ideas within each treatment group's solution-space and grouped the generated unique ideas by category i.e. commitment vs. compliance support, applying the following measures of performance, based on (Dennis et al., 1996):

The **quantity** variable was defined as the *total number of unique ideas.*

The **quality** variable was represented through three indicators defined at the end of the paper:

- *Total quality;*
- *Mean quality;*
- *The total number of good ideas;*

We also looked at the total number of good ideas by category when analyzing the results of the treatment group. A scale of 1 to 5, 1 meaning very poor, and 5 meaning very good, was used to rate the quality of each idea.

Analysis and results of the experiment

Table 1 below shows that the treatment group generated more unique ideas. The group generated 38.5% more unique ideas than the control group. They also generated 40% more *good ideas* and their *total quality* index is 32.6% higher than the control group's total quality index. However the *mean quality* index from the control group is 9.6% higher than treatment group's *mean quality* index.

Table 1. Summary results for the defined variables

	Control Group		Treatment Group		Difference
	No.	**%**	**No.**	**%**	**%**
Total number of unique ideas	32		52		38.5
Total quality (index)	124		184		32.6
Mean quality	3.88		3.54		-9.6
Number of good ideas	27	84.3	45	86.5	40.0

The statistical effect of task structuring on the quantity and quality of generated ideas

Statistically we make the assumption that the population distribution is normal and that the sample variances are equal. We tested our assumption of equal variances by doing the test for the homogeneity of two variables (Alder and Roessler, 1977:314; Pollard, 1977). The test showed that the differences in the variances of the two data sets are not significant. We used further the t-test for two independent samples to verify our two propositions defined above. That is discussed below.

Let X denote the intact-task control group and Y the decomposed-task treatment group with arithmetic means m_x and m_y respectively. For the null hypothesis H_0 we test whether the mean number of ideas in the control group (X) is significantly higher than the mean number of ideas in the decomposed-task treatment group (Y) and define the alternative hypothesis, H_1 below.

$$H_o: m_x \geq m_y$$
$$H_1: m_x < m_y$$

(where m_x and m_y define the means of the X and Y data sets respectively – see Table 2 for the descriptive statistics).

The test is for the inequality of the two means so the critical region is less than the lower 5 percent of the t-distribution with 10 degrees of freedom (Pollard, 1977:160). The corresponding critical value of *t* at the 5% level of significance is equal to **–1.812** (Pollard, 1977). Table 2 shows a summary of the testing of the hypothesis for the two propositions (the second one being tested for the three indicators)

Table 2. Statistical outcomes values on the variables, quantity, quality (three measures)

Variable	t-statistic	Null hypothesis test outcome
Quantity of ideas	-1.95	Reject H_o
Quality: *total quality*	-1.412	Fail to reject H_o
Quality: *mean quality*	0.830	Fail to reject H_o
Quality: *number of good ideas*	-1.931	Reject H_o

The results shown in Table 2 show that we can reject the null hypothesis in favor of the alternative hypothesis for the first proposition, that is, task decomposition did result in a significantly larger *number of unique ideas* than no decomposition at the 5% level of confidence.

Similarly, Table 2 shows that the testing the null hypothesis for the second proposition on the third dimension of the quality variable, *number of good ideas* lead to its rejection and the acceptance of the fact that task decomposition lead to higher number of good ideas at the 5% level of confidence. However the results here are inconclusive. For two of the three quality measures (*total quality* and *mean quality*) we failed to reject the null hypothesis at the 0.05 level of significance and therefore the data do not contradict the null hypothesis for those measures.

The obtained results do compare nonetheless favorably with the work of Dennis et al. (1996) and Dennis et al. (1999) in terms that the decomposition of the task lead to a greater number of unique ideas. Dennis et al. (1996) also found no statistically significant differences in the *mean quality* of ideas as a result of task decomposition in their experiments. Therefore it can be concluded that the different technology and cultural background of the participants in our research do not play a significant role in the results of the hypotheses on the two propositions.

The distribution of ideas across subcategories

The task had two delineated subcategories: *commitment* and *compliance* support. During the analysis a third subcategory emerged, which addressed the question from a more holistic view, a *both* category. An example of a *both* category idea taken from the decomposed-task treatment group is:

> *"Provide a simulation of customer buying habits to determine the future stock levels, to always provide what the customer wants and when."*

Knowledge about time-related customer buying habits can help improve customer service (*commitment* support). It can simultaneously be used to implement stock control measures by setting stock holdings and re-order points (*compliance* to business procedures).

Table 3. Analysis of the number of ideas generated by sub-category

	Intact Task		**Decomposed Task**		**Difference**
	No.	%	**No.**	%	%
Total Number of Unique Ideas by subcategory:	**32**	**100**	**52**	**100**	**35.8**
Commitment	2	6.3	8	15.4	75.0
Compliance	23	71.9	13	25.0	(43.5)
Both	7	21.9	31	59.6	77.4

The (intact-task) control group interpreted the task to relate predominantly to one subcategory of the problem. 72% of the *total number of ideas* generated related to *compliance* support measures. Only 6% related to the *commitment* support and only 22% could be interpreted as applicable to the *both* category (see Table 3). Two factors may have contributed to this group exploring only a single line of thought. The first is members' individual cognitive behavior; the second is (group) social norms that inhibit the contribution of ideas that are not related to the subject being discussed.

Following the findings of Dennis et al (1996), we had expected the control group to view the problem more holistically because they were presented with a complete problem. The results in our experiment demonstrate the converse however. On the other hand, we had anticipated that the decomposed-task treatment group would be more inclined to view the problem in localized chunks and that their idea contributions would be more evenly spread between the two delineated subcategories. These two expected conditions preclude a holistic solution.

Yet, Table 3 shows nearly 60% of the ideas by the decomposed task group fall into the *both* category, 25% are *compliance* support ideas and 15% are *commitment* support ideas. Furthermore, additional results on the three dimensions of quality of ideas for the three categories generated by the task decomposition group (not shown here for space reasons as well as the primary data for each member of both groups) the ideas falling into the *both* category were generally of higher quality: the *total quality* index is 115 (versus 184 for all unique ideas under the three categories, generated by this group), a contribution of 63% to the overall *total quality.* In addition, the *mean quality index* is higher at 3.71 (versus 3.54 for the entire solution space for the treatment group)**.**

Discussion of the experimental results and some facilitator observations

This section contains a general discussion and some observations that were made by the facilitator. We report the observations because, even though they were not subjected to rigorous statistical testing and validation with many groups of participants, they provide us with exploratory results regarding the effect of the decomposition of tasks in contrast to groups tackling an intact-task. These observations encourage us to investigate task decomposition further.

Both groups were given equal opportunity to interact initially only electronically and subsequently also verbally. The facilitator observed relatively less verbalized interaction in the control group. Members were content to interact through the group support system. On the other hand, the multiple-question group made use of the opportunity to verbally interact. This is especially true for the second session when the group was brainstorming on the second subcategory. It was as if presenting the second question had made the members ask themselves, "how is this different from the previous question? What problem are we trying to solve? Are we correctly answering this question? Did we answer the previous question?" By asking each other questions, some members realized that they had perhaps misunderstood the current question(s). There was a flurry of additions and modifications to the already captured ideas (for the second session only). Gauging by the output ideas, we know the control group had relatively similar misunderstandings about the question, but no effort was made to correct this. We speculate that task decomposition induced task clarity. Additional research is required to systematically test the effects of task decomposition on *evaluation apprehension*, *groupthink and group cohesion*.

It was noted earlier that there are two risks to decomposition: an incomplete structure and the inability to see the whole picture and its corresponding inter-related constraints (and opportunities) Our findings suggest that task decomposition appears to instill a better understanding of the problem as a whole especially as the group progressively tackles the subsequent subcategories. Fifty percent of the ideas generated by the treatment group during the second session were of the *both* type and no "off target" ideas (*mis-hits)* were observed during this time. Ultimately, this group produced more holistic idea solutions than the control group.

Finally, although we did not test for time-effects, the facilitator observed the *intact-task* control group appeared to have run out of ideas in the last ten minutes of the session judging from the fact that all but two members had stopped inputting ideas into the GSS. The multiple-question group complained about not having enough time to complete the task. These complaints were also articulated in the answers to the post-session questionnaire (not discussed here in detail).

CONCLUSION

In comparing the results between the two groups, it was concluded that the decomposed-task treatment group outperforms the intact-task control group overall and by category in terms of quantity of ideas generated. Task decomposition led to nearly 40% more unique ideas. Our results are consistent with the findings of Dennis et al. (1999).

The findings on the testing of the proposition about idea *quality* were ambiguous. The data about two of the three measures of quality (*total quality* and *mean quality*) showed that there was not enough evidence to reject the null hypothesis at the 0.05 significance level and accept that task decomposition leads to greater total quality and greater mean quality of ideas. Whereas with respect to *number of good ideas* we proved the hypothesis that task decomposition results in higher number of good ideas. Even though this result is consistent with the studies of Dennis et al. (1996) and Dennis et al. (1999), it poses some questions about (a) the understanding of the appropriate quality measure and (b) the conditions under which each measure is appropriately used. These are discussed below.

The purpose of empirical research is to test, verify and build on existing theory. This includes assessing the operationalization of the constructs entailed in our theories. Empirical findings should help guide future researchers on what measures to use and under what conditions.

There are various reasons why groups brainstorm, e.g. to get group buy-in to the proposed solution. Usually groups brainstorm in recognition of the fact that a solution arising out of the process should be superior to one generated by any single individual or even groups of individuals working nominally. Rewarding bad ideas in this context appears inconsistent with the main objective. Yet, that is precisely what the *mean quality* index does; the *total quality* measure does the same although to a lesser degree; *number of good ideas* rewards groups for all their ideas except the poor and very poor ones. The latter measure is functionally more useful for brainstorming tasks. The above conclusion provides another justification of the importance of the third measure for quality of ideas: number of good ideas. This is in addition to the statistical results obtained here and by Dennis et al. (1996) and Dennis et al.(1999).

Contrary to expectation the decomposed-task treatment group generated significantly more holistic ideas in general (these correspond to the *both* category, 60% of the total number of unique ideas according to Table 3) and more than the control group. We cannot say conclusively why this was so. But this is a significant problem because ideas and solutions may be plentiful and good but they may be irrelevant if the problem requires a holistic solution that accounts for the inter-relationships between the sub-categories of a task Thus, we suggest a third proposition that needs to be investigated in further studies:

Proposition 3: *The decomposed-task formulation will result in a more holistic perception of the problem as subcategories of the tasks are solved in (increasing) sequence.*

The suggested proposition begs the question, how many subcategories are too many, when do diminishing returns start to set in? Only further research can address these issues. For now, we can conclude that the idea quantity effects of task-decomposition cannot be ignored. Our results are significant because in contrast to prior similar research we employed a different GSS environment in a different country. The consistency of our exploratory results with previous research provides evidence that the effects of task decomposition on the effectiveness of GSS usage cannot be deemed technologically or culturally specific.

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REFERENCES

Abualsamh, R. A., Carlin B. and McDaniel, R. R. Jr. "Problem Structuring Heuristics in Strategic Decision Making", *Organizational Behavior and Human Decision Processes* (45), 1990, pp. 159-174.

Anderson, J. R., Skill Acquisition: Compilation of Weak Method Problem Solutions, *Psychological Review* (92), 1987, pp. 192-210.

Campbell, D. J., (1988). Task Complexity: A Review and Analysis, *Academy of Management Review*, 13, 40-52.

Connolly, T., Routhieaux, R. L., and Schneider, S. K., (1993). On the Effectiveness of Group Brainstorming: Test of the Underlying Cognitive Mechanism, *Small Group Research*, 24, 490-503.

Dennis, A. R., Valacich, J. S., Connolly T., and Wynne, B. E., (1996). Process Structuring in Electronic Brainstorming, *Information Systems Research*, 7(2), 268-277.

Dennis, A. R., Aronson, J. E., Heninger, W. G., and Walker, E. D. (1999). Structuring Time and Task in Electronic Brainstorming, MIS Quarterly, 23(1), 95-108

Dennis, A.R. and Wixon, B.H. "Investigating the moderators of the group support systems use with meta analysis" *Journal of Management Information Systems* (18:3), Winter 2001-2002, pp. 235-257.

Fjermestad, J. and Hiltz, S,R. "An Assessment of Group Support Systems Experimental Research: Methodology and Results" *Journal of Management Information Systems,* (15-3), Winter 1998-1999, pp. 7-149.

Gettys, C. F., Pliske, R. M., Manning, C. and Casey, J. T., (1987). An Evaluation of Human Act Generation Performance*, Organizational Behavior and Human Decision Processes*, 39,23-31.

Giddens, A., (1984). *The Constitution of Society: Outline of the Theory of Structure*, University of California Press Berkeley, CA

Haines, B. and Amabile, T., (1988). The Conditions of Creativity, in R. Sternberg (ed.), *The Nature of Creativity: Contemporary Psychological Perspectives*, Cambridge University Press, Cambridge, MA, 11-38.

Huber, G. P., (1984). Issues in the Design of Group Decision Support Systems, in *MIS Quarterly*, September: 195-204.

Hwang, M., (1998). Did Task Type Matter in the Use of Decision Room GSS? A Critical Review and a Meta- analysis, *Omega International Journal of Management Science*, 26(1), 1-15.

Jennings, D. and Wattam, S. (1994). *Decision Making An Integrated Approach*, Pitman Publishing, Long Acre London

Keen, P. G. W., and Scott Morton, M. S. (1978). *Decision Support Systems: An Organizational Perspective*, Addison-Wesley Publishing Co., Reading.

Lamm, H. and Trommsdorff, G., (1973). Group Versus Individual Performance on Tasks Requiring Ideational Proficiency (Brainstorming): A Review, *European Journal of Social Psychology,* 361-387

Loy, S. L., (1991). The Interaction Effects Between General Thinking Skills an Interactive Graphics-Based DSS to Support Problem Structuring, *Decision Sciences*, 22, 846-868.

Maier, N.R.F., (1970). *Problem Solving and Creativity*, Brooks Cole, California.

Mintzberg, H., Raissinghani, D. and Theoret, A., (1976). The Structure of "Unstructured" Decision Processes, *Administrative Science Quarterly,* June, 246-275.

Nagasundaram, M. and Dennis, A. R., (1993). When a Group is not a Group: The Cognitive Foundation of Group Idea Generation, *Small Group Research*, 24,463-489.

O'Brien, B. (1995*). Information Management Systems – Briefings and Critical Thinking*, Pitman Publishing, Long Acre, London.

Osborn, A. F., (1957). *Applied Imagination* (rev. ed), Scribner, New York

Pitz, G. F., Sachs, J. N. and Heerboth, J., (1980). Procedures for Eliciting Choices in the Analysis of Individual Decisions, *Organizational Behavior and Human Performance*, 26, 396-408.

Pollard, J.H. (1977). *A Handbook of Numerical and Statistical Techniques,* Cambridge University Press.

Rosenhead, J. *Rational Analysis for a Problematic World,* John W*iley* & Sons, Chichester, 1989.

Samson D. *Managerial Decision Analysis,* Irwin, Homewood, IL, 1988.

Volkema, R .J. (1983). Problem Formulation in Planning and Design, *Management Science*, 29, 639-652.

Zigurs, L. and Buckland, B. "A Theory of Task-Technology Fit and Group Support Systems Effectiveness" *MIS Quarterly* (22-2), 1998, pp. 313-334.

APPENDIX – DEFINITIONS OF THE MEASURES OF QUALITY OF IDEAS

Total Quality is the sum of all quality scores for each unique idea generated by a group. This measure rewards groups for all ideas generated including very poor ones. Total quality according to Dennis et al. (1996) has proven to be the **most reliable** measure across most studies.

Mean Quality measures the average quality of ideas generated by a group. It is the total quality score divided by the number of ideas. This measurement is biased towards groups that generate a minimum of high quality ideas and against groups that generate some poor quality ideas. For instance, a group that generates one high quality idea (score = 5) would have a mean score of 5. Whereas a group that generated 3 high quality ideas (score = 5) and 3 neutral ideas (score = 3) would have a mean score of 3. Mean quality according to Dennis et al. (1996) has been **most unreliable** across studies.

The Total Number of Good Ideas, that is ideas scoring at three or above on the defined five point scale. This measure tries to strike a balance between the total quality and mean quality measures (Dennis et al., 1996). This measure rewards groups for all ideas generated, except those ideas that are poor or very poor. This measure had an intuitive or common sense appeal to this author.

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