1. Introduction

'Human minds with computers to aid them are our principal productive resource.' (Simon, 1987).

The quote of Herbert Simon (1987) suggests that it is necessary to combine human thinking with computers in order to achieve a more productive society. The mission of information system (IS) community is clear-the development of effective computer-based procedures and systems to improve the productivity of human beings. The industrial revolution has brought about a significant increase in productivity by mechanization of repetitive laborous work (Productivity Perspectives, 1985). In the 60s and 70s, the focus of IS community was to automate repetitive procedural work with an aim to increase the productivity of information workers. While many success stories have been reported, some argue that information technology did not lead to an improvement in productivity, the so-called "productivity paradox" (Roach, 1988; Brynjolfsson, 1993). It appears that the real promise of IS is on providing effective support for non-repetitive managerial work because managers are the group of people whose work steers the course of society and its economic and governmental organizations.

The organizational decision support system (ODSS) community aims at improving managerial performance by exploiting information technology. ODSS includes both individual and group DSS. Individual DSS is the application of available and suitable computer-based technology to help improve the effectiveness of a manager's decision making in semi-structured tasks. An Group DSS is an integrated combination of computer, communication, and decision support technologies designed to support group work (DeSanctis and Gallupe, 1987). Sprague (1987) suggests that ODSS deals with a class of information handling activities that are goal and problem driven rather than procedure driven. He calls this class of information handling activities Type II activities. Managers make decisions and solve problems; their work are characterized as defining problems, setting goals, finding and designing feasible courses of action, and evaluating and choosing among alternative actions (Simon, 1987). These tasks tend to be semi-structured or non-programmable (Simon, 1977). Indeed, as it was originally conceived, ODSS was defined as 'the application of available and suitable computer-based technology to help improve the effectiveness of decision making in semi-structured tasks' (Keen and Scott Moton, 1978).

Several successful implementations of ODSS have been reported in the field (for a review see Sharda, Barr and McDonnell, 1987). These case studies however tend to be ad-hoc and lack the rigor of laboratory or field experiments. Thus we are plagued by the question of whether ODSS helps to improve productivity of managers or more generally information workers. This question is of particular importance because the well-known productivity paradox of information technology may well apply here (Roach, 1988). This paper reviews 46 prior empirical ODSS studies both at individual and group levels and attempts to provide a more definitive answer to the question. Based on our extensive review, we could not conclude that ODSS is always beneficial. We postulate several explanations and suggest that ODSS researchers should be more integrative in their research. We believe that one of the main reasons why some ODSSs have not been effective is that these systems are designed without a proper understanding of the cognitive limitations of managers and their work environments.

This paper is organized as follows. Section 2 reviews the empirical literature on individual DSS use. We propose a simple framework based on Simon's (1977) three stage decision process model and Sprague's (1987) DDM (Data-Dialogue-Model) paradigm to classify the empirical studies. Section 3 reviews the empirical literature on group DSS use. An extension of DeSanctis and Gallupe's (1987) framework is used to classify the studies. A number of explanations to account for the
mixed findings are formulated in Section 4. Section 5 proposes a new approach to increase the likelihood of successful ODSS use.

2. Individual Decision Support System (IDSS)

The empirical research on IDSS use has focused on evaluating the software features of IDSS. Following Sprague (1987), we examine the benefits of three software features: data, model, and dialogue. Different steps in problem solving involve different cognitive processes and hence the needed software features for support can be different (Simon, 1977). Using these two dimensions, we develop a framework for classifying the empirical IDSS literature. Figure 1 shows where the various empirical studies positioned in the framework. Note that some studies appear more than once in the framework because they address research questions beyond a single cell. We shall review the studies in a cell-by-cell manner.

(1) Data-Step 2

King and Rodrigue (1978) developed an IDSS to support the unstructured strategic and policy planning activities of an organization by providing user with problem-related information that may go beyond what the user might identify as necessary for generating sound alternatives. The system is similar to a competitive database system in terms of the competitive information that it makes available to the user. On the other hand, the system is analogous to 'corporate-model' systems in its utilization of information structure models and its capabilities for allowing the user to inquire in terms of problem-related issues. Thus the system provides support to users in the design phase of the human problem solving process with additional information. King and Rodrigue found that system users and nonusers did not perform differently. Thus the system did not bear out its value in this study.

(2) Data-Step 3

Benbasat and Schroeder (1977) tested whether the availability of additional reports which were not necessary to make the best decisions affect decision performance. The experimental task required subjects to make production and inventory ordering decisions in a stochastic market environment. They found that there were no significant differences in cost or time performance between those subjects who only had the necessary information and those who hand additional data. They also found that subjects with low functional knowledge requested more reports without improving decision performance.

Using a similar task, Ghani and Lusk (1982) examined the impact of a change in the amount of information on decision performance. The amount of information was varied by providing a finer partition of demand information (demand information for sunny, cloudy, and rainy instead of sunny and rainy only). It was found that the additional information seemed to cause subjects to select an inappropriate inventory ordering strategy resulting in a considerable loss in profits. Thus the study shows that additional informa-

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Fig. 1 A Classification Scheme of IDSS Use
tion can hurt managerial performance.

The above three studies support Ackoff’s ‘management misinformation systems’ hypothesis. Ackoff (1967), in his classic article challenges the assumption that the manager needs the information he wants. He contends that ‘the manager who does not understand the phenomenon he controls plays it safe with respect to information and wants ‘everything’. Sol and Bots (1993) make a similar observation by questioning the basic premise of IDSS: an increase in the information quantity and quality automatically results in better decision making.

(3) Dialogue-Step 1

Dos Santos and Bariff (1988) examined whether greater flexibility and choice in software aids led to improved user performance. The effects of user versus system-guided model manipulation, variable versus exception-based report content, and display of incremental changes versus actual outcomes on strategy formulation were investigated in a laboratory experiment involving 46 undergraduate subjects. The findings suggest that a system-guided model manipulation strategy and the display incremental changes significantly improved performance. This study shows that greater flexibility and choice in software aids may not lead to improved decision performance.

(4) Dialogue-Step 2

Elam and Mead (1990) tested whether DSS can make individuals more creative. Deriving from the creativity literature a set of guidelines for designing IDSS, they examined the use of these creativity enhancing software features on 12 auditors’ decision making processes and the creativity of their solutions proposed in two planning tasks. There were three treatments: no IDSS and two versions of creativity enhancing IDSS. The first version of creativity enhancing IDSS encouraged the subjects to look backwards for causes and depth of understanding in developing plans; the second focused on looking ahead at each step to practical solutions. Protocol analysis was used to categorize the decision making process as either single step (immediate decision) or multi-step (several steps to reflect about the task). All subjects with a IDSS followed a multi-step process; only 40% of those without a IDSS did so. Version 1 IDSS generated more creative responses than the no IDSS group, whereas the version 2 IDSS group generated less than no IDSS group. Overall, the study indicated that the kind of software features provided to the users could impact the decision outcomes.

(5) Dialogue-Step 3

Benbasat and Schroeder (1977) studied whether the form of report presentation could impact decision performance. Two different forms were used to present historical information reports to the decision maker: listed tabular or graphical data. The listed tabular data format showed daily demand figures for twenty days and the graphical data format plotted the same twenty daily figures versus time. The experimental task required subjects to make production and inventory ordering decisions in a stochastic market environment. They found that there was no significant difference in cost performance between the subjects who had the listed tabular data and those who had graphical data.

Ghani and Lusk (1982) also examined the effects of changes in information presentation format on decision performance. Laboratory results indicated that a change in information format part-way through the experimental task (from tabular to graphical, or vice versa) increased decision time but did not alter profit performance. Subjects generally preferred the representation they initially used. Neither representation format was found to be superior to the other.

Dickson, DeSanctis, and McBride (1986) conducted a series of three laboratory experiments involving 840 subjects to study the effectiveness of different presentation formats. Their first experiment compared tables and bar charts. No significant differences in interpretation accuracy and decision quality were observed for the two groups. The second experiment compared line plots to tables and subjects with graphical reports outperformed those with tables in decision quality and interpretation accuracy. The third experiment compared graphical and tabular reports for their ability to convey a ‘message’ to the reader. Graphics were superior when large amounts of information were presented and relatively simple impressions were to be made.

In the same vein, Benbasat, Dexter, and Todd (1986) assessed the influence of color and information presentation differences (tabular reports and line graphs) on decision quality and decision making time. The major finding of these studies was that depending on how well the presentation format supported the task solution, decision making effectiveness was improved. The benefits of graphics were limited to reducing decision making time but only when they were in a form that provided an additional perspective of the solution to the task. The benefits of color-enhanced reports were not pervasive. The benefits of color were more evident for the use of graphical reports than tabular ones.
Linang (1986) found that presentation format did not change decision performance but positively affected user satisfaction. Each subject in the experiment assumed the role of the president of marketing in a hypothetical company and made price and promotion decisions for new products in six cases. Contrary to the above findings, tabular reports were superior to graphs. This outcome could be a consequence of the nature of the task; accurate numbers, as opposed to trend information, were required.

Jarvenpaa (1989) examined the effects of graphical formats and task demands upon decision processes and outcomes. Presentation formats were organized either by showing all alternatives within an attribute (e.g., displaying costs of all the various options in one report) or showing all attributes within an alternative (e.g., displaying cost, sales, location, etc for one option).

The task was varied by providing subjects with task instructions which in theory would elicit specific processing strategies. Report format influenced information acquisition, i.e., reports organized by alternative induced information acquisition by alternative. The demands of the task reduced some of the influence of format, i.e., for graphs organized by alternative, tasks eliciting attribute processing led to less processing by alternative (as compared to tasks eliciting alternative processing).

Hale and Kasper (1989) studied the effects of different human–computer interchange protocols on decision performance in a traveling salesman problem. Four protocols were examined: unconstrained interaction, ability to change IDSS heuristic solution at the end, alternating human and computer decisions at each node in the network, and an initial route selection by the human followed by the IDSS heuristic completing the route. The latter two are termed human–computer collaboration.

Results indicated that human–computer collaboration outperformed the unconstrained and completely constrained (modify final IDSS solution only) modes of interaction. Neither human nor IDSS alone lead to good performance.

Sobol and Klein (1989) investigated the use of bar graphs, tabular reports, and star graphs for two types of tasks: credit rating and classification of firms into similar graphs based on financial statistics. Results indicated that star graphs led to longer decision times as compared to bars and tables. Use of tables led to highest decision accuracy in terms of correctly identifying the best or worst credit risks. However, for ranking risky projects from high to low, star graphs by virtue of providing a superior overall pattern recognition were the best. Therefore, it is important to evaluate information presentation formats in the context of the type of task they are best suited for.

In summary, we note that a greater flexibility in dialogue choice does not necessarily lead to improved decision making performance. A dialogue style that pools expertise from human and computers is better than one that elicits answers from human or computers only. Finally, it appears that there is no single best presentation format; the best format depends on the underlying task to be solved.

(6) Model–Step 1

Aldag and Power (1986) tested an interactive heuristic program called DECAID. This IDSS was used by one group of students in solving a case problem while another group of students solved the same case without such help. Both groups then solved a second case. This time, the group initially exposed to DECAID did not use it while the other group did. The students were then asked to prepare written case analyses. Three raters assessed these analyses, and it was found that DECAID did not improve the independent ratings on students' decision reports and recommendations. However, students' attitudes toward the computerized aid were favorable.

Pracht and Courtney (1988) conducted an experiment to study the relationship between decisionmaker characteristics and use of a graphical problem-structuring tool. Eighty-four subjects were divided into two groups: a control group that did not use the tool and an experimental group that did. The results indicated that high analytic subjects effectively used the tool to understand the structure of the problem domain, but low analytic subjects were ineffective. There were no significant differences in problem structuring by low analytics subjects who used the tool and those who did not.

The above two studies suggest that providing model capability in the first step of problem solving process does not necessarily lead to improved performance. This model capability must match with the characteristics of the decision maker.

(7) Model–Step 2

Cats - Baril and Huber (1987) examined the effectiveness of an IDSS in a career planning problem. They found that decision aids provided in the form of interactive heuristics had a positive effect on decision quality (measured as ratings of developed career plans by four career counselors). However, the subjects using the decision aid on the computer did not outperform those using the same interactive heuristics with paper
and pencil. Thus the study suggests that structure imposed by the model rather than computer technology helps the decision maker.

(8) Model-Step 3

Benbasat and Schroeder (1977) employed three decision aids: forecasts of demands, suggested outputs, and optimal order quantity and reorder points based on the Wagner-Whintin algorithm. These model capabilities were used in a production and inventory planning task in a stochastic market environment. They found that these decision aids improved cost performance over simple intuition. They also noted that subjects with decision aids took longer to make decisions than their counterparts.

Chakravarti, Mitchell, and Staelin (1979) examined managers' abilities to estimate the parameters of a decision-calculus model (ADBUDG) and the value of this model in decision making. The subjects assumed the role of product managers who must wrestle with advertising budget decisions. They showed the existence of biases in human judgment. In certain situations, users of the model actually earned less profit than the nonusers.

In the same vein, McIntyre (1982) evaluated the impact of judgment-based marketing models, employing a version of the CALLPLAN model developed by Lodish (1971). The study was a controlled laboratory experiment involving 96 subjects. They found that participants who had access to the model made higher average profits.

Benbasat and Dexter (1982) evaluated the effect of a decision aid based on a simulation model. The decision environment was a multi-period inventory/production game in which the participants made three decisions: an order point, an order quantity, and the daily production for the next 20 days. They concluded that the participants with a computer aid earned a higher profit than those without such an aid. In addition, they found that high analytics subjects with the decision aid took more time to make decisions than those without the aid.

Dickmeyer (1982) tested TRADES, a computer-based, interactive financial model for assisting university administrators in making decisions on faculty size, salaries, tuition, and new investment. In this experiment, one group of subjects used TRADES while the other group was provided with a printed university forecast. The subjects were asked to rank-order a number of five-year financial policies. Users of TRADES were found to make more policy preference changes than the nonusers. That is, the model users, who could get computer supported budgets and projections under different scenarios, made better decisions than those who could not.

Fripp (1985) made three types of IDSS tools available to a large number of managers in a laboratory study dealing with managing a retail organization. Two of the tools, REGMOD and MYMOD, were used for forecasting sales. REGMOD was a conventional regression model to forecast sales. MYMOD also forecast sales but was based on user specified model parameters depicting relationship between variables, such as a $1 drop in price will increase sales by 5%. The third tool, FINMOD, generated performance income statements based on a set of decisions provided by the subject. Results showed that MYMOD was the most frequently used model and FINMOD the least used. MYMOD significantly improved problem understanding. The results also indicated that REGMOD users performed significantly better than any other groups. Non-users had a significantly higher variance in their performance than the others.

Liang (1986) proposed a framework based on Simon's three stage decision process model and Fishbein's intention-behavior model to integrate the many factors that affect successful implementation of IDSS. An experiment was conducted to investigate the relative importance of the factors. Each subject in the experiment assumed the role of the president of marketing in a hypothetical company and made price and promotion decisions for new products in six cases. He found that quality of the system was the most critical factor. Among the factors that affected the quality of the system, accuracy of the model was the most critical factor affecting decision performance, with increased accuracy having a larger positive effect on performance.

Sharda, Barr and McDonnell (1988) examined the effectiveness of IDSS-aided decision makers relative to decision makers without a IDSS over an eight week period. An executive decision making game was used. Overall, the groups with access to the IDSS made significantly more effective decisions than their non-IDSS counterparts. The IDSS groups took more time to make their decisions than the non-IDSS groups at the beginning of the experiment. However, this disadvantage disappeared after the third week when the IDSS groups became sufficiently familiar with the IDSS.

Todd and Benbasat (1991) utilized protocol analysis to investigate the influence of different decision support tools on the choice of problem solving strategies in a multiattribute multialternative problem. Comparing IDSS to no IDSS, they found that strategy selection
In summary, we observe that appropriate models embedded in an IDSS help to improve decision performance. Models change managers’ problem solving strategies and are preferred by high analytics managers.


Most empirical research studies in GDSS adopt an input-output perspective and compare the decision outcomes of the GDSS groups with the traditional face-to-face groups. Common dependent variables used are decision quality, consensus, equality of participation, domination by a few members, and satisfaction with the process. Some research include an additional treatment where groups are manually supported by structure that are equivalent to the GDSS support (Lewis, 1987; Watson, DeSanctis, and Pool, 1988; Ho and Raman, 1991). In these studies, the manually supported groups are used to isolate the impact of structure on group decision making so that the impact of GDSS technology, over and above the impact of the structure, can be determined.

These empirical studies deal with a large number of issues. It is difficult to compare them because these studies solved different tasks under different situations. It becomes, therefore, necessary to develop a framework for analyzing and organizing the findings of these studies. Pinsonneault and Kraemer (1989) developed a framework from the literature of organizational behavior and group psychology and applied it to the literature of GDSS. The framework is very complex and considers more than 50 variables. We prefer a simpler framework based on the taxonomy for GDSS research developed by DeSanctis and Galuppo, and later modified by Watson, Ho and Raman (1993). This taxonomy rests on the information exchange and cross-cultural perspectives and is specifically developed for the study of GDSS. The taxonomy uses group size, member proximity, task type, and national culture to organize research studies. Figure 2a-b shows the various studies positioned in the framework. As indicated, most studies were conducted in the western culture involving small groups. We shall describe each study below.

3.1 Western Culture

(1) Planning-Face-to-face

A complex international crisis planning task was used in a controlled experiment by Steeb and Johnston (1981). The task required the group to agree on a course of action for a crisis situation. The study used a structured integrative GDSS system called Perceptronics' Group Decision Aid and compared performances between five aided and five unaided groups. The results suggested that the aided groups produced higher quality decisions, involving more detailed courses of actions. In addition, the study showed that the aided groups were more confident in the choice and more satisfied with the decision making process compared to
the unaided groups. In conclusion, they suggested that a GDSS with a structuring tool can be very useful for decisions with numerous objectives, with major risks, and long time horizons.

Vogel et al. (1989) conducted two field studies intended to evaluate the effectiveness of GDSS use at IBM. The first study focused on meeting process and outcome effectiveness, efficiency, and user satisfaction at a single IBM site. The second study collected data on GDSS tool use and facilitation approach within meeting sessions at four IBM sites. They found that GDSS use enhanced effectiveness, efficiency and user satisfaction. Facilitation training was found to be a critical requirement for successful integration and application of GDSS with procedures and group processes.

(2) Creativity-Face-to-face

Nunamaker et al. (1987) involved real-life managers in their experiment. The study engaged seven brainstorming groups in 18 meeting sessions. The mean length of the meeting sessions was approximately four hours. The study found that GDSS users were highly satisfied with the decision making process. The groups also reported a more even participation by their group members and less domination by a few group members when compared to meetings held in their respective organizations.

Lewis's (1987) study included three levels of support: no support, pencil-and-paper support structurally equivalent to GDSS, and a GDSS. Lewis found that GDSS supported groups produced decisions of higher quality and reduced member domination by a single member when compared to pencil-and-paper supported groups. When compared to unsupported groups, GDSS supported groups generated more alternatives and reduced member domination by a single member. The pencil-and-paper supported groups were the least satisfied with the decision making process. There were significant differences in decision scheme satisfaction between the GDSS groups and the other two groups.

Connolly, Jessup and Valacich (1990) conducted an experiment to evaluate the effects of anonymity and evaluative tone on computer-mediated groups using a GDSS to perform an idea generation task. Evaluative tone was manipulated through a confederate group member who entered supportive or critical comments into the automated brainstorming system. Groups working anonymously and with a critical confederate produced the greatest number of original solutions and overall comments. The average solution quality per item was not significantly different across conditions. Identified groups working with a supportive confederate were the most satisfied and had the highest levels of perceived effectiveness, but produced the fewest original solutions and overall comments.

Easton et al. (1990) compared two different GDSS tools in a controlled experiment. The study found that one software tool helped produce better quality solutions to a combination of creativity and intellective tasks but the other helped generate more unique alternatives. They concluded that there should be a match between the GDSS tool and the task to be performed.

Jessup, Connolly and Galegher (1990) investigated the influence of anonymity on group process in groups using a GDSS. They found that group members whose contributions were anonymous generated more comments, were more critical and probing, and were more likely to embellish ideas proposed by others than those who contributions were identified by names.

DeSanctis et al. (1991) conducted a longitudinal field study to understand how quality control teams use a GDSS in their quality improvement efforts. They found that voluntary use of the GDSS system was quite high, and in general, these uses cover quite a wide range of software tools. Groups most often use the system for task- and process-oriented activities. The group members were quite satisfied with the system.

Nunamaker et al. (1991) studied how GDSS help negotiating groups in generating options for mutual gain. They found that the use of anonymity improved option generation in some circumstances, particularly those with increased criticalness and/or power differences among the participants. Larger groups were found to be more effective than smaller groups, several small groups combined, and nominal groups.

(3) Intelective-Face-to-face

There are two studies solving an intellective task in a face-to-face environment. Gallupe, Poole, and DeSanctis (1988) administered two versions of experimental task, one high in difficulty and other lower in difficulty, to GDSS supported and unsupported decision making groups. The study indicates that a GDSS increases decision quality for both types of tasks. In addition, GDSS supported groups tend to generate more alternatives and are less satisfied with the decision making process.

The study by Jarvenpaa et al. (1988) involved software development teams working on unstructured, high level conceptual software design problems. Two types of GDSS: (1) a networked workstation technology and (2) electronic blackboard technology were contrasted with their conventional counterparts. Conventionally
supported meetings appeared to result in the highest level of communication thoroughness, followed by the electronic blackboard groups. Workstation-supported groups showed the lowest level of communication thoroughness. The two GDSS tools had no impact on the equality and perceived equity of participation, had better performance than the conventional meeting groups. They found that electronic blackboard groups came up with better software designs than conventional groups.

(4) Intellective—Dispersed

Turoff and Hiltz (1982) conducted two experiments in which GDSS was used to support meetings with dispersed group members solving an intellective task. The first compared the process and outcome of face-to-face versus unstructured computerized conferences. The results of the first experiment suggest that a dispersed decision making group may use computerized conferencing to aid its decision making and that the quality of decision reached can be just as good. However, the results show that it will be difficult for such a decision group to reach consensus on a decision, without face-to-face meetings. The second experiment was a field experiment that varied two factors, human leadership and computer feedback, with computer conferencing support. The treatment condition (no leader and no computer feedback) was comparable to the unstructured conferencing used in the first experiment. The results suggest that either human leadership or computer feedback alone has a significant effect on the ability of a group to reach consensus in the computerized conferences. However, together they interact to produce an effect that is not significantly different from unstructured computer conferencing.

Hiltz, Johnson, and Turoff (1991) engaged 24 groups of five professionals and managers to use computer conferences to reach consensus on the best solution to an intellective task. Two software tools for structuring the conferences were employed in a two-by-two factorial design. Groups with 'designated leadership' used software support to elect a discussion leader. Groups with 'statistical feedback' were presented with tables periodically that displayed the mean rank and degree of consensus for each item. They found that designated leadership improved levels of consensus. In the absence of a leader, 'statistical feedback' improved level of agreement slightly. Statistical feedback was detrimental to the ability of a group to reach a decision.

(5) Preference—face-to-face

The use of GDSS to support a preference task was examined by Jelassi and Beauchair (1987). The study engaged groups in policy formulation in the context of student misconduct at a university. The study found that there were no significant differences in decision quality and equality of participation between the supported and unsupported groups.

Zigurs, Poole and DeSanctis (1988) took a process perspective and examined the protocols of meetings. They compared the amount and pattern of influence behaviors between GDSS and unsupported groups. The findings showed no significant difference between the overall amount of influence behavior attempted in the two groups. Significant differences, however, were found in the pattern of the influence behaviors, i.e. the different types of behaviors used.

Gallupe and Mckeen (1990) investigated whether GDSS support and member dispersion affect group performance and satisfaction with the decision process. They found that GDSS did not improve decision quality. GDSS groups took longer time to reach a consensus. Groups in the remote decision setting were significantly less satisfied than those in the face-to-face setting.

(6) Preference—Dispersed

Siegel et al. (1986) performed three experiments to explore the effects of GDSS on communication efficiency, participation, interpersonal behavior, and group choice. In the first experiment, groups were asked to reach consensus on a career choice dilemma problem in three contexts: face-to-face communication, anonymous computer-mediated communication, and non-anonymous computer mediated communication. In the computer-mediated conditions, the subjects were physically separated. The results of the first experiment suggest that groups using computer-mediated communication to reach consensus experience some inefficiencies in communicating, participate more equally within group, are more uninhibited, and reach decisions which deviate further from the initial individual preferences. In the second experiment, the software was modified to impose greater structure on the group discussion by permitting only one person to communicate at a time. In addition, subjects were given more training in the use of the system and were allowed more time to reach consensus on each problem. The results are essentially the same as those of the first experiment. As a result, the authors conclude that computer-mediated communication has a social-psychological impact which is relatively robust with respect to variations in the communication software. The third experiment introduced computer mail as one of the treatments. Again, the results are similar to the first experiment. This series of experiences...
ments on computer-mediated communication indicates that computers can effectively assist group decision making. The research discussed supports the notion that the additional communication channel provided by GDSS technology can substantially influence the pattern of group communication.

(7) Cognitive Conflict-Face-to-face

Watson, DeSanctis, and Poole (1988) examined a fund allocation task that requires resolution of conflicting personal preference structures. The significant findings of the study are: ① manually supported groups perceived a higher level of decision quality and report a higher level of decision scheme satisfaction than GDSS aided groups; ② unsupported groups were more satisfied with their decision scheme, and took less time to reach decision than either of the aided groups; ③ group size had no impact on group performance.

Poole, Holms, and DeSanctis (1991) tested the effectiveness of GDSS support in helping groups to resolve conflicts. Results indicated that the unsupported groups had more alternative-related discussion than did manually supported groups, which had more than GDSS groups. GDSS groups had a greater proportion of analytic remarks than other groups, suggesting a moderate depersonalization tendency. There were no significant differences among groups in level of participation.

(8) Mixed Motive-Face-to-face

Horton et al. (1992) compared small groups writing managerial memoranda in a computer supported meeting room and with conventional writing tools. The found that the technology altered the writing process, resulting in less group planning, more individual work, and more revising than when conventional tools were used. The GDSS technology did not affect overall document quality but it can enhance writers' audience adaptiveness.

3.2 Eastern Culture

(1) Cognitive Conflict-Face-to-face

Ho and Raman (1991) investigated the effect of a group decision support system and elected leadership on meetings of five-person groups. They found that manual groups displayed a significantly higher postmeeting consensus than GDSS groups. Elected leadership did not increase postmeeting consensus. There was a significant correlation between equality of influence and premeeting consensus in GDSS groups. Groups that had high premeeting consensus seemed willing to let one member to dominate the final decision.

Lim, Raman, and Wei (1993) studied the effect of a GDSS on leadership in groups. They used a preference task and measured the amount of influence behavior, influence distribution, and dominance significance. The results show that GDSS groups generated a large amount of influence behavior than manual groups, and groups without elected leaders. GDSS helped to induce a more equal distribution of influence behavior in groups without elected leader, but no such effect was observed for groups with leader. Dominance significant was found to be higher in manual groups than in GDSS groups; it was also higher in groups with elected leaders than in groups without elected leaders.

(2) Intellective versus Cognitive Conflict-Face-to-face

Tan and Wei (1993) studied the effect of task on group performance. Half of 68 5-member groups performed an intellective while the other half performed a preference task. They found that intellective task groups produced lower consensus change than preference task groups. Also the intellective task groups experienced greater influence equality than preference task groups. The level of support had no impact on the change in consensus and influence equality.

Huang, Raman, and Wei (1993) studied the effects of a GDSS on informational and normative influence in small groups using an intellective task and a preference task. They found that: ① informational influence predominates in intellective task groups and normative influence predominates on preference task groups and ② the GDSS used in the study has the potential to amplify informational influence and attenuate normative influence. The former positively affects the decision making process in intellective task groups, whereas the latter negatively impacts the decision making process in preference task groups. These findings suggest that a GDSS may have beneficial effects for certain task types but not for others.

3.3 Cross-Cultural

Watson, Ho and Raman (1993) suggested that the oriental cultures have a different model of desirable group behavior, and a GDSS designed for western culture may have unintended consequences in an oriental setting. They controlled for the software used and the task solved by two groups of subjects (Singaporean and American). They found that Singaporean groups had higher pre-meeting consensus than American groups. Since both groups had the same level of post-meeting consensus, the change in consensus was greater in the American groups than Singaporean groups. Influence was more equal in Singaporean than American groups. In Singaporean groups, a GDSS led to unequal influence in groups with a high level of agreement before meeting.
Culture is an important dimension of ODSS research as organizations move beyond the confines of national boundaries. Managers in one country must work hand-in-hand with managers in another country in a global market. Raman and Watson (1992) suggest that chief information officers responsible for global information systems must understand cultural differences and their effects on MIS management. They provide two case studies to illustrate how a successful IS system meant for a particular culture might fail under another cultural environment. Thus, culture is an important variable of ODSS research.

Figure 3 summarizes the research findings (a few studies are not included because they do not study the common dependent variables of interests to most other studies). In the figure, a 'H' means A has a significantly higher mean than B, a 'L' lower mean, a 'N' no difference in a A-B comparison. For instance, seven studies reported that GDSS improved decision quality when compared to unsupported groups; four studies reported no change; and one study showed that GDSS lowered decision quality. Similarly, two studies reported that GDSS led to a higher consensus when compared to unsupported groups, three studies reported a lower consensus for GDSS, and four studies indicated no change.

4. Possible Explanations

Based on the reviews in the previous two sections, we cannot conclude that an ODSS will always lead to improved decision performance. These mixed findings call for a comprehensive theory to explain the observed inconsistencies. This is a daunting task and here we can only offer some possible explanations for the inconsistent results in terms of some contingent variables:

(1) System Characteristics: The studies reviewed above used different IDSSs and GDSSs with different system characteristics. Some of the studies show that these characteristics have a significant impact (e.g., Fripp, 1985) on decision making. Therefore researchers should consider developing IDSSs and GDSSs with a set of very similar characteristics to permit comparison across studies. In addition, an IDSS or a GDSS may be dysfunctional because it is incomplete or incongruent with respect to a decision problem. Future research should ensure that the system is functional and is congruent with the decision problem.

(2) Task Characteristics: Inadequate attention has been paid to task characteristics in IDSS and GDSS research. Research on groups has shown that task can explain much of the variance in group performance (Poole et al. 1985). This has been factored into the framework for studying GDSS and recent studies of GDSS have confirmed the importance of tasks. How-
ever, GDSS has used creativity, preference, and cognitive conflict tasks based on McGrath’s taxonomy (1984). A more comprehensive taxonomy of tasks and task characteristics is needed and further GDSS research using other task types is needed.

Figure 1 shows that most existing IDSS research has focused on the evaluation and choice phase of problem solving process. Problem definition and presentation are important phases in the decision making process (see the car manufacturer problem in 5.2). Thus, future research in IDSS should address the first two phases of problem solving.

(3) Characteristics of Decision Makers: The review reveals that the characteristics of decision makers significantly impact the ways the ODSS technology are exploited. Individual differences can affect styles of interaction with the system and this will affect individuals’ abilities to exploit the system’s full capability. In Section 5.2, we highlight that people often rely on simple rules of thumb in their decision making (Kahneman, Slovic, and Tversky, 1982). IS researchers must understand these cognitive limitations of managers in order to design an effective ODSS to support them.

The inconsistent results could also be due to the artifacts of experimental methods used in the studies:

1. Decision Costs: Subjects may be asked to tackle difficult tasks. In their attempt to avoid decision costs, they tend to adopt simple decision rules.

2. Response Mode: Subjects may be induced to behave in a certain manner because of demand effects from the experimenter. This is likely to be the case if the experiments are conducted as part of a class. The student subjects have behaved the ways they believe the instructors expect them to behave.

3. Mis-specified Incentives: Unlike experiments in experimental economics (Smith, 1982), experiments in IS do not normally pay the subjects. Theories about decision-making costs do suggest that unmotivated choice may be very different from the highly motivated choice behavior. Thus the results of experiments where subjects may be bored, playing games, or otherwise unmotivated must be taken with caution.

4. Experimenters were psychologists: In a very real sense this can be a problem. Subjects nearly always speculate about the purposes of experiments and psychologists have the reputation for deceiving subjects. It is also well known that subjects’ choices are often influenced by what they perceive to be the results of the experiment.

5. Unsophisticated Subjects: In some experiments, undergraduate subjects were asked to assume the roles of managers. These subjects may not have the experience and background to tackle assumed tasks effectively.

The first set of explanations requires the development of a comprehensive theory and the second set of explanations calls for a more systematic empirical methodology.

5. Problems and Challenges

We observe that ODSS does not always lead to improved decision performance. A major challenge for the research community is to develop a theory to explain the observed results. ODSS researchers must be more manager-driven. That is, they must better understand the environment the managers face and the characteristics of organizational decision making. In other words, a user-driven demand-pull approach rather than a technology-push approach should be the guiding force in designing ODSSs. We believe that the former approach has a greater likelihood of success because it aims at solving the problems of the managers. The approach however requires IS researchers to go beyond their technology-based disciplines to understand their ‘clients’ and their work patterns. Only through such a deep understanding will the decision ‘losses’ be eliminated and decision ‘gains’ be enhanced.

5.1 Pattern of Work

Average manager engages in a different activity every nine minutes. Consequently, managers tend to avoid hard (that is, systematic, analytical) data and rely more on their intuitive judgment (Mintzberg, et al. 1976). We expect this phenomenon to become worse because of the increased turbulence and complexity of the post-industrial environment (Huber, 1984). Thus we need a system design approach that addresses the requirements and realities of managerial work pattern.

Sometimes, the introduction of ODSS may affect the work pattern of the managers. The merit of such change must be assessed within the broad organizational context. The process reengineering literature suggests that a quantum leap in performance can be derived from redesigning organizational processes (Davenport, 1993). We believe that using information technology to change managers’ work pattern is risky and should be done with caution. One point is clear: IS researchers need to shift their focus from the technological components of ODSS to the organizational and managerial components of
ODSS. In this way, they will then be able to develop 'products (systems)' that truly meet the needs of the 'customers (managers)'.

5.2 Biases in Managerial Judgment and Choice

There is ample evidence to suggest that managers often rely on heuristic principles in their decision making (Kahneman, Slovic, and Tversky, 1982). They suggest that people rely on a number of simplifying strategies, or rules of thumb, in making decisions. Individuals frequently adopt these heuristics without being aware of them. In general, these heuristics work well, but sometimes they lead to severe and systematic error. Below, we briefly describe two biases and refer the interested readers to the excellent book by Bazerman (1986) for a comprehensive review.

(1) The Availability Heuristic: Managers assess the frequency, probability, or likely causes of an event by the ease with which instances or occurrences can be brought to mind. For instance, the product manager bases his/her assessment of the probability of a new product's success on his/her recollection of the successes and failures of similar products. This heuristic can be a useful managerial decision making strategy and will often lead to accurate judgment, since instances of events of greater frequency are generally revealed more easily in our minds than events of less frequency. The heuristic is fallable, however, because the availability of information is also affected by other factors that are related to the objective frequency of the judged event. These irrelevant factors can inappropriately influence the ease an event can be recalled. For instance, many people respond that flying a commercial airliner is far riskier than driving a car. The media has tendency to sensationalize airplane crashes contributes to this perception. In actuality, the safety record for flying is far better than that for driving.

(2) Anchoring and Adjustment: Managers make assessments by starting from an initial value that is adjusted to yield the final answer. The initial value may be suggested from historical precedent, from the way a problem is presented, or from random information. For example, managers make salary decisions by adjusting from an employee's past year salary. Research (Kahneman, Slovic, and Tversky, 1982) has shown that regardless of the basis of the initial value, adjustments from the initial value tend to be insufficient. Thus, different initial values can yield different decisions for the same problem.

The above biases are in managerial judgment. Other biases relate the managerial choice. One particularly interesting choice bias relates to the framing of a problem and information. Consider the following problem (Bazerman, 1986):

A large car manufacturer has recently been hit with a number of economic difficulties, and it appears as if three plants need to be closed and 6,000 employees laid off. The VP of production has been exploring alternative ways to avoid this crisis. He/She has developed two plans:

- Plan A: This plan will save one of three plants and 2,000 jobs.
- Plan B: This plan has a 1/3 probability of saving all three plants and all 6,000 jobs, but has a 2/3 probability of saving no plants and no jobs.

Reconsider this problem, replacing the choices just provided with the following choices:

- Plan C: This plan will result in the loss of two of the three plants and 4,000 jobs.
- Plan D: This plan has a 2/3 probability of resulting in the loss of all three plants and all 6,000 jobs, but has a 1/3 probability of losing no plants and no jobs.

The two sets of alternative plans are objectively equivalent. For example, saving one of the three plants and 2,000 of 6,000 jobs offers the same outcome as losing two of the three plants and 4,000 of 6,000 jobs. However, empirical evidence demonstrates that most individuals (more than 80%) choose plan A in the first set and plan D in the second set (Bazerman, 1986). Thus the frame of problem can significantly change the decision.

The above biases have not been fully explored in the context of an ODSS. Since the ultimate aim of ODSS is to improve the effectiveness of decision makers, a fruitful way to make the technology effective is to develop software features to debias these biases of managerial decision making. In sum; we advocate a more user-driven demand-pull system development approach that incorporate the constraints of managers' work environment and cognitive limitations.

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References


(10) W. L. Bate-Baril & G. P. Huber : "Decision Support Systems for Ill-Structured Problems: An Empirical Study", Decision Sciences, 18, 3, 300-312 (Summer 1987)


(17) N. Dickmeyer : "Measuring the Effects of a University Planning Decision Aid", Management Science, 29, 4, 675-685 (June 1983)


