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# The Effects of Integrating Cognitive Feedback and Multi-Attribute Utility-Based Multicriteria Decision-Making Methods in GDSS

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***Abstract***

Cognitive conflicts arise within groups because the members of a group view a problem from different perspectives, even when they have similar interests in achieving a goal. Disagreement within a group may occur due to: (a) differing judgment policies among the members, (b) inconsistency by any member in using a judgment policy, (c) group process losses that prevent group members from understanding each other better, or (d) limited processing capability which may prevent group members from processing all information effectively. Disagreement is especially likely when policies, processes, or information are conflicting in nature.

A level 2 GDSS to aid judging in cognitive conflict tasks is presented that combines cognitive feedback and Multi-attribute utility (MAU) theory based multicriteria decision-making techniques with the communication structure and activity-structuring capabilities of a level 1 GDSS. Though cognitive feedback and MAU methods have been used separately to help groups resolve cognitive conflicts, never before have the two decision aids been used together in a computer-based collaborative system.

The contributory effects of the components of this GDSS design were empirically tested in a laboratory setting. Three treatments: an unaided face-to-face meeting, a level 1 GDSS supported meeting, and a level 2 GDSS supported meeting were compared in a repeated measures experimental design.

Results largely supported the proposed research hypotheses. Some specific findings include: (1) the level 2 GDSS reduced disagreement between group members and improved consistency of judgments better than the other meeting environments did; (2) there was no significant difference in the reduction of disagreement between the level 1 GDSS and face-to-face meetings; and (3) while there was no difference in improvement of consistency of individual judgments between the face-to-face and level 1 GDSS supported meetings, group judgments made in face-to-face meetings were more consistent.

**Key words:** group decision support system, management information system, multi-attribute utility theory, multi-criteria decision-making method, cognitive feedback, group judgment, conflict management

## Introduction

Group decision support systems (GDSS) have been recognized to potentially improve the performance of group work (Jessup and Valacich 1993). A GDSS integrates computer support, communication facilities, and decision process techniques for use in face-to-face or dispersed meetings to support decision-making and related group activities (DeSanctis and Gallupe 1987; Huber 1984). The notions that task-oriented groups are creatively stimulating to the members, rich from pooled knowledge, better in detecting errors, and balance biases to such a degree that group work is generally to be preferred to individual work have a long history (Davis 1992; Lamm and Trommsdorf 1973; Levine and Moreland 1990; Shaw 1932). Yet, group decision-making behavior in the traditional setting that lacks computer support has been found lacking in many respects, known collectively as group process losses (Steiner 1972). One type of process loss is that judgments by individuals often display systematic biases (Kahneman et al. 1982), which in a group is likely to generate conflict. Groups affected by conflict are less likely to produce judgments that are accurate, consistent, and committed to by the group members.

Such situations are very likely to occur when a group works on judgment tasks (McGrath 1984). Among the several decision analytic models that have been offered to explain the complexity of a judgment task, social judgment analysis has clearly demonstrated its effectiveness in improving performance on judgment tasks by reducing cognitive conflict between individuals (Brehmer 1976; Rohrbaugh 1988). Unlike conflicts of interest that arise primarily because of differences in stakeholdings or motives among the group members, cognitive conflicts arise because the members view a problem from different perspectives, even when they have similar interests in achieving a goal (Bazerman 1986; Hammond 1965; Jelassi and Foroughi 1989; McGrath 1984). One's perspective on a problem situation is dependent on values and beliefs that are constructed with the aid of memory and other information (Anderson 1986; Paradice and Courtney 1987). Therefore, clarification of a person's value system should help improve the judging process. Researchers have suggested that the use of effective group communication (Hirokawa and Johnston 1989) and a structured group interaction technique (Druckman 1977; Shakun 1988; Sparks 1982) may help resolve conflicts and thus improve decision making as well as judging.

GDSS's promise in promoting productive conflict management and enhancing group decision-making (Poole et al. 1991) depends on the conflict management techniques that it supports. These are (a) improving communication among participants, (b) separating people from the problem and (c) using objective data and criteria (Jelassi and Foroughi 1989; Nunamaker et al. 1991a; Shakun 1988). However, for a group of judges to gain a common understanding of a judgment policy, it is also necessary to reduce (i) differences that arise due to conflicting objectives and viewpoints among judges, and (ii) differences in the judges' cognitive orientations. While communication support of a level 1 GDSS may lead to increased extraction of the group members' cognitive orientation, the simple structuring methods available in a level 1 GDSS (DeSanctis and Gallupe 1987) (e.g., voting, ranking, and grouping), are likely to be incapable of managing complex problems. For example, voting suffers from the "paradox of voting" which involves cyclical ranking among alternatives. The ranking and grouping methods are simplified and adopt a satisficing approach because efforts to structure the large number of variables in complex problems are constrained by limited human ability to process information (Hogarth 1987). Need has been felt to augment level 1 GDSS with other decision aids to help manage group judgment tasks (Gallupe 1990).

Conflicts over judgment policies typically relate to disagreement about values, and such disagreements are often about degree, not kind (Edwards 1977). A multicriteria decision-making technique using Multi-attribute utility (MAU) measurements can make explicit the values of each decision maker, show how and how much they differ, and in the process reduce the extent of such differences (Cook and Hammond 1982). However, the MAU method manages conflicts in an individual's judging process with no mechanism to interact with the judgment structuring process of a co-member of the judgment-making group. One approach to bridge across the individual judging processes can be to provide continuous feedback to each judge separately as well as to the whole group.

This study proposed and tested an innovative level 2 GDSS to help in judgment tasks that uses the MAU theory-based structuring approach modified by incorporating feedback at various stages that guide judges to share ideas and information and gain a better insight into trade-offs that must be made. Using this approach, all group members begin by forming their individual judgment policies – initially relying on an individual belief system and subsequently modifying those assessments by sharing in the belief systems of other group members. The final result is a group judgment policy that is expected to be well understood by all of the group members who can then use it consistently. Laboratory tests answer the key research question of this study: does the enhanced, MAU theory supported, iterative GDSS based procedure perform better than a conventional face-to-face group meeting and a meeting aided by a system that uses the support tools of a level 1 GDSS on judgment tasks? The opportunity of having an experimental setup designed for judgment tasks has also been used in this study to use social judgment analysis to investigate the effectiveness of computer-mediated communication in judgment tasks.

The following section reviews related research literature and provides the rationale for an enhanced GDSS to support judgment tasks. It is followed by a presentation of the research hypotheses. Next, the research method and analysis are described. Finally, the paper presents the results and discusses their implications for future research.

## Rationale for an enhanced GDSS for judgment tasks

### *Background*

Literature in conflict and information systems suggest several principles that may be used to structure the conflict resolution process (Fisher and Ury 1981; Folger et al. 1992; Jelassi and Foroughi 1989; Nunamaker et al. 1991a; Poole et al. 1991; Sambamurthy and Poole 1992; Sengupta and Te'eni 1993; Shakun 1988). Though most of these studies concern conflicts of interest, the suggested conditions are expected to help reconcile cognitive conflicts, too, thus making way to improved group judgments. The conditions include (a) improving communication among participants, (b) focusing on the problem rather than personal and emotional issues, (c) using objective data and criteria, (d) maintaining an organized and orderly process, (e) considering a wide range of alternative solutions, (f) maintaining a cooperative atmosphere, (g) avoiding artificial conflict-reducing mechanisms such as voting or a leader's veto power, and (h) providing computer-mediated cognitive feedback. From the several features of GDSS, the impacts of which have been investigated in numerous studies (e.g., Alavi 1994; Bui 1987; Chidambaram et al. 1990; Dennis et al. 1988; DeSanctis et al. 1989; Gallupe et al. 1988; Hiltz et al. 1989; Jarvenpaa et al. 1988; McCartt and Rohrbaugh 1989; Nunamaker et al. 1991b; Sambamurthy and Chin 1994; Siegel et al. 1986; Stefik et al. 1987), those that can be generally used to manage conflict include facilities for (a) representing members' positions, (b) maintaining a group memory, (c) structuring agendas that guide the group through deliberation of conflict, (d) maintaining utilities for problem definition and alternative generation, (e) utilizing structures to promote members' participation and anonymity, and (f) using structured techniques for options analysis (Bryson et al. 1994; Colson and Mareschal 1994; Dennis et al. 1988; Huber 1984; Kraemer and King 1988; Poole et al. 1991).

Among research in GDSS that specifically addresses cognitive conflict resolution and group judgment, Reagan-Cirincione (1994) devised a GDSS-based process that established judgment policies for cognitive conflict tasks that are more accurate than the ones produced by any of the members individually. However, the study did not answer the question of whether the GDSS-based process produced more accurate group judgments or ones more committed to by the group members than a typical level 1 GDSS. Sengupta and Te'eni (1993) used the Social Judgment Theory (SJT) (Brehmer 1976) paradigm in their research of cognitive feedback on cognitive conflict tasks in a GDSS environment. They identified the positive role played by computerized cognitive feedback in resolving cognitive conflict tasks. However, the networked system's electronic communication channels were not used for exchanging messages. Electronic communication has been acknowledged in numerous GDSS studies to provide many of the group process gains mentioned earlier.

In a study of conflict management processes, Sambamurthy and Poole (1992) found that GDSS with structuring capabilities better resolved conflict than GDSS with communication capabilities alone. Since it did not use measures based on SJT, it is difficult to relate their findings to the traditional body of research in group judgment tasks. In a study of group consensus attainment using social judgment analysis, DeSanctis et al. (1989) found that GDSS groups achieved higher consensus after the group process. However, there was no non-computer-based control group to ascertain whether the increase in consensus was an effect of the computerized system. Nor were the important judgment analysis parameters studied. From the aforementioned survey of literature, we can surmise that electronic communication, structured processes, and feedback help improve consensus when used either alone or in combination. This study combines all three aids into a level 2 GDSS using an MAU theory-based structuring method and compares it to a level 1 GDSS that also combines all three types of aids but uses typical process structuring tools (e.g., ranking, scoring, and voting).

### *Social judgment theory*

Performance on judgment tasks has traditionally been studied in the context of Social Judgment Theory (Brehmer 1976). The SJT model explains that when two or more judges are trying to arrive at a consensus judgment, their disagreement may be based on underlying differences in the structure of their judgments - the way their objectives or cues are weighted, the organizing principle by which cues are combined, and/or the function forms that relate the cues to the environmental patterns and to the individual's judgments. This structure of judgments, the judge's judgment policy, may be represented as a linear combination of cues in most situations. The linear model can be represented by

$$y_i = \Sigma_{k=1,m} b_{ik} X_k$$

where $y_i$ is the judgment of individual $i$, $m$ is the number of cues, $b_{ik}$ is the weight for individual $i$ on cue $k$, and $X_k$ is the value of cue $k$. Another source of disagreement would be inconsistency by any one member in using a judgment policy.

The fact that most real world judgment tasks involve multiple, often conflicting cues is an indication of the severity of information processing load placed on the judge. The limited information processing capability of humans can be expected to make it difficult to weight cues and estimate the function forms of the cues objectively. The resulting judgment policy may not be well understood by the owner himself, which makes it unlikely that colleagues will understand it. Consequently, an agreement of judgments among group members will be difficult to come by.

### *Multi-attribute utility theory and cognitive feedback*

Decision making problems involving multiple conflicting cues and multiple persons have been analyzed by multicriteria decision making (MCDM) methods in various forms (Bui 1987; Iz and Gardiner 1993; Steeb and Johnston 1981). The MAU method (Saaty 1980) is an MCDM method that decomposes a complex problem into smaller sub-problems that can be better managed in terms of scaling, weighting, and combining of criteria or objectives. Reintegration typically occurs within MAU through the application of utility functions and relative importance weights. An MAU model essentially shows a decision-maker how to aggregate the utility or satisfaction derived from each of the various attributes or cues into a simple measure of the overall utility of the Multi-attribute alternative. Bose, Davey and Olson (1997) argue that quantified identification of individual preferences in MAU theory-assisted group judging is a very effective means for representing and understanding a situation objectively.

However, while the MAU method manages conflicts in an individual's judging process, it has no mechanism to interact with the judgment structuring process of a co-member of the group. After the individual members have acquired a reliable and consistent judgment policy using the MAU method, an integration phase is required that combines the members' individual judgment policies into a group policy. Aggregation of individual policies can be carried out by arranging for feedback of group and member preferences. This process will give the group members the opportunity to assess where they stand with respect to other group members and provide them the option to revise their preferences. The better understanding of group and member preferences is likely to support use of the judgment policies in a consistent manner, which in turn will improve the group's consensus. This concept of frequent feedback, often through electronic communication, integrated into the MAU theory-assisted group judgment is built into the level 2 GDSS that was implemented and tested in this study. An overview of the integrated group process is shown in Table 1.

## Constructs and hypotheses

### *Constructs*

Considering that a primary objective for GDSS designs is to reduce disagreement, the performance criteria can be specified in terms of the lens model equation. Three variables of task-related judgment outcome (i.e., characteristics of the group judgment) are *degree of agreement, index of policy similarity,* and *index of consistency.* In terms of the lens model equation (extended to represent situations of two or more decision-makers (Cvetkovich 1973; Brehmer 1976; Tucker 1964)), the definitions of these variables are as follows.

*Degree of agreement*, $r_A$, is the correlation between the judgments made by persons *S1* and *S2*.

*Index of consistency*, $R_{S1}$ and $R_{S2}$, are the squares of multiple correlations between the cues and judgments made by *S1* and *S2*, respectively.

*Index of policy similarity*, $G$, is the correlation between the linearly predictable variance in *S1*'s judgment and *S2*'s judgment.

*Table 1.* Overview of the group judgment making process

| |
|---|
| Phase A: Structuring cue information - initial stage<br>As a first step to arrange the cues into an hierarchical structure, group members generate and arrive at a consensus through feedback the categories in which the cues are to be placed. |
| Phase B: Structuring cue infomiation - final stage<br>Cues are placed in the categories obtained from previous phase and arranged into an hierarchical structure first by individual members followed by the group as a whole with the help of feedback. |
| Phase C: Construction of individual judgment policies<br>Using the consensus hierarchy of cues and MAU theory-based analysis, group members construct their own judgment policies in a linearly additive model. The utility function forms of cues are constructed with the help of feedback of results of own as well as other group members' efforts. Individual members estimate the weights of cues through trade-off analysis. |
| Phase D: Integration of individual judgment policies to form group judgment policy<br>Group arrives at consensus for weights of cues. The utility values for each cue for each alternative is determined for the group. The weights and utility values are used to estimate the group's judgment for all the alternatives. |

When $r_A$, $R_{S1}$ and $R_{S2}$, are measured directly, it is not necessary to measure $G$ directly because its value can be determined from the lens model equation. Considering agreement and consistency, when measured at the individual level the variables indicate the degree of interpersonal agreement among the group members and the consistency in individual judgments. When applied to the group the variables indicate the overall level of agreement in the group measured through post-decisional agreement, and the consistency of the group judgment.

Figure 1 illustrates the conceptual model used in this study. The model takes into consideration the technological support, task and group characteristics that influence the level of pre-existing cognitive conflict, individual, inter-personal, and collective processes, and individual and group outcomes that reflect the extent to which cognitive conflict has been managed.

### *Hypotheses*

Conflict can be reduced if approached in two distinct phases: differentiation and integration. In a differentiation phase, members attempt to communicate their initial

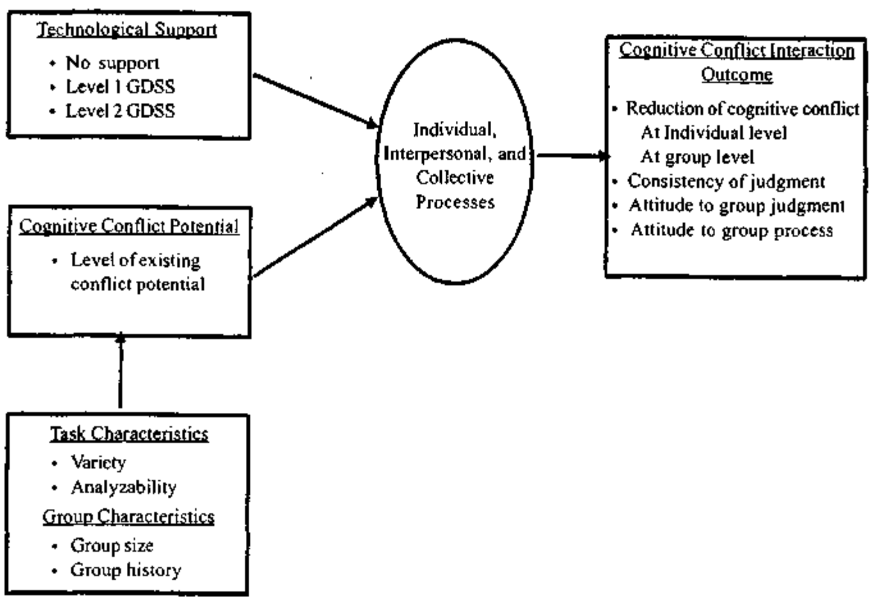


*Figure 1.* Research model to evaluate the effect of a Level 2 GDSS on cognitive conflict tasks.

interpretations and underlying assumptions in order to increase other members' understanding of the range of interpretations. This phase is followed by an integration phase in which members attempt to synthesize their interpretations into a shared set of group interpretations (Folger et al. 1992). Cognitive conflict emerges in the differentiation phase through revelation of disagreement over judgment policies. The disagreements gradually converge to support adoption of a common policy. The conflict is finally resolved when the group can apply the newly acquired policy consistently. The group members come out of the group process with measurable perceptions of the outcome and judging process. Using these variables – *degree of agreement, consistency of judgments,* and *perceptions of the outcome and process* – three hypotheses have been developed.

Past research in GDSS (Reagan-Cirincione 1994; Sambamurthy and Poole 1992; Sengupta and Te'eni 1993) indicates that the use of technology influences cognitive conflict resolution primarily through two means: communication support and group process structuring. In the context of group communication, computer-mediated communication is expected to resolve differences in viewpoints thereby increasing the degree of agreement in several manners. First, it curbs apprehensions which may prevent a person from bringing forth his viewpoints. If such apprehensions are not checked, some issues may never be raised and need for more information may not be met, causing participants never to surface differences and maintain a false consensus (Folger et al. 1992). If the cognitive viewpoints do not surface, then the differentiation phase of the conflict resolution process is incomplete. Second, it reduces pressures to conform induced by domination by individual personalities and status (Hackman and Kaplan 1974) that may cause disagreements to be suppressed or issues to be dropped and group judgments to be forced. In these cases, post-decisional agreement to such group judgments will be low.

Group research indicates that when structure is added to the group process, the group is guided to consider the procedures they use in reaching their conclusions (Hackman and Kaplan 1974). It also suggests that groups can benefit from contemplating the process regardless of the specific process they adopt. However, when dealing with a complex judgment task involving several conflicting cues, the specific structuring method can be expected to influence the extent of benefits obtained by the judges. The structuring aids and feedback mechanism in a level 1 GDSS (i.e., ranking, scoring, voting, and summary display) are unlikely to be capable of objectively determining relative importance and utility of multiple conflicting cues in a judgment task. A level 2 GDSS equipped with an MAU analysis tool and a graphical display tool to provide progressive feedback will better facilitate differentiation of positions followed by aggregation of individual judgment policies. Consequently, group members will not only understand each other better, but will also be more committed to the group judgment.

*Hypothesis 1: Degree of agreement*

1. The degree of interpersonal agreement and post-decisional agreement will be influenced by the type of support provided to the group.

1a. The degree of interpersonal agreement and post-decisional agreement will be higher in the level 1 GDSS discussions than in the manual discussions.
1b. The degree of interpersonal agreement and post-decisional agreement will be higher in the level 2 GDSS discussions than in the level 1 GDSS discussions.

In order to use one's own judgment policy consistently, one must have a good understanding of it. Typically, we pick only a few of the many cues we recognize, then we use our beliefs and personally adopted judgment rules to make our judgments. By spending most of the time on shared information and avoiding conflict (Stasser 1992), manual face-to-face meetings will do little to move individual members away from their pre-meeting beliefs and judgment rules. The consistency of individual judgments then will remain unaffected and group judgments that have been forced are unlikely to be used consistently.

The anonymous environment of electronic communication in a level 1 GDSS is, however, likely to reveal more alternative opinions – some conflicting. While the anonymity may encourage individuals to adopt diverse opinions, the limited capacity of the structuring aids in level 1 GDSS will continue to constrain the users from being able to use all of the cues available. Thus, while possibly using a different set of cues after 'listening' to other group members, they would still be processing about the same number of cues as they did after the face-to-face meetings. The level of control in using their own judgment policies will then be about the same as before. The consistency of the group judgments in level 1 GDSS meetings is expected to go the same way.

The MAU theory-based structuring method will give judges a better understanding of their own policies and the ability to use all the cues. This along with the feedback mechanism that focuses on the judgment process is expected to provide them with better control of their policies. The capability of the feedback mechanism to provide feedback of every member's judgment process simultaneously will increase the amount of shared information which, when structured by the MAU analysis giving equal consideration to all the cues, is likely to empower the group to apply its collective judgment in a controlled manner. Therefore, the following hypotheses can be posited.

*Hypothesis 2: Degree of consistency*

2. The degree of consistency with which the judgment policies are applied at the individual and collective levels will be influenced by the type of support provided to the group.
2a. The degree of consistency with which the judgment policies are applied at the individual and collective levels will be the same in level 1 GDSS discussions as in the manual discussions.
2b. The degree of consistency with which the judgment policies are applied at the individual and collective levels will be higher in the level 2 GDSS discussions than in the level 1 GDSS discussions.

While positive effects have been noticed in many studies (Siegel et al. 1986; Turoff and Hiltz 1982) there have been indications that GDSS technology gives rise to negative feelings (Gallupe 1985). The level of satisfaction may also be influenced by the degree of interpersonal and post-decisional agreements and the control the judges have over their judgment policies individually and collectively. Therefore, we can expect differences over attitudes to the varying levels of support.

*Hypothesis 3: Attitudes and perceptions*

3. Attitude toward the group process and perception of consensus and cooperation of judging groups attempting to work on a judgment task will be influenced by the type of support provided to the group.

## Research method

These hypotheses were tested in a laboratory experiment using a repeated measures design with a single treatment factor: the type of GDSS support. The same groups of subjects' performances were compared (i.e., measured repeatedly) on a set of dependent variables under three different treatments: the type of GDSS support. The subjects were used as their own controls. Repeated measures designs are very sensitive because the variability due to individual differences (which are the major cause for error variance), are removed from the error term. The assumptions for multivariate repeated measures analysis of (a) independence of the observations and (b) multivariate normality were tested and found to be true.

The experiment had six stages: creation of profiles of experimental tasks, pilot study, GDSS usage training, pre-experimental stage, experimental state, and post-experimental debriefing. The pilot study tested the operation of the GDSS designs, ensured that the subjects could follow the instructions, and helped in designing and validating the tasks. The pre-experimental state involved forming groups of subjects with an initial level of cognitive conflict and a balanced mix of computer skills, and assessing the pre-treatment values of dependent variables. In the post-experimental debriefing, post-meeting values of variables were measured and opinions about the experimental treatments collected.

*Subjects and group composition*

Twenty-four three-persons groups made up of undergraduate and graduate students enrolled in MIS classes participated in the study. Since judgments are often exercised by *ad hoc* groups, such as committees formed for a specific task only (e.g., selection of new hires), the experimental groups were made ad hoc. Besides possessing external validity for judgment making tasks, participation by ad hoe groups increases internal validity of experimental results (Dennis et al. 1991).

Since differences in cognitive abilities and psychological traits of individuals may affect group performance (Bottger and Yetton 1983; Hackman and Morris 1975; Hirokawa and Johnston 1989; McGrath 1984), a pre-existing level of conflict in a group was established by controlling which subjects formed the group. This was done by assessing the subjects to obtain their judgments about the tasks prior to group meetings. Subsequently, subjects were clustered on the basis of systematic differences in their judgment policies, thereby providing a statistical method for creating heterogeneous groups in terms of initial cognitive bias with members in initial disagreement. Individual differences across treatments were controlled through the repeated measures experimental design. Homogeneity of participants in terms of aspects other than cognitive bias was surveyed by the use of a background questionnaire. To bring all subjects using GDSS up to a common level of GDSS knowledge, they were trained in the basic use of GDSS and drawn from classes which had had instruction on GDSS and decision support technology.

Since the performance of GDSS groups has been found to be significantly affected by context characteristics (Dennis et al. 1988; Hiltz et al. 1989), attention was given to organizational culture, time pressure, reward structure (Nunamaker et al. 1991b), and information overload (Hiltz and Turoff 1985). The participants were provided with academic incentives by allocating 10% of the course grade to the subject's diligence in participation in the study. In a judgment task, information overload is primarily dependent on the number of cues associated with the judgment policy. Previous studies of cognitive conflict tasks have used two to six cues (Brehmer 1976; Cook and Hammond 1982; Hammond 1965; Harmon and Rohrbaugh 1990; Reagan-Cirincione 1994; Sengupta and Te'eni 1993). Considering the information explosion that already exists today, a high level of information overload (eight cues) was used.

### *Task setting*

The tasks required the group of judges to make a judgment to select the best-fit candidate in various settings. The information about the tasks was presented to the groups of all treatments (i.e., no GDSS, level 1 GDSS, and level 2 GDSS) in the same format. The format consisted of a description of the task and the list of criteria that was to be used for evaluating the candidates. Providing the task-related information in the same format for all the treatments ensured that the structure of the provided information did not confound the study. The groups used the information to evaluate a set of candidates, or cases, using the judgment process for the given treatment.

Since this study used a repeated measures design, different tasks had to be administered to the same subjects over different treatments to eliminate the learning effect that occurs if the same task is used repeatedly for all treatments. The task characteristics were controlled to make them evenly comparable for the profiles used in the different treatments. There are two types of characteristics to judgment tasks: substantive and formal (Brehmer 1976). Substantive characteristics that relate to the task content (e.g., admission policies, budget allocations, or stock choices) do not affect conflict as measured in the SJT paradigm (Brehmer 1976; Hammond and Brehmer 1973). However, the formal characteristics, which are a set of dimensions which characterize all policy tasks regardless of their content (e.g., the number of cues, the intercorrelations among the cues), do affect cognitive conflict. The judgment tasks containing similar formal characteristics and different substantive characteristics were designed using Stewart's (1988) approach which consists of describing the context for judgment, defining the judgment of interest, identifying the cues, defining the distributions of the cue values, and defining relations among the cues. To relate the tasks to the training of the subjects and increase the validity of the judgments, contexts were chosen that reflected the skills and knowledge possessed by the subjects.

In order to make the tasks representative, a two step approach was taken. First, a list of characteristics relevant in each task context was generated from the IS literature. This list was reviewed by students who were representative of the subjects used in the actual study. This survey determined what characteristics make an effective systems analyst, a results-producing CIO, and an efficient decision support system. This comprehensive list of candidate cues was ultimately narrowed down to the eight cues considered most important. The range of values taken on by each cue, their units of measurement, and the distribution of values (usually uniform or normal) over the cases were defined.

To bring the intercorrelations among the cues as close as possible to those in the environment, a procedure suggested by Stewart (1988) for subjective estimation of correlations was used. A large number of cue profiles were generated and a few subjects picked at random were asked to indicate which profiles were unrealistic or atypical. These profiles were then discarded. A cue profile was atypical if a value for a cue was beyond the environmentally existing range, or the values individually were typical but were non-existent in the combination of cues presented in the profile. Task descriptions were checked for clarity in the pilot study and intercorrelations between cues were checked to ensure these were comparable across the tasks. This control over the representativeness of the tasks in terms of cue importance, intercorrelations between cues, and the distribution of cue values was expected to provide a high level of validity to the judgments.

The number of cases that a subject must judge in a task must be large enough to produce stable statistical results, yet small enough that the subject can complete the task within time constraints. A lower bound on the number of cases is determined by statistical requirements for stable results and depends on the number of cues, the fit of the statistical model to the judgments, and the cue intercorrelations (Stewart 1988) The use of forty cases satisfied the statistical needs while not becoming too overwhelming to the subjects.

As an example, in one task the group simulated the activities of a recruiting committee set up to hire a Systems Analyst for the Information Systems department of a retail manufacturing company. Profiles of forty (40) applicants were considered. (In later sessions, the sequence of these profiles are altered to avoid any learning effects.) The applicants were evaluated on eight criteria (i.e., eight cues): (i) programming languages known, (ii) ability to communicate, (iii) operating systems used, (iv) quality of formal technical IS training received, (v) non-computer business experience, (vi) interpersonal relation skills, (vii) salary, and (viii) sizes of projects he has worked on. Group members individually and collectively used these criteria with the help of different communication supports, feedback mechanisms, and/or structuring methods in the different treatments to devise the judgment policies which they then used to rate an applicant's profile on a scale of 0 to 100, with 100 being the most favorable judgment.

In other tasks, the groups formulated a policy to guide ways to motivate the Information Systems staff and improve their job satisfaction, acted as a recruiting committee to select a candidate to fill the position of the Head of the Information Systems department in a retail merchandising company, and evaluated the prototypes of a Decision Support System to be used by the Sales Managers of a retail merchandising company.

### *GDSS environment*

The GDSS environment constitutes the three levels of research treatments: face-to-face (no GDSS), level 1 GDSS, and level 2 GDSS. The level 2 GDSS contained a computer-mediated judgment making structure comprised of MAU analysis integrated with cognitive feedback. Its effect was assessed by comparing it with an alternative computer-based design labelled as level 1 GDSS. Important characteristics of both designs are summarized in Table 2. The level 1 GDSS contained a judgment making structure made of a combination of scoring, ranking, and voting mechanisms. The feedback in the level 1 GDSS involved display of each group member's scores, ranks, and votes during the judgment making process. This structuring method was picked as the alternative design because these evaluation tools occur in a typical level 1 GDSS, such as the VisionQuest system (1992). Both level 1 and 2 designs were incorporated as separate modules in the VisionQuest system.

*Table 2*. Characteristics for the alternative SS designs used for research

| | No GDSS<br>Face-to-face | GDSS-1<br>Level 1 GDSS | GDSS-2<br>Level 2 GDSS |
|---|---|---|---|
| Communication Capabilities | | | |
| Anonymous input of ideas | Not available | Available | Available |
| Simultaneous input of ideas | Not available | Available | Available |
| Public display of ideas | Available | Available | Available |
| Cognitive Conflict Reduction Capabilities | | | |
| Evaluation of ideas | Allows only summary evaluation methods — voting, ranking, scoring | Allows only summary evaluation methods – voting, ranking, scoring | Allows evaluation specifically against each criterion, their utility functions and trade-off analysis |
| Aggregation of individual member's evaluations | Uses only summary aggregation methods | Uses only summary aggregation methods | Aggregation method considers utility of criterion |
| Feedback | Display of outcomes from individual and group evaluations | Display of outcomes from individual and group evaluations | Display of individual member and group's states at multiple stages of decision-making |
| Anonymous input of evaluations | Not available | Available | Available |

and feedbacks were face-to-face with the help of scratch-pads and blackboard in the manual group, these were through anonymous electronic communication in the level 1 GDSS. Also, the ranking, scoring, and voting were done electronically in the level 1 GDSS.

The level 2 GDSS meetings began with the group constructing a hierarchical structure of the task cues using electronic communication and tools which aided in grouping cues having common themes. The tools let the group members share their individual hierarchies with each other and assess group consensus through a voting mechanism. After a group hierarchy was determined, the MAU-based MCDM tool was activated from within VisionQuest to let each group member begin creating his/her utility function form (displayed graphically) for the cues on their own terminal. With each cue the group members viewed each other's function forms, discussed the differences and similarities, and went back to their function forms for the cue to modify it, if they so desired. This process was reiterated until all members were satisfied with their function forms for the cue. This method was repeated for all the cues. The group's function form for each cue was determined by averaging the function forms of all group members.

Next, the members individually assessed the relative importance of the task cues by trade-off analysis using the MAU-based MCDM tool. They discussed these relative importances through electronic communication and reverted to trade-off analysis to modify their assessments, if they so desired. The individual relative importance assessments of cues were averaged to determine the group's assessment. This assessment and the group's function forms of cues were used to construct the group's judgment policy which was then used to produce the group judgment scores.

After completion of any group process, each group member used the same decision-aids as used in the group process to individually judge the same 40 cases. This exercise revealed their post-decisional cognitive view. Once again the sequence of the cases were altered. A sample set of judgment scores is shown in Table 3. The last activity of the subjects involved filling out a questionnaire that assessed the subject's attitudes and perceptions toward the group judgment and group process.

### *Measurements of agreement and consistency*

The degree of interpersonal agreement for a group both at the pre-treatment and post-treatment levels, is determined by first calculating the degree of interpersonal agreement (rank correlation of judgment scores at the pre-treatment or post-treatment level, as the case may be) between each pair of members of the three-person group, followed by averaging the three values. The change in the degree of interpersonal agreement due to the group process is determined by subtracting the pre-treatment level from the post-treatment level. The degree of post-decisional agreement measures the agreement that a subject may have with the group's consensus judgment after participating in the group process. The level of agreement of each group member at the post-decisional level is measured by the coefficient of rank correlation between the judgment ratings made by the group and those made by the member after the group process. When averaged for the three members this produced the degree of post-decisional agreement for the group.

*Table 3.* Sample set of judgment scores

| GDSS I Treatment for Group 7 with Task 3 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sequence of Cases | Pre-treatment Individual Scores | | | During treatment Group Scores | Post-treatment Individual Scores | | |
| | Member 1 | Member 2 | Member 3 | | Member 1 | Member 2 | Member 3 |
| 1 | 27 | 80 | 71 | 59.2 | 65 | 80 | 70 |
| 2 | 33 | 85 | 68 | 70.3 | 76 | 80 | 50 |
| 3 | 50 | 90 | 95 | 77.7 | 89 | 78 | 80 |
| 4 | 10 | 87 | 90 | 63.0 | 85 | 70 | 53 |
| 5 | 41 | 92 | 70 | 77.7 | 80 | 79 | 75 |
| 6 | 59 | 95 | 78 | 70.3 | 84 | 84 | 78 |
| 7 | 42 | 75 | 75 | 55.5 | 73 | 60 | 77 |
| 8 | 25 | 70 | 68 | 44.4 | 65 | 60 | 55 |
| 9 | 59 | 90 | 85 | 77.7 | 85 | 85 | 78 |
| 10 | 50 | 70 | 75 | 59.2 | 75 | 65 | 70 |
| 11 | 39 | 88 | 80 | 70.3 | 78 | 70 | 62 |
| 12 | 59 | 91 | 80 | 66.6 | 86 | 68 | 65 |
| 13 | 63 | 78 | 75 | 51.8 | 72 | 60 | 70 |
| 14 | 50 | 85 | 86 | 66.6 | 77 | 74 | 65 |
| 15 | 62 | 88 | 95 | 85.2 | 90 | 81 | 93 |
| 16 | 39 | 80 | 83 | 66.6 | 83 | 70 | 50 |
| 17 | 57 | 72 | 82 | 70.3 | 85 | 70 | 85 |
| 18 | 50 | 79 | 70 | 74.1 | 68 | 60 | 65 |
| 19 | 40 | 68 | 68 | 55.5 | 80 | 58 | 70 |
| 20 | 47 | 82 | 85 | 66.6 | 70 | 75 | 70 |
| 21 | 69 | 76 | 78 | 66.6 | 80 | 70 | 82 |
| 22 | 69 | 80 | 95 | 85.2 | 87 | 85 | 92 |
| 23 | 53 | 87 | 90 | 88.8 | 95 | 82 | 70 |
| 24 | 89 | 89 | 88 | 88.8 | 86 | 80 | 85 |
| 25 | 50 | 94 | 70 | 66.6 | 72 | 78 | 80 |
| 26 | 70 | 70 | 90 | 85.2 | 84 | 75 | 85 |
| 27 | 66 | 76 | 85 | 70.3 | 85 | 70 | 80 |
| 28 | 72 | 78 | 85 | 74.1 | 75 | 70 | 82 |
| 29 | 62 | 74 | 78 | 66.6 | 78 | 70 | 80 |
| 30 | 50 | 74 | 88 | 74.1 | 79 | 72 | 82 |
| 31 | 55 | 80 | 95 | 81.4 | 95 | 85 | 85 |
| 32 | 57 | 80 | 75 | 55.5 | 73 | 77 | 75 |
| 33 | 63 | 77 | 70 | 66.6 | 83 | 70 | 70 |
| 34 | 70 | 84 | 76 | 70.3 | 77 | 70 | 85 |
| 35 | 75 | 82 | 85 | 70.3 | 75 | 75 | 80 |
| 36 | 77 | 84 | 83 | 77.7 | 85 | 74 | 73 |
| 37 | 77 | 82 | 93 | 96.3 | 92 | 84 | 90 |
| 38 | 77 | 87 | 93 | 77.7 | 86 | 88 | 88 |
| 39 | 60 | 78 | 92 | 66.6 | 77 | 70 | 85 |
| 40 | 66 | 82 | 88 | 88.8 | 87 | 90 | 95 |

The index of judgment consistency of each group member is the coefficient of determination or the square of coefficient of multiple correlation between the cues and judgments made by the member. The change in the index of consistency for each group member due to the group process is determined by subtracting the pre-treatment level from the post-treatment level. A group's index of consistency is the square of the coefficient of multiple correlations between the cues and judgments made by the group.

## Results

### *Hypothesis 1: Degree of agreement*

Reduction of cognitive conflict leading to increased agreement was hypothesized to occur from use of some GDSS designs both at the interpersonal and post-decisional levels. Since the two dependent variables may be correlated and share a common conceptual meaning, a multivariate analysis of variance (MANOVA) was carried out to detect significant effects. Also, even if the treatments might not produce significantly different effects on any of the variables individually, jointly the set of variables might reliably differentiate the treatment effects, which can be detected through MANOVA. Additionally, the effect of using different tasks in the experiment was tested in the MANOVA. The results indicate that for the null hypothesis of no overall effect of task on change in interpersonal agreement as well as change in post-decisional agreement, the Wilk's lambda ($W$) was 0.99 and the multivariate $F$ for 6 and 116 degrees of freedom was 0.14 which corresponded to a $p$-value of 0.99. Therefore, the null hypothesis could not be rejected at an alpha level of 0.05 concluding that task did not affect the dependent variables. The multivariate test for interaction between task and GDSS failed to reject the null hypothesis that there is no overall effect of interaction between task and group support system ($W$ = 0.80, $F(12,116) = 1.16$, $p = 0.32$).

The multivariate test for overall GDSS effect rejected the multivariate null hypothesis and indicated that the two levels of GDSS and the non-computer-supported face-to-face environment differed overall on the set of two variables ($W = 0.44$, $F(6,116) = 14.74$, $p = 0.0001$). Individual *post-hoc* analyses consisting of testing two null hypotheses separately in a one way analysis of variance (ANOVA) and means comparison tests (using Tukey's Range Procedure) were carried out. The null hypothesis stating that the reduction in disagreement among individual judgments after a group process are no different (regardless of GDSS support), was rejected ($F(2,59) = 34.31$, $p = 0.0001$). The Tukey test indicated that while the improvement in interpersonal agreement level was highest for groups supported by the level 2 GDSS (GDSS-2), there was no statistically significant difference between groups supported by the level 1 GDSS (GDSS-1) and those without any GDSS support (No GDSS) (Table 4).

The null hypotheses that the population means are zero were rejected in $t$-tests at an alpha level of 0.05. The same pattern was detected in the post-decisional conflict levels reflected in the change in level of disagreement between the post-meeting individual judgments and their group judgments. The null hypothesis stating that the reduction in disagreement between individual members of a group and the group as a whole after a group process are no different regardless of GDSS support, was rejected ($F(2,59) = 32.09$, $p = 0.0001$).

*Table 4.* Means comparison of changes in levels of agreement

| Group Support | Increase in level of interpersonal agreement (Coeff. of Correlation) | | Increase in level of post-decisional agreement (Coeff. of Correlation) | |
|---|---|---|---|---|
| | Mean | Tukey Grouping | Mean | Tukey Grouping |
| No GDSS | 0.1727 | B | 0.1298 | B |
| GDSS-1 | 0.0894 | B | 0.0653 | B |
| GDSS-2 | 0.4627 | A | 0.3213 | A |

Means grouped with the same alphabet are not significantly different.

### *Hypothesis 2: Degree of consistency*

Improvement of judgment consistency was hypothesized to occur from use of the level 2 GDSS both at the individual and group levels. The consistency of judgment at the individual level can be measured again at two levels. One level is the change in the individual's consistency due to the group process in a particular GDSS environment. The other level is the post-decisional judgment consistency of the individual, that is, how committed the individual is to his or her group's judgment. This was measured as the deviation of the individual's judgment consistency from the group's consistency.

To detect whether these two dependent variables measuring individual member's consistency of judgment might be correlated and share a common conceptual meaning, and to check whether jointly the set of variables might reliably differentiate the treatment effects even if individually they do not, a multivariate analysis of variance (MANOVA) was carried out. The multivariate test for group support system rejected the multivariate null hypothesis and indicated that the three levels of group support system differ overall on the set of two variables ($W = 0.71$, $F(4,400) = 18.73$, $p = 0.0001$). Task did not affect the dependent variables and no interaction was detected between task and the GDSS designs.

*Post-hoc* analyses through ANOVA tests indicated that the GDSS design significantly affected an individual member's consistency of judgments ($F(2,201) = 27.70, p = 0.0001$). Tukey's test (Table 5) indicated that the improvement in judgment consistency was highest for individuals when their groups were supported by level 2 GDSS. There was no statistically significant difference between level 1 GDSS and non-computer based face-to-face groups in improving consistency levels of individuals though both these conditions did provide some improvement. The mean change in consistency levels were found to be non-zero at an alpha level of 0.05 for all levels on the GDSS factor. Concerning the post-decisional consistency of an individual's judgment (i.e., how close an individual's judgment consistency is after the group process to the group's consistency), the GDSS factor was found to have a significant effect ($F(2,201) = 11.15, p = 0.0001$). The means comparison test showed that the consistency of judges supported by both level 1 GDSS and level 2 GDSS were closest to their group's consistency.

The consistency of group judgments was significantly affected by GDSS designs ($F(2,59) = 13.72$, $p = 0.0001$). The means comparison tests (Table 5) indicated that the highest

*Table 5.* Means comparison of consistency of judgments

| | Individual level | | | | Group level | |
|---|---|---|---|---|---|---|
| Group | Change in consistency[1] | | Deviation from group's consistency | | Absolute consistency | |
| Support | Mean | Tukey[2] grouping | Mean | Tukey grouping | Mean | Tukey grouping |
| No GDSS | 0.076 | B | –0.130 | B | 0.830 | A |
| GDSS-1 | 0.060 | B | 0.003 | A | 0.671 | B |
| GDSS-2 | 0.294 | A | –0.011 | A | 0.914 | A |

[1]Unit of consistency is coefficient of determination. [2]Means grouped with the same alphabet are not significantly different.

consistency was demonstrated by groups supported by level 2 GDSS and those without any GDSS support whose means (0.91 and 0.83 respectively) were not statistically different.

### *Hypothesis 3: Attitudes and perceptions*

The attitudes of the subjects were measured in terms of attitude towards the group judgment and attitude towards the judgment-making process by ranking the treatments. Attitude towards group judgment was evaluated by directly measuring perceived judgment process structure, confidence in judgment quality, perceived acceptability of judgment, and enhancement of problem-solving ability. Attitude towards the judgment-making process was assessed through direct measurement of positive affect toward process, perceived process adequacy, and satisfaction with resource expenditure. The perception of subjects of the group judgment-making environments were measured in terms of perceived degree of consensus and cooperation by ranking the treatments.

In a MANOVA test, while the GDSS design was found to be significant as expected ($W = 0.47$, $F(18,392) = 10.06$, $p = 0.0001$), the task used also turned out to be significant at an alpha level of 0.05 ($W = 0.78$, $F(27,573) = 1.93$, $p = 0.001$). Since the responses seeking the subjects' attitude and perceptions of all three group judgment support environments were obtained at the end of the last group session, it is possible that impressions of the task used in the last group session were stronger in a subject's memory. No interaction between task and group support system was detected ($W = 0.80$, $F(54,1004) = 0.83$, $p = 0.81$). ANOVA and means comparisons tests conducted separately on the variables revealed that the subjects had the best opinion about level 2 GDSS on 7 out of 9 variables and second best on the other 2 variables (Table 6). The non-computer-supported face-to-face environment ranked as well as level 2 GDSS in 5 out of 7 variables and outranked it in two others. The level 1 GDSS was perceived as the least effective group support system.

## Discussions and conclusions

Hypotheses 1a and 2a have been rejected. The level 1 GDSS was actually inferior to the face-to-face meetings in reducing cognitive conflicts as well as producing consistent

*Table 6.* Comparison of means of attitude and perception measures across GDSS designs

| Group Support | Attitude towards group judgment: Perceived judgment process structure Mean[1] | Tukey[2] grouping | Confidence in judgment quality Mean | Tukey grouping | Perceived acceptability of judgment Mean | Tukey grouping | Enhancement of problem-solving ability Mean | Tukey grouping |
|---|---|---|---|---|---|---|---|---|
| No GDSS | 2.95 | A | 2.32 | B | 2.38 | B | 2.74 | A |
| GDSS-1 | 2.80 | A | 2.89 | A | 2.81 | A | 2.84 | A |
| GDSS-2 | 1.81 | B | 2.36 | B | 2.36 | B | 2.12 | B |

| Group Support | Attitude towards group judgment-making process: Positive affect towards process Mean | Tukey grouping | Perceived process adequacy Mean | Tukey grouping | Satisfaction with resource expenditure Mean | Tukey grouping | Intentionally left blank |
|---|---|---|---|---|---|---|---|
| No GDSS | 2.38 | B | 2.09 | C | 2.22 | B | |
| GDSS-1 | 2.80 | A | 2.82 | A | 2.81 | A | |
| GDSS-2 | 2.36 | B | 2.64 | B | 2.38 | B | |

| Group Support | Perceived degree of consensus: Group consensus Mean | Tukey grouping | Perceived group cooperation: Degree of cooperation Mean | Tukey grouping | Intentionally left blank | Intentionally left blank |
|---|---|---|---|---|---|---|
| No GDSS | 2.19 | B | 1.91 | B | | |
| GDSS-1 | 2.89 | A | 2.58 | A | | |
| GDSS-2 | 2.56 | B | 2.84 | A | | |

[1]Lower numbers mean better.
[2]Means grouped with the same alphabet are not significantly different.

judgments. Notably, it was perceived to be inferior as well. In fact, it received the lowest rating on all variables used in measuring the users' attitudes and perceptions. This finding is in agreement with Sambamurthy and Poole's (1992) deduction that after generating confrontiveness, the level 1 GDSS features are insufficient to facilitate a participant's understanding of his own judgment model as well of others in the group. The lack of understanding of each other's viewpoints gives rise to interpersonal disagreement. The inability of level 1 GDSS to adequately integrate individual opinions causes a high level of post-decisional disagreement. These conclusions indicate non-completion of the differentiation-integration cycle of the conflict management process (Folger et al. 1992). If a group is unable to enter the integration phase, then the conflict stage that was unraveled in the differentiation phase gets prolonged, leading to dissatisfaction in the process and the outcome. The inferior management of the cognitive conflict process by the level 1 GDSS compared to the face-to-face meetings which had the judgment structuring method can be explained by the propensity of anonymity and parallel communication in level 1

GDSS to reveal widely diverse beliefs and viewpoints in larger volumes than in face-to-face meetings leading to increased level of confrontiveness which could not be reconciled.

Based on earlier findings in SJT research (Brehmer 1976), the large volume of opinions that the group of judges are subjected to in an anonymous environment in a level 1 GDSS may induce them to adopt a few in their own judgment models. This is because when the cause of differences lies in cognitive bias, initial reduction of differences have been found to be prompted by the judge's desire to give up the dependency on cues which he found to be unreliable in the differentiation phase which is brought about partly due to the electronic communications. However, cognitive limitations make it difficult to learn to depend on a new set of cues just on the basis of a superficial look at those cues as aired by other members in the differentiation phase (Hammond and Summers 1972). The communication support structures and the judgment-aiding structures (i.e., ranking, scoring, voting) in level 1 GDSS did not provide a sufficiently detailed analysis of the policy in the attempted integration phase for the individual members as well as the group to understand the implications of it sufficiently. Thus, the individual judges and the group were not able to consistently apply the judgment policies either individually or collectively.

At virtually every level of society, judgment policies involve many objectives or cues, some of which may be conflicting. Since the conflicting nature makes it impossible to optimize all the cues simultaneously, the best possible policy would be one that reflects the most appropriate trade-offs between the cues as envisaged by the judge. Judging is further complicated because a judge judges based upon his/her "view" of the world. This is especially true when judgments involve cues where objective knowledge about that aspect of the problem either cannot be obtained or cannot be formed (Anthony 1965; Mintzberg et al. 1976). Since structuring the intangibles in a problem depends mainly on the cognitive efforts of the member, every member in the group may have a perception that is different from the actual state of a multicriteria problem.

The reality that judgment tasks are multicriteria problems makes a level 1 GDSS ill-equipped to manage them (DeSanctis and Gallupe 1987; Vogel and Nunamaker 1990). Nunamaker, Applegate, and Konsynski (1988) express the need for better support of deliberation and judgment to enable more structured problem solving and decision making. With several conflicting cues involved in a judgment problem, the resulting information overload prompts the judge to use simpler decision rules – an action that is likely to produce inaccurate or less than perfect conclusions (Svenson 1979) and supported by our findings. A more complex decision rule, such as one created using multicriteria methods will require greater information processing capability than is available in a level 1 GDSS. In their contingency model of GDSS based on human information processing theory, Rao and Jarvenpaa (1991) propose that a computational support feature of GDSS will be desirable when the GDSS is used with tasks that have a high proportion of information processing activities. DeSanctis and Gallupe (1987) propose incorporation of MCDM methods in level 2 GDSS, an idea supported by several researchers (e.g., Minch and Sanders 1986; Nunamaker et al. 1988; Shakun 1988; Steeb and Johnston 1981), and implemented along with integrated cognitive feedback mechanisms and tested by us to produce results that are in cognizance with earlier studies.

Our results supporting hypotheses 1b and 2b and the results of testing of hypothesis 3 show that the level 2 GDSS equipped with cognitive feedback and MAU theory-based MCDM tools was the most effective in reducing cognitive conflict, improving consistency of judgments both by individuals and groups, and was perceived as one of the most effective group judgment-making environment. While subjects expressed satisfaction with the non-computer-supported face-to-face meetings and perceived them as effective, the reduction in cognitive conflict from these meetings was not as impressive. The improvement in agreement among group numbers was 2.7 times greater following the level 2 GDSS meetings than after the face-to-face meetings. Group members agreed more closely with the group's judgment after level 2 GDSS meetings than after the face-to-face meetings (2.5 times more). As mentioned earlier, face-to-face meetings often fail to unveil important task related information. If there is unshared information among the group members that may reveal distinct decision strategies, such as relationship among cues and between cues and the criterion, groups may fail to converge on a common decision rule and properly apply it (Stasser 1992). The level 2 GDSS overcame the deficiency by modifying the MAU theory-based structuring approach to incorporate feedback at various stages that guided judges to share ideas and information helped them to gain a better insight into the trade-offs that needed to be made. In such an approach all members of the group began the process by forming their individual judgment policies initially relying on an individual belief system and subsequently modifying those assessments by sharing in the belief systems of other group members. The final result was a group policy that was well understood by all the group members who could then use it consistently.

The improvement in consistency of individual judgments after level 2 GDSS supported meetings was 3.8 times over the next best group environment (the non-computer-supported face-to-face meetings). The consistency of group judgments made in level 2 GDSS meetings was, however, only 1.1 times better than that in the face-to-face meetings. The lower post-decisional consistency of individual members in the face-to-face meetings, however, is indicative of the group's decision rules not being truly consensus building in nature. The level 2 GDSS meetings were characterized by high consistency of group judgments and the individual post-decisional judgments mark a greater degree of commitment by the group members.

The evaluation of the level 2 GDSS in a laboratory setting limits the generalizability of the findings. However, efforts were made to minimize such limiting effects by customizing the task (i) to simulate real judging situations that subjects were knowledgeable about and (ii) to involve human information processing and judging abilities which can be performed competently by students. In designing the cognitive conflict tasks a concession from real life judgment situations was made in that the cues were identified and presented to subjects. In many judging situations, judges usually must first identify the cues or issues involved in the task.

Nevertheless, this study combines knowledge in information systems, management science, and cognitive science that have contributed to an understanding of procedural rationality (how decisions should be or are made in intelligent systems (Shakun 1988) to build and evaluate a more purposeful information system to resolve cognitive conflict tasks under complexity involving multi-participant, multicriteria, and ill-structured problems. The system provided a greater reduction in cognitive conflict and a higher improvement in judgments consistency than conventional face-to-face meetings or level 1 GDSS did. The level 2 GDSS design improves upon the current state of GDSSs which rely primarily on communication mode and outcome feedback, in helping produce more committed and consistent group judgments by encompassing a set of interactive decision-aids that (a) externalize and communicate value functions; (b) provide needed factual information and projections; (c) allow for an integration of facts and values; (d) provide for a tracking and feedback mechanism that can be used to assess sensitivity to changes in assumptions about either factual information or the values of the judges; and (e) order the preferences of judges. The architecture can be used not only to help organize and manage the flow of information regarding cognitive conflict tasks, but also to provide judges with a framework for assessing and communicating their judgment policies, thus leading to more consistent, and more satisfying, judging results.

*Future research potential*

The results of the research conducted provide an excellent basis for further research in several directions. One avenue for future research is to study the quality of group judgments produced by the level 2 GDSS design. Evaluation of quality will require, according to Brunswik's theory of probabilistic functionalism (1952, 1955), a method that compares the experimental judgments with those that were made in the past and were found to deliver the desired outcomes.

While the level 2 GDSS design produced better agreement and consistency of judgments, it did not come out a clear winner in terms of ease of use and perceptions of the users. Another direction for future research would be to carry out a detailed analysis of the conflict resolution process to investigate the reasons which in turn will lead to solutions for improving the level 2 design to make it easier to use, consume less time, and generally be more acceptable to users. Another avenue of future research could be to use other multicriteria methods with appropriate cognitive feedback mechanisms inserted in the group process. Within the MAU method of multicriteria decision-making, the group utility function can be determined in several ways. Further research can provide a comparison of the impact of the various approaches to determining the group utility function built into a level 2 GDSS on the properties of group judgments generated with the help of such GDSSs.

The key for improved resolution of cognitive conflict, it seems, is to help individuals learn from one another in a structured manner and aggregate their individual judgments into a group judgment in an iterative manner where the group members continue to learn from one another and converge to a group judgment gradually.

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