The Group Consolidation Problem During GSS Usage: A New Approach and Initial Empirical Evidence

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ABSTRACT

When a group follows an automated implementation of the "logical decision making process," at some time they must analyze, reduce and categorize the often copious set of possible alternatives generated (consolidation). The traditional approach implemented in current Group Support Systems often follows a difficult and time-consuming, serial process. To address this, we 1) identify a systems bottleneck given the current methods for consolidation; 2) propose a potentially more efficient and effective consolidation process; 3) describe a software system we have developed that demonstrates the feasibility of a parallel approach; 4) and report initial results from an experiment using the system.

INTRODUCTION

There is a growing recognition that computer support can enhance face-to-face meetings by allowing individual group members to work in parallel. Many, if not most, decision processes require groups to meet and discuss concepts, ideas and plans before making decisions individually or as a group. Information sharing, negotiation, argumentation and presentation form the kernel of this interaction.

An area of research which endeavours to support group work is Group Support Systems (GSS). GSS consist of software tools that run on local area networks and allow groups to work in real time and in parallel. In one common configuration, each participant in a meeting has a personal workstation. The group decision making paradigm embedded in the software used in this envrionment often employs an automated implementation of the "logical decision making process" put forth by Simon [25] (i.e., generate alternatives or brainstorm, evaluate alternatives, and then select the best alternative based on the group's goals). A group following Simon's model must analyze, reduce and categorize the copious set of possible alternatives generated. This often used approach to bring organization to chaos has previously been a tedious, error-prone, and time-consuming task for computer supported groups [6, 9]. This procedure, the focus of this paper, will be referred to as **consolidation**.

The goal of this research is to ease the difficulty of consolidation by presenting a new approach operationalized in the form of a computerized tool (**FOLDERS**) that supports the surfacing of issue categories. In addition to surfacing issues, the new system provides immediate feedback of the group's level of consensus during the consolidation process. Thus, this advanced software system is able to provide support for groups of decision-makers to contribute their **personal** categorization of issues while engaged in the group decision-making process. The contributions of this paper are twofold: 1) the design and implementation of a graphical system to support a new process for consolidation, and 2) a report on some preliminary results of groups using the system.

Note that while our discussion focuses on synchronous, face-to-face implementations of GSS, it is equally applicable to asynchronous, computer-based meetings (i.e., computer conferencing). We believe that:

- GSS increases the production of ideas in a brain-storming activity; but
- This increased productivity merely enhances the need for tools to handle the greater output.
- This output is relatively unstructured and needs to be reduced in volume and enhanced in content and format; however
- Current ways of doing this are inherently inadequate and would profit from some sort of process structure.

Section 2 outlines existing Group Support Systems, the components that address group consolidation and results from previous experiments that might be applicable. The architecture of FOLDERS is presented in Section 3 and results of a pilot study are reported in Section 4. Finally, Section 5 discusses conclusions and potential future research.

PREVIOUS GSS RESEARCH

The goal of using a GSS is to reduce the process losses associated with disorganized group activity and other difficulties commonly encountered during group work. At the same time, a GSS should increase efficiency and quality of the resulting group decision while at the least not changing the process gains of group activity. The process losses and gains of group activity, whether computer supported or not, are listed in Table 1 [5, 10, 15, 28].

It has been argued that the electronic medium should allow greater, but more equal, participation in decision-making and increased access to meeting information [5]. Consequently, the resources of a group should be fully extracted in a group discussion, a more democratic decision process should emerge, and some structure should be added to what is otherwise a "muddling through" process for groups. It has also been said that the reduction of social context cues in computer-mediated communication may "reduce normative influence relative to information influence," which in turn might "reduce the impact of reference group norms and of group members' social approval of one another, and increase the importance of arguments or decision proposals..." [24].

Table 1

Group Work Process Gains and Losses

Process Gains	
Cognitive Synergy	Individuals are "sparked" by one another (i.e., the group is greater than the sum of the parts).
Stimulation	People receive feedback from other group members.
Imitation	Participants observe others and learn from them.
Memory	Individuals remember others' ideas increasing the likelihood of the idea being remembered or acted on.
Process Losses	
Production blocking	Group members receive unequal air time to put forth their thoughts.
Evaluation Apprehension	Some individuals are afraid to voice their opinion due to worry about consequences.
Free Riding	Some participants may be content to let others do the work.
Failure to Listen	People may daydream or be close-minded, perhaps depending on who is speaking.
Conformance Pressure	Individuals might comply with the group's implied or explicit wishes.
Cognitive Inertia	It can be difficult to move an entire group from a particular position to a new position.
Member Domination	Individual(s) may control the group interaction.
Socializing	Interaction with other group members may not be focused towards the task.

Where offered and employed, anonymity should decrease the probability of punishment for discrepant or unusual expression. This, in turn, should increase the scope of expressiveess of ideas available in a meeting. Ideas, rather than the initiators of those ideas, become the object under discussion. Group memory should be enhanced because GSS records every idea without loss, alteration or the need for editing. Further, a GSS should foster more even participation in situations where a group must achieve consensus and facilitate a systematic or structured group decision process, thus resulting in more effective conflict management. In summary, the suggested sources of benefit from a GSS are these [29]:

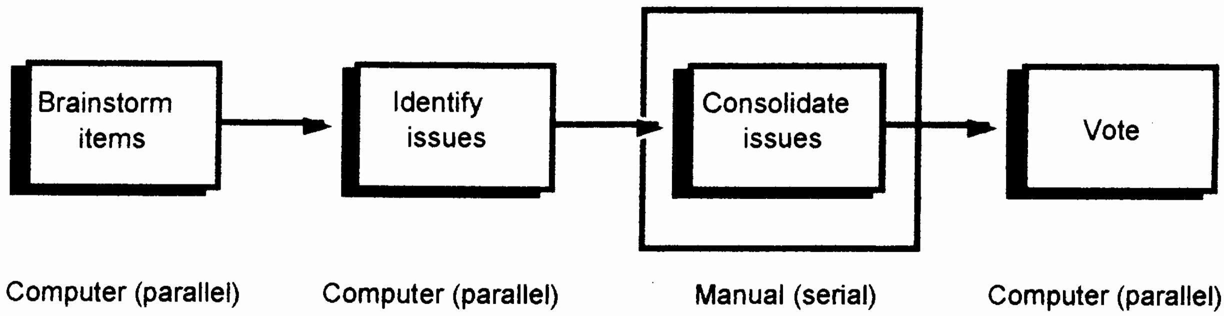
- Structured Interaction Process (to increase process gains)
- Parallel Communication (to increase participation rates)
- Group Memory (to increase retention and the ability to span time)
- Anonymity (to increase the breadth of expression in participation)

Existing GSSs Approach Towards Consolidation

Several popular groupware systems provide support for system design, decision making, and discussion, among other meeting objectives. These include GroupSystems [5, 20], SAMM [30], COLAB [26], NICK [10], Coordinator [11], Information Lens [17], EIES2 [31], and rIBIS [21]. Figure 1 represents the generalized data flow and propagation of the group support systems agenda that the various GSS often follow (i.e., discuss/alternative generation, consolidation and vote sequence). Under this model a session begins with a problem or focus item. Using the specific example of

Figure 1

Group Decision Making Process Model



GroupSystems (a widely known GSS), the problem is replicated in N + 1 (N=number of users) discussion files and users are encouraged to comment upon the problem and one another's responses during a brainstorming session. Users often make one entry into a file and are then switched to another file. This allows N + 1 different discussion streams to develop and encourages all viewpoints to be considered.

Following the brainstorming sequence, users work individually, using the computer, to generate lists of issues or solutions to the problem (phase 2). The lists are then merged and consolidated (phase 3) by verbally instructing the facilitator. Finally, a computerized vote is taken (phase 4). This process can then branch and/or repeat as necessary.

It is the merging and consolidation of information that has been found to be difficult and unenjoyable [6, 9]. One can see that the process is performed anonymously in parallel using the computer up to the point of consolidation, then it becomes serial, public, and verbal as users direct the facilitator. Directly thereafter the process becomes parallel and anonymous again during voting. This is a potential systems bottleneck. Consolidation also reinstates most of the losses inherent in face-to-face meetings that GSS is intended to overcome. A lengthy, frustrating and inherently uninteresting task has the potential to spoil most of the rest of the agenda. Certain members may dominate the process while others may feel inclined to keep silent. This represents an inefficient use of the entire knowledge base of the group and may result in lack of consensus and dissatisfaction with the group process and outcome.

The current set of tools for organizing ideas do not allow either for efficient parallel processing of opinions or anonymity. For example, GroupSystem's Topic Commenter or Group Outliner can be used primarily to obtain each group member's opinions towards consolidation. Yet, after each individual's comments are obtained, the group members must still endure the serial and public discussion process regarding how to consolidate their opinions. The same is true when using COLAB's Argnoter, since group members still need to worry about how to assess all the links. Likewise, the rIBIS system (which builds a network of Issues, Proposals, and Arguments that all group members can traverse) has no mechanism for categorization. To the best of our knowledge, the existing tools merely support the primarily public process by which each group member serially voice their opinions concerning how to group issues or ideas. Instead of using a flipchart or blackboard, group members or the facilitator are given the freedom to perform this task using the computer. Nonetheless, the procedure by which this is done is still primarily a serial one.

GSS Experimental Results in Idea Generation

Most of the studies in GSS research have focused on the earlier stage of idea generation. The results suggest that a GSS has the potential to provide these benefits in idea generation:

- Increased Task Focus through increased synergy and reduced 1) free riding, 2) production blocking, 3) failure to listen, 4) socializing.
- Increased Democratic Process via structured interaction process and reduced 1) member domination, 2) conformance pressure.
- Increased Equality of Participation through increased stimulation and reduced member domination.
- Increased Efficiency because more can be accomplished in less or the same amount of time [19].
- Support for Large Groups since it appears that these gains scale upwards in a somewhat linear fashion [7].

Yet, outcomes are equivocal. For example, Turoff and

Hiltz [27] looked at participation using a GSS that was purely a communication tool. In sets of five, participants were physically isolated in separate rooms. No meeting structure was imposed. Computer-supported group decision quality was not significantly better than face-to-face and in the former groups, no clear leaders emerged and role differentiation was less pronounced and more unstable. Gallupe [8] found that SAMM improved decision quality for difficult tasks but decreased group satisfaction; there was more dissatisfaction in the easy task groups than in the hard task groups. However, groups using the GSS were not restricted to using only the GSS nor was any meeting structure imposed.

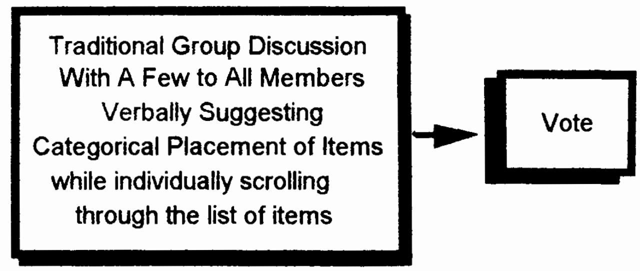
Applegate [2] examined seven cases of planning groups from industry with an average group size of fifteen. Her study found that GroupSystems stimulated task oriented behavior, decreased group interactions and equalized participation. Gallupe, DeSanctis and Dickson [12] found that decision quality is enhanced by the GSS and that the number of alternatives examined before making the decision was increased. However, they also found that the confidence in the decision was reduced and that participation was unaffected by those groups using the GSS. Watson [30] found that SAMM helped groups deal with potential conflicts in such a way that group consensus was improved. However, they did not find that equality of influence was improved by the use of a GSS. Lewis [18] used a GSS that imposed structure on his computer supported groups and found that the GSS groups made significantly better decisions and generated more alternatives to evaluate. As well, Gallupe and McKeen [13] noted that when GSS was employed, dominance in small groups was less than that in traditional face-to-face meetings.

SUMMARY

Previous research has shown that idea generation is greatly enhanced when computer mediation is available in appropriate tools. However, these gains would ultimately prove fleeting if later phases of the agenda treated the ideas and participants in a less-than-optimal way. It is possible that some of the less than favorable outcome results previously mentioned are indirectly linked to difficulties in the subsequent consoldiation stage. In this study, we focus on consolidation because it has not been supported by computers (except in a chauffeured text editing mode). We believe the current approach (see Figure 2) often lead to loss of ideas, unwanted and irrelevant increase in group conflict, and an incorrect and undemocratic reduction of a large list of good ideas into a small list of potentially poorer categories. This concern led us to conceptualize consolidation as a pooled individual exercise along the same lines as brainstorming. We have developed FOLDERS to implement this concept and are attempting to validate the notion through experiments.

Figure 2

Current Approach Towards Consolidation



NEW CONSOLIDATION APPROACH

Contrasted to the traditional consolidation approach used in GSS studies, our new process (see Figure 3) works as follows:

1. Each member is asked to simultaneously sort items into "clusters" according to personal criteria. Sorting can even be done "holistically" without the need for each member to break down their action to specific criteria and weighting schemes.

2. The sortings are automatically collected and two matrices calculated representing: 1) the aggregate group sorting and 2) the level of sorting consensus among each member [3].

3. The "group opinion" represented by the aggregate group co-occurrence matrix is fed into several clustering algorithms (specifically, factor analysis, multidimensional scaling, and hierarchical agglomerative cluster analysis). The results of the clustering algorithm are immediately presented to the group for further discussion.

4. Furthermore, the "group dispersion" (i.e., data representing the level of sorting consensus among members) is also fed into the clustering techniques. Instead of representing the underlying factors for the entire set brainstorming items, the cluster(s) produced here represent the various groups of people whose opinions are similar.

By encouraging individuals to express their particular views of how the items are related, it is expected that member domination, production blocking, evaluation apprehension, and conformance pressure will be greatly reduced. As well, the time required to consolidate may also be reduced due to parallel entry of clusters as opposed to serial discussion of the clusters. The outcome should more closely reflect the group position, but at this point we cannot say if it will lead to a more effective solution (i.e., extremely task dependent).

The system designed to accomplish this, **FOLDERS** (see Figure 4) is implemented in Microsoft Windows 3.1.

Figure 3

New Approach Towards Consolidation

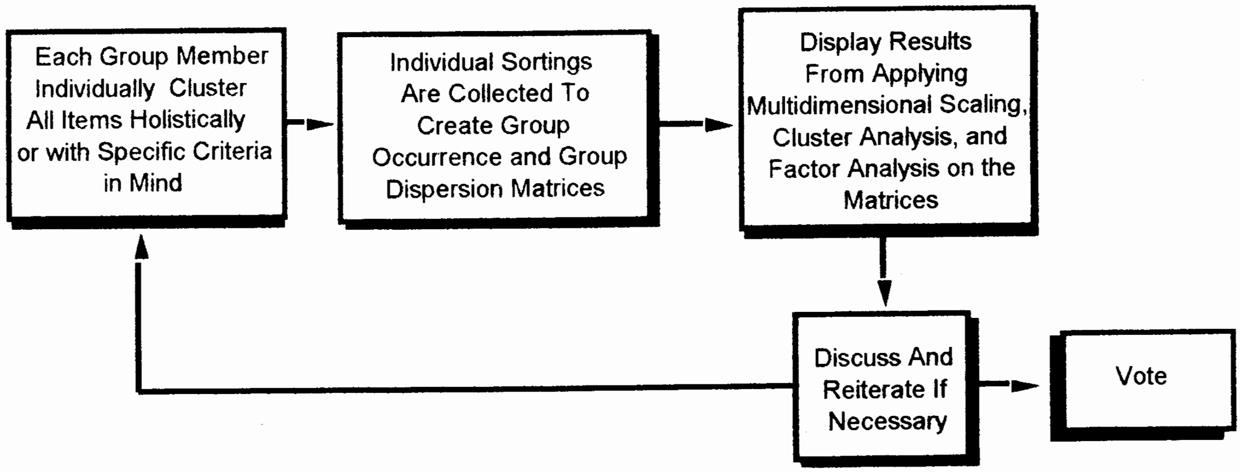
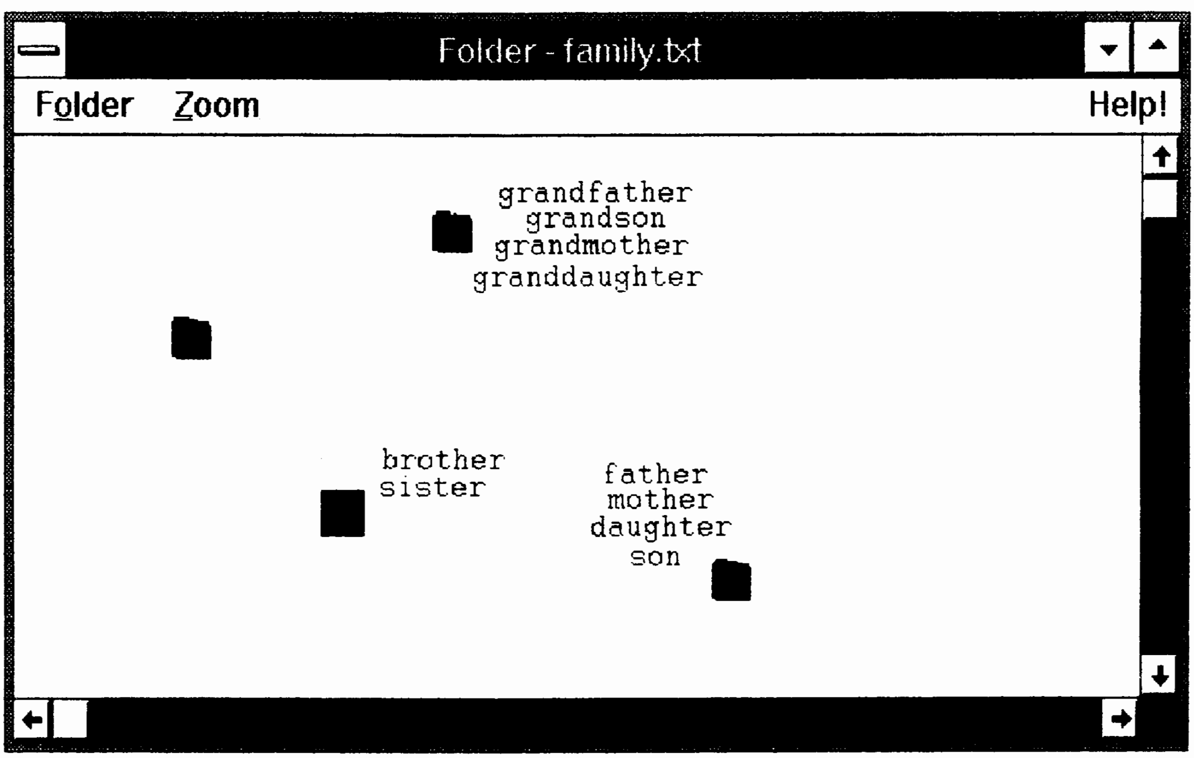


Figure 4

FOLDERS Window



FOLDERS allows users to manipulate text objects with a mouse in a window using the "drag and drop" paradigm on a virtually large work surface. View management functions such as scrolling and zooming are supported; fonts adjust accordingly. Once a user has determined to which category/ cluster a text object belongs, a new "file folder" icon is created, dragged somewhere on the surface and the text object dropped inside. Multiple folders can be created and their contents cut and pasted from one to another (double click with the mouse). Currently, text items may be clustered within only one folder at a time (no multiple occurrences are allowed). Folders may also be labelled although that is not a requirement of the process.

After a user has put all of the clustered text objects into folders (any individual text objects left on the display are assumed to be each in a folder by themselves), their clusters are saved. The matrix module adds their information to the co-occurrence matrix file. When all users have finished (or perhaps even at some intermediate point), the facilitator's cluster module reads the matrix file and produces the group clusters and group dispersions. The output of this module is made available to all users for display and manipulation. Differences between the averaged group clustering and each individual user are displayed as well as differences in clustering among users. At this point, users are free to discuss the clusters produced verbally or electronically, perhaps shuffling items and determining labels. They can then proceed to the voting step (choice).

The choice of results displayed can also vary depending on the purpose and level of detail individuals in the group

Figure 5

Hierarchical Cluster Analysis of Kinship Terms

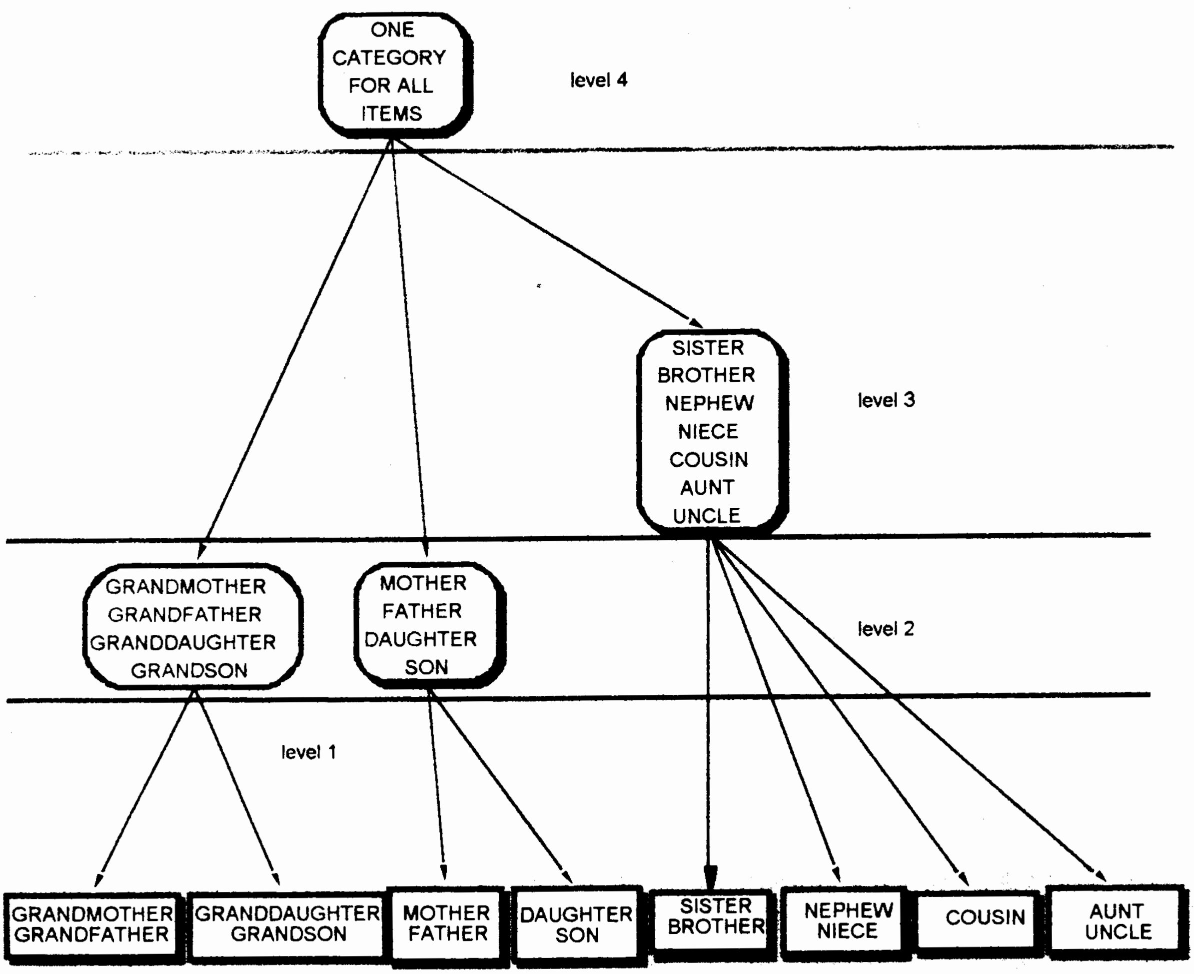
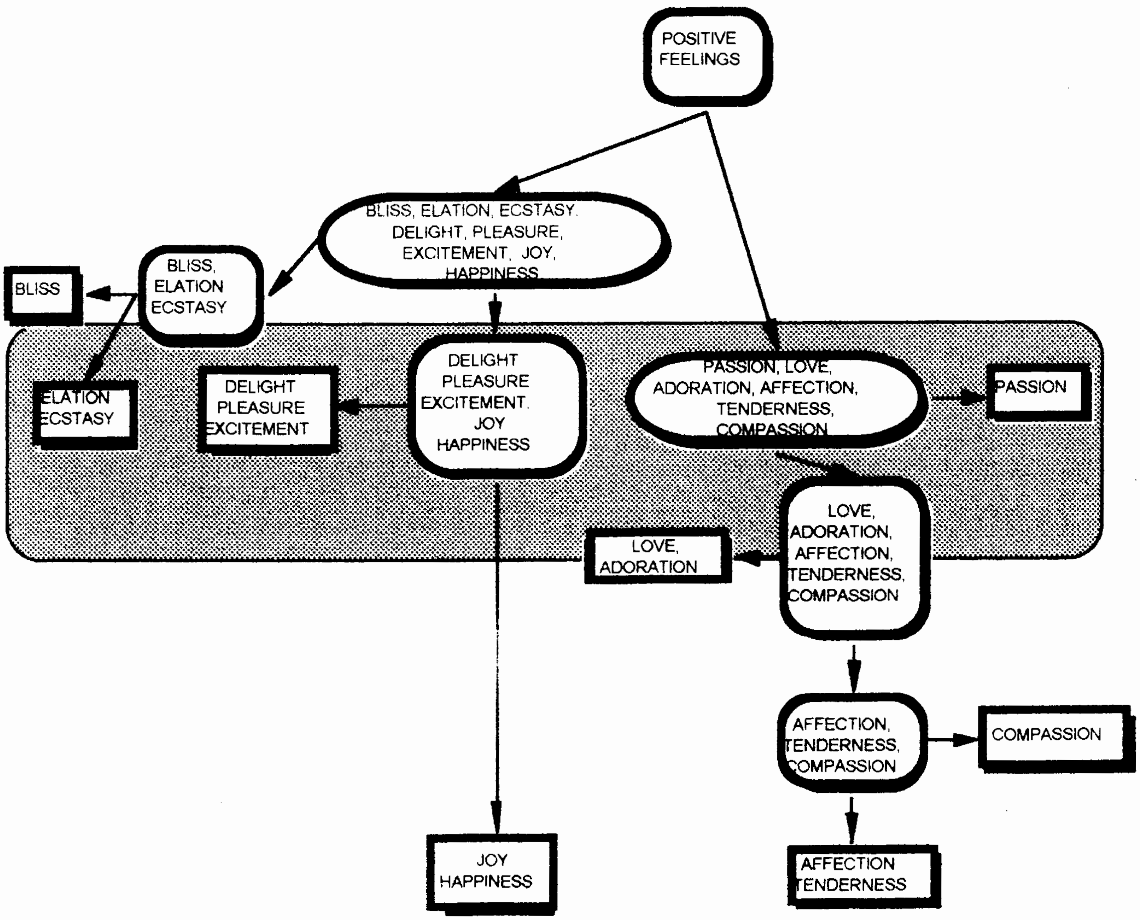


Figure 6

Hierarchical Cluster Analysis of Positive Emotion Terms



desire. At a holistic level where members wish to see the clusters in a "gestalt" manner, output from multidimensional scaling can be presented in a 3-dimensional graph (e.g., Figures 8 & 9) [4]. The group average clustering can also be represented in a hierarchical fashion allowing the group the freedom to discuss and choose the level of granularity for categorizing items (e.g., Figures 5, 6, & 7) [1]. Alternatively, it can be represented in a simple tabular form as a result of applying factor analysis [14].

SYSTEM VALIDATION AND OBSERVATIONS

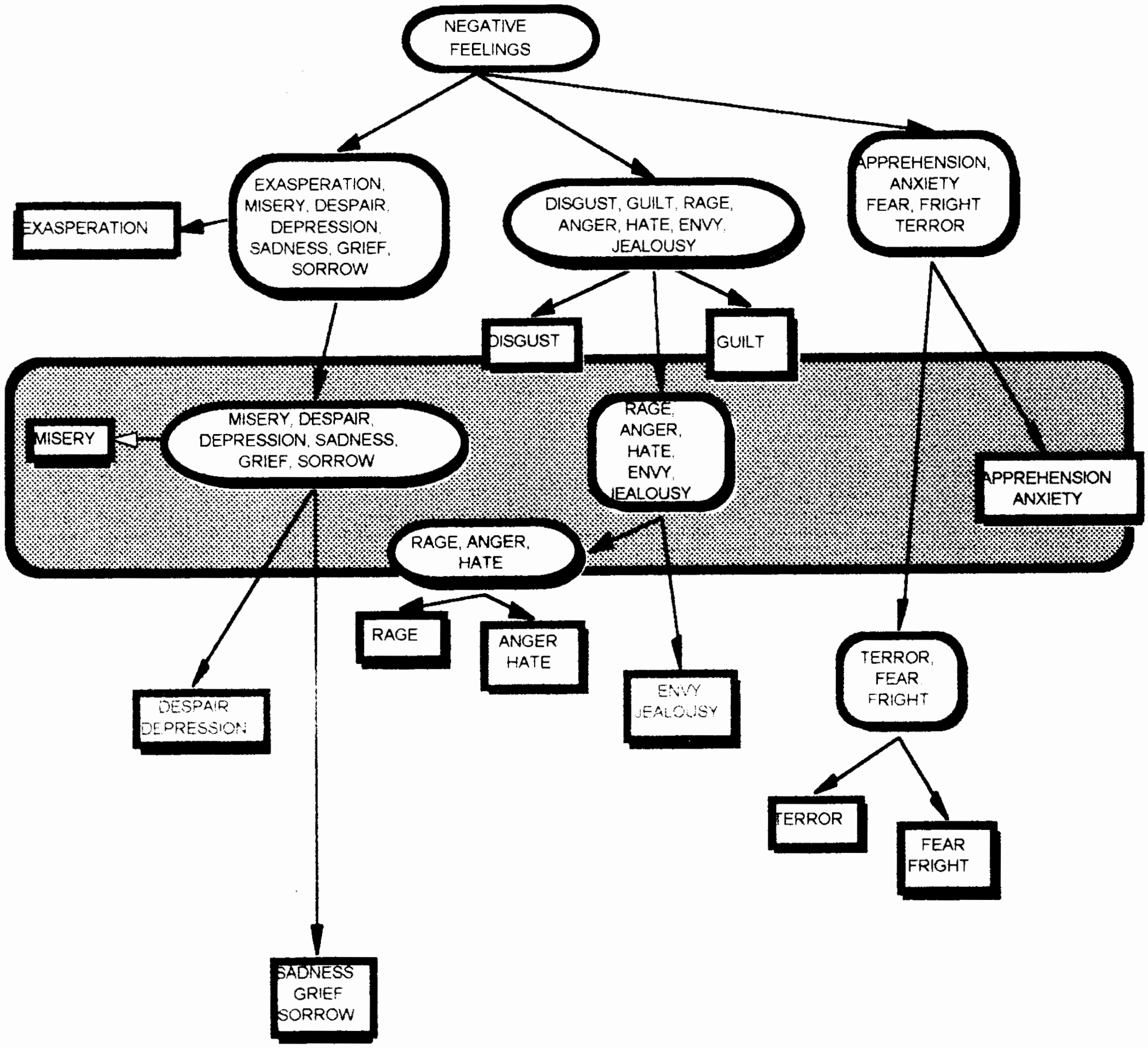
As previously mentioned, the method of consolidation supported in the existing GSS tools is facilitator driven, i.e., the facilitator "hand-culls" or clusters the text objects either using a standard text editor or "sticky wall"and verbal input from the group. We believe this to be inefficient as well as open to user and facilitator bias. In order to evaluate the differences between the "traditional" technique and our new approach, we are currently conducting experiments. As the experiment is still in progress, we are reporting the findings from a study examining differences in results using the traditional group consolidation approach and results from initial clustering performed through FOLDERS.

The experimental design used was a 2x2x2 factorial. We recruited subjects from second year undergraduate business courses; group sizes ranged from 11 to 26. Independent variables were: 1) Clustering **Tool** (3x5 cards vs. FOLDERS); 2) **Task Setting** (individuals vs. group); 3) Materials **Set** ((E) asy vs.(H) ard).

Tools: Subjects were presented with sets of 15 (E) and 33 (H) items which they were asked to sort into clusters.

Figure 7

Hierarchical Cluster Analysis of Negative Emotion Terms



They were instructed, in terminology appropriate to the task setting and tool, to sort the items into clusters so that the items in the clusters represented categories based on some aspect of meaning. Which aspect and which meaning was to be entirely up to the subjects' inclination. Half the subjects used 3x5 cards and copied the numbers from the back of the cards onto a response form; the remaining subjects used FOLDERS and the data was automatically collected, of course.

Task Setting: Members of groups worked in both of two task settings: as individuals and as a group. As individuals they employed their clustering tool (FOLDERS or 3x5 cards) to create individual judgments of clusters. The individual tasks were always done first; thus the influence of the group on individuals was restricted to that operating in the group setting only. After collecting the results of both individual tasks (with the E and H materials), the session facilitator began the group task setting in the same room. Passive facilitation was used, i.e. the subjects were required to indicate to the facilitator how to consolidate the items but no active prompting was used. The two facilitators were trained and subsequent observation showed that they had similar styles. An assistant chauffeured a computer running Word for Windows on a PC while the facilitator led the discussion. A videobeam projector provided a common view of the information to all subjects and the facilitator.

For the group task, the facilitator stressed that such clustering was to be by consensus, that if significant dissent to a particular clustering existed, then the cluster would not be created. Group members suggested clusters and sometimes names for the clusters; the outline feature of Word for Windows was used to create and display the created clusters. When no more suggestions were forthcoming from the group, the facilitator then asked for agreement that this was, in fact, the group "opinion" on the clusters. All four tasks were completed within 70 minutes even though subjects were given as much time as they wished to take.

Materials: Two sets of materials were used, each taken from previous psychological experiments [22, 23]. The first (E) contains 15 kinship items (see Figure 6). This set is described as "easy" because there are known (and intuitively obvious) classifications for kinship. The second (H) is a list of 33 emotions. This set is called the "hard" list, primarily because much disagreement can exist about which emotions go with others. We employed two sets because it was clear that consolidation tasks vary in terms of difficulty. Sometimes a group may generate a relatively short list in easy-to-understand terms; other groups may create longer lists of difficult statements. Each group of subjects saw and sorted both lists of materials twice, once as individuals (in one of the two orders E-H or H-E) and once as a group (using the same order). To balance learning effects, half the groups saw the materials in the order E-H and the other half saw them in the order H-E. In addition, to prevent order effects in the presentation of materials within a set, all card sets were shuffled between administrations and all computer-presented materials (for the FOLDERS individual tasks and all the group tasks) were randomized before presentation.

Table 2

Text Items used in Experiment

EASY	HARD	
grandfather	anger	passion
grandmother	rage	ecstasy
		bliss
granddaughter	apprehension	elation
grandson	anxiety	
		joy
brother	exasperation	excitement
sister	disgust	delight
		pleasure
father	envy	happiness
mother	jealousy	
		adoration
daughter	sadness	affection
son	grief	love
	despair	
niece	depression	tenderness
nephew	misery	compassion
	sorrow	
aunt		
uncle	terror	
	fear	
cousin	fright	
	guilt	

(Words are grouped according to the results obtained using the traditional approach.)

RESULTS

Due to space considerations, only the detailed results from one of the sessions (consisting of 14 group members) using FOLDERS are presented. This output is fairly similar to the other sessions. The group results for both the Easy Set (Task A) and the Hard Set (Task B) using the traditional "facilitation" process is seen in Table 2. In contrast, the results of the initial pooled individual clusters using FOLDER are displayed in Figures 5, 6, 7. Figures 5, 6, and 7 represent the group averaged clusters obtained from applying an agglomerative cluster analysis on the group co-occurrence matrice [1]. Figures 8 and 9 presents the level of consensus among individuals' sorting obtained as a result of using multidimensional scaling on the group dispersion matrice.

Figures 5, 6, and 7 represent a hierarchical structure in which the bottom of each figure (if shown) would represent the most disaggregated level with all words belonging in a separate category. As one moves vertically upwards, different clusters form thereby representing a different level of abstraction. For example, in Figure 5, the next level of abstraction (level 1) beyond individual items (indicated by the shading) is the clustering of mother with father, brother with sister, and so on. If this level represents too much detail, one can move further upwards to the next level (level 2) where 6 cluster/categories occur (i.e., the "grand" cluster, the mother/father/daughter/son cluster, sister/brother, nephew/niece, cousin, and aunt/uncle). A little further up (level 3) and there are only 3 clusters where sister, brother, nephew, niece, cousin, aunt, and uncle finally coalesce. Figures 6 and 7 similarly represents the emotion terms with the positive terms shown in Figure 6 and negative terms in Figure 7. Not shown here is the final level where the positive and negative categories combine to form the one all encompassing "emotion" categories.

Figure 8

Multidimensional Scaling Plot of Consensus in Sorting Among Group Members for Task A (each circle is an individual)

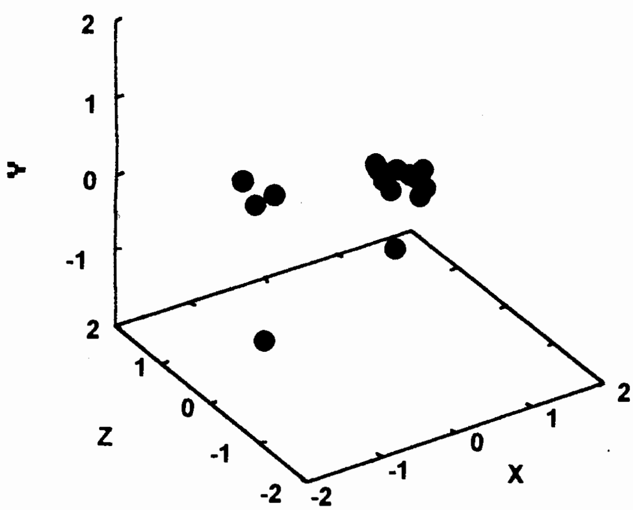
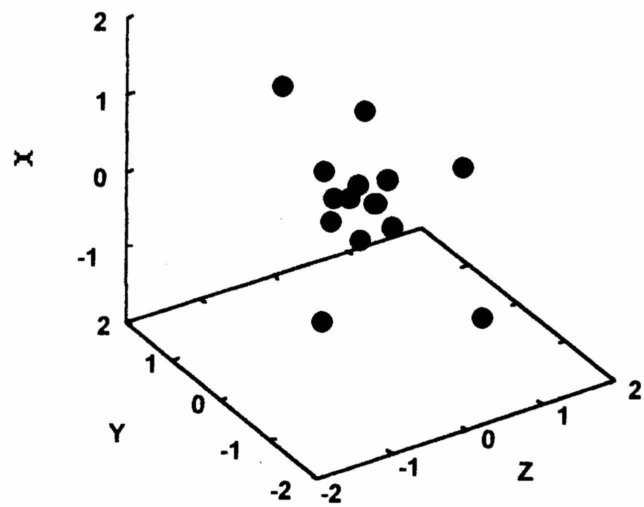


Figure 9

Multidimensional Scaling Plot of Consensus in Sorting Among Group Members for Task B (each circle is an individual)



The results from Figures 5, 6, and 7 fit remarkably well with those of the old approach. The shaded portion of these figures represent the approximate level of abstraction that the group ended up using the old approach (i.e., Table 2). For the kinship terms, the group as a whole agreed to cluster at a very low level of abstraction with 8 clusters. For the emotion terms, the level of abstraction was not as consistent. First, some of the clusters produced by the group as a whole were not at the same level of specificity. For example, the tenderness/compassion cluster is not at the same level as the joy/happiness/excitement/delight/pleasure cluster. Furthermore, the group ended up classifying the positive clusters at a slightly higher level of abstraction than those of the negative clusters.

Figures 8 and 9 presents the level of consensus in sorting among the group members. Each circle represents an individual. The closer two individuals are in the graph, the more similar they were in their respective sorting. The similarity of sortings were determined using the pairbonds formula developed by Arabie and Boorman as described by Coxon [3]. These results were obtained by submitting the group dispersion matrix for both the kinship terms (Task A) and emotion terms (Task B) into a multidimensional scaling module. The final stress coefficients for a 3 dimensional solution were .01 and .06 respectively indicating an excellent fit [16]. For the kinship terms, the graph shows a large cluster of people with one individual nearby, a separate group of 3, and one person quite different from the rest. For the emotion terms, we also find a core group of people with very similar sorting surrounded by a periphery of 4 individuals.

It should be noted that the time it took the group to reach a consensus as a whole was longer than the time for individual sorting. Individual averages for sorting the kinship and emotion terms were 6 and 10 minutes respectively. For the group as a whole, it took 7 and 19 minutes respectively. While this is consistent with the other groups in this study, it would be premature to suggest this is generalizable across all situations. This remains an empirical question we are currently pursuing with further experiments.

Finally, the clusters obtained from the individual sorting for both kinship and emotion terms were consistent with previous theoretical and empirical research [22, 23]. Furthermore,the results using FOLDERS were consistent with those obtained with cards. What were not in agreement, as noted above, were the consolidation results by the group as a whole. Although not extremely far removed, the categories produced using the old approach tends to vary in level of specificity compared with both the aggregate individual sorting reported here and previous empirical studies.

The issue of specificity can also be explored by examining tables produced by our system. Tables 3 and 4 gives information regarding how each individual clustered tasks A and B relative to the other members. Each of these tables has three columns of numbers associated with the column iden-

Table 3

Information of Individual Sortings for Task A

	No. of Pairs Entered	Height of Sortings	Average Distance
Individual 1.	37.00	0.352	39.78
Individual 2.	9.00	0.086	22.36
Individual 3.	33.00	0.314	36.50
Individual 4.	9.00	0.086	24.21
Individual 5.	13.00	0.124	24.21
Individual 6.	42.00	0.400	43.00
Individual 7.	11.00	0.105	24.21
Individual 8.	19.00	0.181	27.64
Individual 9.	7.00	0.067	21.50
Individual 10.	42.00	0.400	43.00
Individual 11.	57.00	0.543	52.93
Individual 12.	10.00	0.095	23.43
Individual 13.	13.00	0.124	23.07
Individual 14.	19.00	0.181	25.93
Individual 15.	17.00	0.162	26.50

Table 3

Information of Individual Sortings for Task B

	No. of Pairs Entered	Height of Sortings	Average Distance
Individual 1.	64.00	0.121	74.57
Individual 2.	72.00	0.136	77.14
Individual 3.	127.00	0.214	119.93
Individual 4.	39.00	0.074	74.79
Individual 5.	93.00	0.176	99.64
Individual 6.	110.00	0.208	102.57
Individual 7.	66.00	0.125	78.14
Individual 8.	88.00	0.167	89.29
Individual 9.	69.00	0.131	81.64
Individual 10.	92.00	0.174	98.14
Individual 11.	141.00	0.267	137.64
Individual 12.	106.00	0.201	143.57
Individual 13.	42.00	0.080	75.71
Individual 14.	69.00	0.181	73.07
Individual 15.	34.00	0.064	83.29

tifying each individual sorting. The first column presents the number of pairs of terms an individual contributed to the aggregate group occurrence matrix. This number can be used to calculate the level of specificity at which each member conceptually grouped the items. This is in the second column and is refered to in the tables as the height of the sortings. If an individual perceives each item as a distinct and independent issue, the height would be zero. Alternatively, another individual may view all the items as representing one single conceptual category. In this situation, the height would be calculated as one. Finally, the degree of similarity of an individual's sorting relative to all other members is given by the column labelled average distance. Here the distance (i.e., similarity of the individual to another group member) is averaged across all members in the group.

Both Tables 3 and 4 demonstrate that group members were not clustering the items at the same conceptual level of specificity. In Table 3, we see that individuals 1, 3, 6, 10, and 11 with sorting heights from .314 to .543 represent a group who viewed the kinship terms at a higher level of aggregation. Whereas individuals 2, 4, 9, and 12 with sorting heights of .067 to .095 practically saw each term as separate categories. In the case of Task B, the range of heights were not as great. Nonetheless, we can still see that sorting heights tended to vary among individuals.

While the outcomes obtained using FOLDERS were similar to those obtained via the traditional facilitated method, several points should be noted. First, the time to task completion was found to be equal or shorter using FOLDERS. Second, the issue of level of abstraction was never discussed during the group consolidation. Nonetheless, if this issue were brought up, we believe it would have represented a difficult task for the group to perform. The ability of FOLDERS to present hierarchically displayed results (as shown in Figures 5, 6, and 7) offers the group the additional freedom to discuss which level of abstraction is ideal for the goals of the meeting. Furthermore, this display helps the group avoid creating categories at different levels of abstraction. Finally, the visualization of group consensus (as determined from the group dispersion matrix) aids the group in assessing the relative merits of the pooled individual sorting. In this study, the groups were relatively similar in their sortings, but one can imagine the situation where the may be several coalitions. The group dispersion output, therefore, can help determine whether substantial, consistent, and reliable differences in perspectives exist among group members and whether more discussion is warranted.

To summarize, when a group follows an automated implementation of the "logical decision making process," at some time they must analyze, reduce and categorize the often copious set of possible alternatives generated in a consolidation task. This is a difficult and time-consuming process. To address this, we have:

- identified a systems bottleneck given the current methods for consolidation.

- proposed a potentially more efficient and effective consolidation process.
- demonstrated the feasibility of a parallel approach.
- shown that the time for consolidation is reduced based on our initial studies
- unexpectedly discovered that groups using the traditional approach will consolidate at different levels of specificity (often without being aware of it). Our method can show the possible levels for further group discussion.
- developed a group dispersion measure that can give the group members feedback on where they fit within the group.

Further experiments are being conducted which will provide insight into the efficiency and effectiveness of the process described within this paper.

REFERENCES

[1] M. S. Aldenderfer and R.K. Blashfield. *Cluster Analysis.* Sage Publications, Los Angeles, 1985.

[2] L.M. Appelgate, B.R. Konsynski, and J. F. Nunamaker. A group decision support system for idea generation and issue analysis in organizational planning. In *Proceedings of the Conference on Computer-Supported Cooperative Work,* pages 16-34, 1986.

[3] A. Coxon. Perspectives on social networks. In P. W. Holland and S. Leinhardt, editors, *Perspectives on Social Network Research,* pages 489-500. Academic Press, New York, NY, 1979.

[4] M. L. Davison. *Multidimensional Scaling.* John Wiley and Sons, New York, 1983.

[5] A. R. Dennis, J. F. George, L. Jessup, J. F. Nunamaker, and D. Vogel. Information technology to support electronic meetings. *MIS Quarterly,* 12(4): 591-694, 1988.

[6] A. R. Dennis, A. R. Heminger, J. F. Nunamaker, and D. Vogel. Bringing automated support to large groups: The Burr-Brown experience. *Information and Management,* 18(3):111-121, 1990.

[7] A. R. Dennis, J. S. Valacich, and J. F. Nunamaker. An experimental investigation of the effects of group size in an electronic meeting environment. *IEEE Transactions on Systems, Man, and Cybernetics,* 20(5):1049-1057, 1990.

[8] G. DeSanctis and B. R. Gallupe. *Group decision support systems: A new frontier. Data Base,* pages 3-10, Winter 1985.

[9] G. Easton, J. F. George, J. F. Nunamaker, and M. O. Pendergast. Using two different electronic meeting system tools for the same task: An experimental comparison. *Journal of Management Information Systems,* 7(1):85-100, 1990.

[10] C. A. Ellis, S. J. Gibbs, and G. L. Rein. Groupware: Some issues and experiences. *Communications of the ACM,* 34(1):38-58. 1991.

[11] F. Flores, M. Graves, B. Hartfield, and T. Winograd. Computer systems and the design of organizational interaction. *ACM Transactions on Office Information Systems,* 6(2):153-172, 1988.

[12] B. R. Gallupe, G. DeSanctis, and G. W. Dickson. Computer based support for group problem-finding: An experimental investigation. *MIS Quarterly,* 12(2):277-298, June 1988.

[13] B. R. Gallupe and J. D. McKeen. Enhancing computer-mediated communication: An experimental study into the use of a gdss for face-to-face versus remote meetings. *Information and Management,* 18:1-13, 1990.

[14] H. H. Harman. *Monder Factor Analysis.* University of Chicago Press, Chicago, 1976.

[15] R. Johansen. *Groupware: Computer Support for Business Teams.* Free Press, New York, 1988.

[16] O. Kim and M. Walker. The free rider problem: Experimental evidence. *Public Choice,* 43 (1):3-24, 1984.

[17] K. Y. Lai and T. W. Malone. Object lens: A spreadsheet for cooperative work. In *Proceedings of the Conference on CSCW,* pages 115-124, 1988.

[18] L. F. Lewis. A decision support system for face-to-face groups. *Journal of Information Science,* 13:211-219, 1987.

[19] P. McLeod. An assessment of the experimental literature on electronic support of group work: Results of a meta-analysis. Working Paper, School of Business Administration - University of Michigan, 1991.

[20] J. F. Nunamaker, L. M. Appelgate, and B. R. Konsynski. Facilitating group creativity: Experience with a group decision support system. *Journal of Management Information Systems,* 3(4):5-19, Spring 1987.

[21] Rein, G.L. and Ellis, C.A. rIBIS: A real-time group hypertext system, *International Journal of Man Machine Studies,* 34(3):349-368, 1991

[22] S. Rosenberg and M. P. Kim. The method of sorting as a data-gathering procedure in multivariate research. *Multivariate Behavioral Research,* 10:489-502. 1975.

[23] P. Shaver, J. Schwartz, D. Kirson, and C. O'Connor. Emotion knowledge: Further exploration of a prototype approach. *Journal of Personality and Social Psychology,* 52(6): 1061-1086, 1987.

[24] J. Siegel, V. Dubrovsky, S. Kiesler, and T. McGuire. Group processes in computer mediated communication. *Organizational Behaviour and Human Decision Process,* 37:157-187, 1986.

[25] Herbert A. Simon. *The New Science of Management Decision,* Harper and Brothers, New York, 1960.

[26] M. Stefik, G. Foster, D. G. Bobrow, K. Kahn, S. Lanning,

and L. Suchman. Beyond the chalkboard: Computer support for collaboration and problem solving in meetings. *Communications of the ACM,* pages 32-48, January 1987.

[27] M. Turoff and S. R. Hiltz. Computer support for group versus individual decisions. *IEEE Transactions on Communications,* Com-30(1):82-91, January, 1982.

[28] J. S. Valacich, A. R. Dennis, J. George, and J. F. Nunamaker. Electronic support for group idea-generation: Shifting the balance of process gains and losses. Working Paper, University of Arizona, 1990.

[29] D. R. Vogel, J. F. Nunamaker, L. M. Applegate, and B. R. Konsynski. Group decision support systems: Determinants of success. In *Conference on Decision Support Sciences,* 1987.

[30] R. Watson. *The Impact of a Computer System on Individual Behavior and Collective Decision Making in a Group Meeting,* PhD thesis, University of Minnesota, 1987. Unpublished Dissertation.

[31] J. Whitescarver, P. Mukherji, M. Turoff, R. Deblock, R. M. Czech, and B. K. Paul. A network environment for computer-supported collaborative work. *Computer Communications Review,* 17(5):260-272, 1987.

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