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Abstract

The issue of information dimension has not received enough attention in the group support systems (GSS) research. The major information dimensions are information diversity and information repetitiveness. Information overload is a function of the information dimensions. Prior research demonstrates that increasing information diversity and repetitiveness can have information overload effect on decision time in structured and unstructured tasks. Group tasks, such as cognitive conflict tasks involve the use of diverse and repetitive information cues. This paper discusses a research to examine the diversity and repetitiveness of information cues accessed by group decision makers engaged in cognitive conflict tasks. The study results demonstrated the negative effect of information diversity and information repetitiveness on decision time. The research further explores whether the use of a collective memory can influence the extent of diverse and repetitive information cues accessed by the group decision makers.

Introduction

As computer supported group decision-making gain widespread acceptance, the issue of improving the decision-making performance becomes more and more important. Improvement in decision quality and decision time is a major consideration for information systems (IS) managers and researchers. Although considerable research has been done to explore if the use of group support systems (GSS) can influence decision quality and time, the issue of information dimension has hitherto received relatively scant attention in the GSS research.

While studies have suggested how increase in number of information cues provided to decision makers can impact their decision making performance (Miller, 1956; Streufert, 1973; Schroder, Driver, and Streufert, 1967; Streufert, 1970), the related research in GSS domain is limited. Schroder, Driver, and Streufert (1967) depicted the relationship between information processing and environmental complexity in terms of an inverted U curve. The environmental complexity is primarily characterized by information load, information diversity, and rate of information exchange (Schroder, Driver, and Streufert, 1967). Subsequently researchers (Chewning and Harrell, 1990; Iselin, 1989; Hwang and Lin, 1999) have investigated these relationships in the context of individual decision-making. The relative effectiveness of different dimensions of information on decision-making performance is virtually unknown in GSS research. The major information dimensions are information diversity and information repetitiveness. Prior research (Iselin, 1989; Hwang and Lin, 1999) shows that information diversity and repetitiveness can influence decision quality and decision time in structured and unstructured tasks. While addressing the issue of information processing support in GSS, a careful consideration of the information dimensions may help in improving the group decision-making performance and effectiveness. A means to strengthen the information processing support in organizational decision-making is the use of schema, which provides the context of decision-making and action (Starbuck, 1983). Weick (1979) discussed how information is processed through schema in organizations. This schema can result in frame of reference for information acquisition; information that is not relevant in terms of the schema may be ignored. The collective memory in organizations or groups can present a schema that can help organizations or groups to influence their decision performance and effectiveness.

This paper discusses a research that examines the diversity and repetitiveness of information cues on the performance of the group tasks. As a representative of the group tasks that involve analyses of diverse (and perhaps repeated) information cues, a cognitive conflict task was chosen for this research and relationships between information dimensions (information diversity and repetitiveness) and group performance were explored. Cognitive-conflict tasks do not have any correct answer; determination of decision quality by comparing the outcome of group work with any pre-specified/ desired outcome might not be feasible. The group performance variable considered in this research is the decision time. The research further explores whether the use of collective memory can influence information diversity and repetitiveness of the information acquired by the groups.

Conceptual Foundations

Information Diversity, Repetitiveness, and Decision Time in Cognitive Conflict Tasks

The participants engaged in a cognitive-conflict task have a clear goal but they may have diverse viewpoints to start with. They have different preferences as well as systematically different preference structures (McGrath, 1984). "They may interpret information differently, may give different weights to different dimensions, and/or may relate dimensions to preferences via different functional forms" (McGrath, 1984: page 64). The key issue in the cognitive-conflict task is to resolve the conflict of preference structure. McGrath (1984) draws examples from social judgment theory, legislatures and board of directors in this context.

Participants engaged in cognitive conflict tasks may have to access a huge pool diverse information cues to gather necessary information on all relevant preferences and preference structures. Streufert (1973) found that as the number of cues provided to a decision maker increases beyond a certain limit (about 10 cues), the decision performance deteriorates. Iselin (1989) found that in unstructured tasks, information diversity negatively affected decision time. The Iselin (1989) discussed the concept of absolute information diversity, which is the number of different dimensions in a cue set. As the participants of cognitive conflict tasks may have to deal with diverse dimensions on preferences and preference structures, it is likely that they will access only a portion of the diverse pool of information cues presented to them. As they start accessing higher proportion of information cues, the effect of information overload will increase (Iselin, 1989). As a result, the decision time is likely to increase. Thus,

Hypothesis 1: In GSS meetings of cognitive conflict tasks, as the proportion of diverse information cues accessed by group members increases, the decision time will increase.

Another important information dimension discussed in the literature is the information repetitiveness. Iselin (1989) defines the quantity of repeated dimension as the number of cues less the number different dimensions in the cue set. Although Iselin (1989) did not study information repetitiveness, Hwang and Lin (1999) found that information repetitiveness also leads to information overload. The participants of cognitive conflict tasks repeatedly access information cues, the information overload effect and hence the decision time is likely to increase. Thus,

Hypothesis 2: In GSS meetings of cognitive conflict tasks, as the degree of repetitiveness of information cues accessed by group members increases, the decision time will increase.

Collective Memory, Cognitive Conflict Task and Information Processing Support

The word "memory" usually refers to individual memory which is the faculty of retaining and recalling things from past (American Heritage Dictionary, 1969). Although the primary focus of memory-related research is on individuals, Halbwachs (1950) proposed the idea of there being memory at the collective level. The collective memory is a socially constructed notion. Members of different social groups and institutions (such as family, associations, organizations) draw on their current context to recreate the past. Commemoration of past events, festivals, social get-together all evoke collective memory among the participants.

The recent interest in collective memory can be traced to the works of Halbwachs (1992) who asserted that memories have a collective context within which they are formed and organized. Zarecka (1994) describes collective memory as a socially articulated and socially maintained reality of the past. Pennebacker and Banasik (1997) highlight the dynamics that can contribute to the issues associated with building and maintenance of collective memories. Although it may appear that collective memory of past events is nothing but history itself, it is contrasted from history. In the words of Schwartz (1997: 470) "History is objectively conceived, sustained by evidence, and unaffected by the social context in which practitioners work. In contrast, collective memory, the way ordinary people conceive the past, reflects the concern of the present."

In recent times, the concept of organizational memory, a form of collective memory has been discussed extensively in the organization, management and information systems literature (Walsh & Ungson, 1991; Hedberg, 1981; Stein and Zwass, 1995). Organizational memory is an instance of collective memory and is retained in its individuals, cultures, transformations (that occur in organizations), structures and workplace ecology (Walsh & Ungson, 1991). Two different roles (interpretation role and action guidance role) of organizational memory have been discussed in the literature (Moorman & Miner, 1997). Organizational memory can act as a filter to categorize information and knowledge (Interpretation role); organizational memory can also influence the action of an individual or group (action guidance role).

The collective memory in group work, such as meetings, projects have been termed as group memory in the literature (Jessup & Valacich, 1993; Nunamaker, Dennis & Valacich, 1991). Nunamaker, Dennis and Valacich (1991) mention group memory as a component in the University of Arizona's GroupSystems, an electronic meeting system. Weiser and Morrison (1998) describe the use of a project memory that captures, retains, and indexes project information so that people external to the project can use it later. In order to perform a group task, group members may have a series of meetings.

The specific nature of support that a collective (or group) memory can provide also depends on the type of group task. Although it is intuitively conceivable that memory support is useful for most of the task types presented in McGrath's (1984) group task circumplex, this paper focuses on the cognitive conflict tasks. The participants in cognitive-conflict tasks can benefit from the use of a repository that includes various preference structures used for similar tasks in the past. For example, a committee making decision on admission of students to a program can use a collective memory that contains information on various criteria (such as, GPA, test score etc.) used in the past, the decision rule employed (such as, lexicographic, elimination by aspect, additive linear etc), values/weights of each criteria under a specific rule and the consequent decision outcome. The historical data that are embedded in the repository and shared by later groups constitute the collective memory. The participants can interpret it to develop a better idea about the preference structures that have resolved cognitive conflicts in the past and resulted in solutions.

Thus, collective memory can be a source of past preferences, preference structures, policies, and norms of groups engaged in cognitive conflict tasks. By using the collective memory the participants can learn what type of information (on preference, preference structure, norms, procedures) is meaningful and hence should be gathered from the task environment; how to filter the relevant information from a diverse pool of information; and how to categorize and evaluate the information that has been gathered from the environment and/or generated during the group work. This can be characterized as information-processing support following the framework proposed by Zigurs and Buckland (1998). By assisting in queuing and filtering information, the group (and hence collective) memory can reduce information overload (Nunamaker, Dennis, and Valacich, 1991). Thus,

> *Hypothesis 3:* In cognitive conflict tasks, the use of collective memory will result in lower proportion of diverse information cues accessed by group members.

Conditions favorable to learning occur when the knowledge on the relevant preferences and preference structures of cognitive conflict tasks is stored in collective memory and is made available for shared interpretation by group members (Cyert & Goodman, 1997). The group members may focus on the relevant information cues from a diverse pool of information and thoroughly examine the preference and preference structures associated with these cues. As such, they are likely to access these selected pool of information repeatedly. Thus:

> *Hypothesis 4:* In cognitive conflict tasks, the use of collective memory will result in higher degree of repetitiveness of the information cues accessed by the group members.

Research Methodology

The data collected from a controlled experiment were used to test the hypotheses. This experiment was administered at a large public university in the mid-western part of the USA. Fifty-four five-member groups were drawn from undergraduate business students in introductory information system classes. They used a group decision support system integrated with a web-based Intranet application that presented the information on the decision situation to the subjects. Each study participant received a waiver for one assignment in a mandatory introductory information systems course. Participation was voluntary. Subject to the time constraints indicated by the students, participants were randomly assigned to one of the fifty-four groups in the experiment.

Each group had *five* members and a coordinating workstation. The participant using the coordinating workstation had to perform some additional tasks. Face-to-face communication among the group members was discouraged. However, communication between the coordinator (i.e. the participant with coordinating workstation) and other members of the group was allowed at specific transition points from one activity to another (such as, end of browsing the Intranet web pages, end of allocation of weights, beginning next iteration, and end of experiment). The experiments were conducted in a group decision room equipped with VisionQuest. Each experiment session could extend up to two hours. Pilot sessions were held before conducting the actual experiment sessions. The participants in the pilot sessions did not have any difficulty in working with the system. The agenda of the meeting is shown in figure 1. The descriptions of the decision situation and the collective memory are presented below.

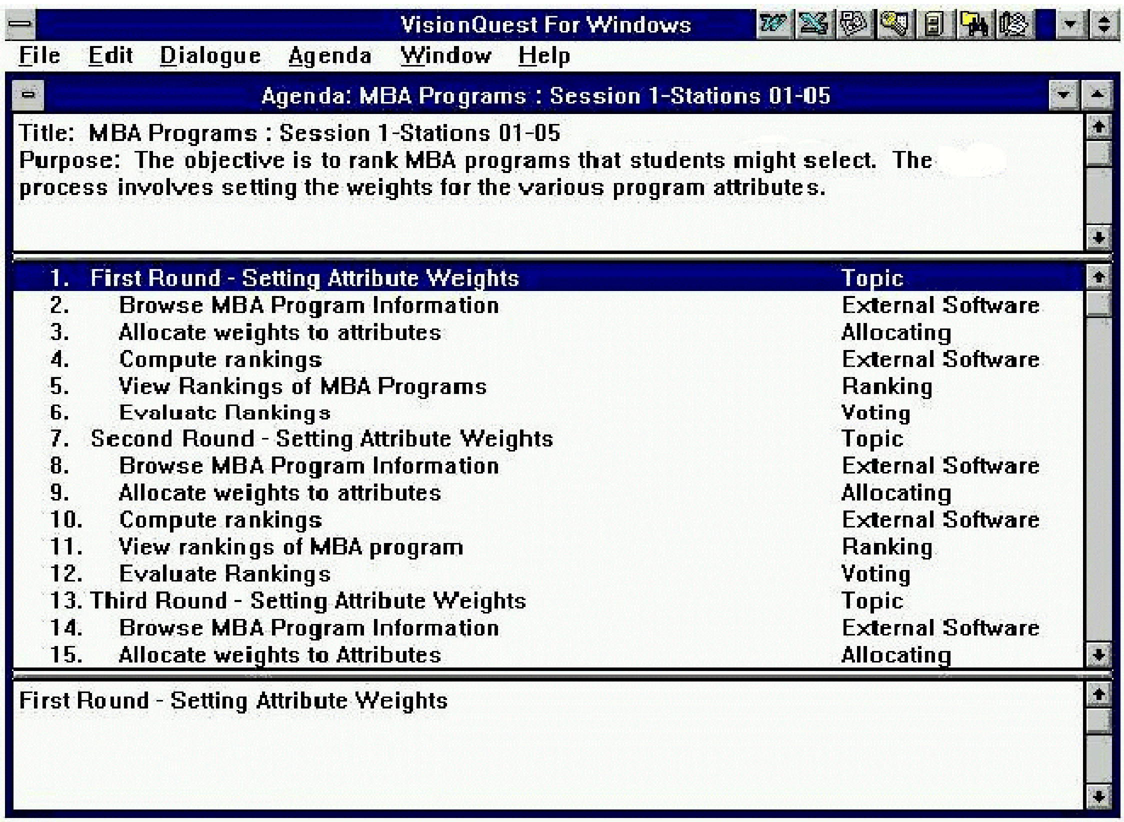

Figure 1. VisionQuest Agenda for the Experiment

Decision Situation

The participants developed group level preference structure for the attributes for MBA programs so that a rank ordered list of the programs could be formed. Undergraduate business students have natural interest in evaluating the MBA programs and are chosen as the decision makers in this experiment. Each participant allocated 100 points among a fixed set of attributes of MBA programs that a typical undergraduate student is likely to consider while evaluating various programs (possibly for admissions consideration). Each participant received feedback on the individual as well as the group level weights and had the option to revise it until a joint decision on the weights was reached. The decision task chosen for this research is classified as a cognitive conflict task because the participants depending on their individual preference structures for MBA attributes may present multiple conflicting solution schemes. The task has significant similarity with the techniques followed in social judgment theory (SJT) paradigm (McGrath, 1984). Turban and Aronson (2001) also discuss a somewhat similar group task where the students were engaged in group work to identify the criteria for college selection.

A fixed set of attributes for MBA admission (Appendix 1) was presented to the groups. Each group allocated weights to the attributes using a group support system (GSS). Based on the attribute weights allocated by a group, the computer generated a rank-ordered list of schools following the principle of the "simple additive weighting" method (Churchman & Ackoff, 1954;

Hwang & Yoon, 1981; MacCrimmon, 1968). A score for each school was computed by multiplying the weight on each attribute by a predetermined normalized rating of the MBA program on that attribute. Next, schools were ordered in the sequence of their final scores. Thus, the rank-ordered list of schools produced in this approach was a consequence of the decision made on the attributes and their weights. The group could retain the combination of attribute weights and rank-ordered list of schools and hence terminate the session; alternately, attribute weights could be revised to generate a new rank-ordered list of schools.

The Collective Memory Prototype

The prototype consisted of two major modules: MBA admissions information system and collective memory information system. Both the information systems were implemented as hypermedia-based web pages. The main page of this system had links to the individual attribute pages and MBA program pages; in addition, the main page had links to the pages containing collective memory information. The control groups were presented with a main page that did not have any link to the collective memory pages. It, however, had links to the individual attribute and MBA program pages. The hypermedia based information system was integrated with groupware (VisionQuest). After discussing with faculty experts and a few prospective users, the following information was included in the collective memory information system:

- Various attributes selected by the previous groups.
- Percentage of groups selecting an attribute.
- Average weights allocated to each attribute
- The rank-ordered list of schools based on the attributes selected and the average weights allocated by peer groups.

Operationalization of Variables

The independent variable of this research is the availability of collective memory. The dependent variables are proportion of diverse information cues accessed during the meeting, the degree of repetitiveness of information cues accessed and decision time. The control variables are the decision task, experimental task, motivation of the subjects and familiarity with the system. We also controlled statistically for gender, Internet skill, college GPA and age. These demographic variables (i.e. age, college GPA, gender etc.) displayed no variance across the fifty-four groups. A brief description of the independent and dependent variables is presented here:

<u>Availability of collective memory</u>: A prototype of a group memory information system was developed. "Control" groups did not have any access to the group memory prototype, whereas this was made available to the "treatment" groups. The variable can assume only one of the two possible values: having or not having access to the prototype of group memory.

<u>Proportion of diverse information accessed</u>: This was measured as the number of *different* information cues accessed divided by the total number of *different* information cues available to each group. The control groups (with no memory) had forty-five different information cues available (eighteen attribute pages, twenty-four school pages, list of attribute page, list of school page, and the home page). Three additional pages on collective memory information were made available to the treatment groups.

<u>Degree of repetitiveness of information accessed</u>: The quantity of repeated information cues accessed is calculated as the total number of information cues accessed less the number of diverse information cues accessed. The degree of repetitiveness is calculated as follows:

Degree of repetitiveness = (Number of repeated information cues accessed) / (Total number of diverse information cues accessed)

<u>Decision time</u>: This was measured as the elapsed time between the start and end of decision-making activities of a group. The data was collected from the Intranet server log file.

Results

Hypotheses Testing

A paired comparison t-test and regression analyses were employed to test the hypotheses presented in this paper. SAS software was used to develop the General Linear Models (GLM) for the regression analyses. Significance level of .05 or better was used for testing the hypotheses in this research. Any significance level in the range of .05 to .10 would indicate weak significance and was treated as suggestive of the nature of relationship between the variables. The results of the hypotheses testing are shown in Tables 1 through 3.

H1: Proportion of diverse information cues accessed and decision time

Regression analyses were performed separately on the data from control and treatment groups. The result of the regression analysis is presented in Tables 1A and 1B. The analysis demonstrates a statistically significant relationship between decision time and proportion of diverse information cues accessed by the participants of the control groups. For the treatment groups, the relationship is weakly supported by the test data. Figures 2A & 2B show the plots of the dependent and regressor variables for the control and treatment groups respectively.

Table 1A. Regression Results for Decision Time – Hypothesis 1 [Control Groups]

Source of Variation	SS	Df	F	Significance
Proportion of diverse information cues accessed	787.537	1	6.51	0.017
Model	787.537	1	6.51	0.017
Error	3024.463	25		
R Square = 0.2066				

Table 1B. Regression Results for Decision Time – Hypothesis 1 [Treatment Groups]

Source of Variation	SS	Df	F	Significance
Proportion of diverse information cues accessed	410.779	1	3.28	0.082
Model	410.779	25	3.28	0.082
Error	3127.073			
R Square = 0.1161				

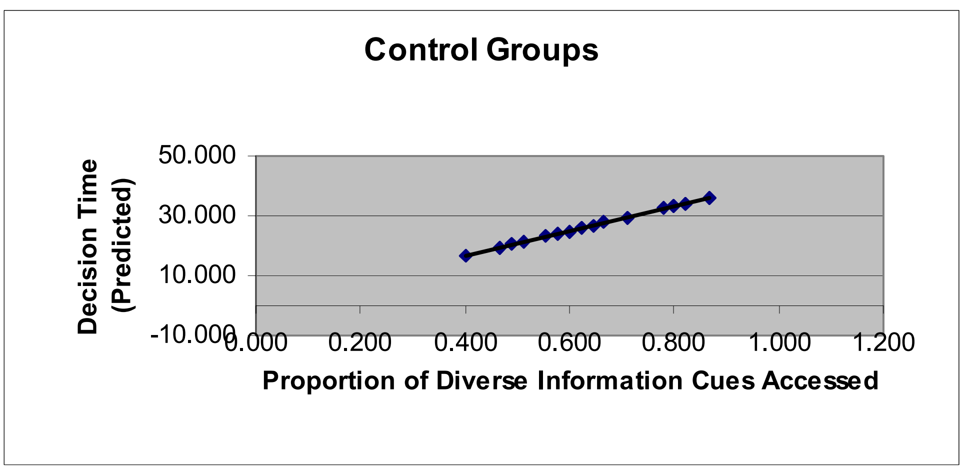

Figure 2A. Proportion of Diverse Information Cues Accessed vs. Predicted Decision Time [Control Groups]

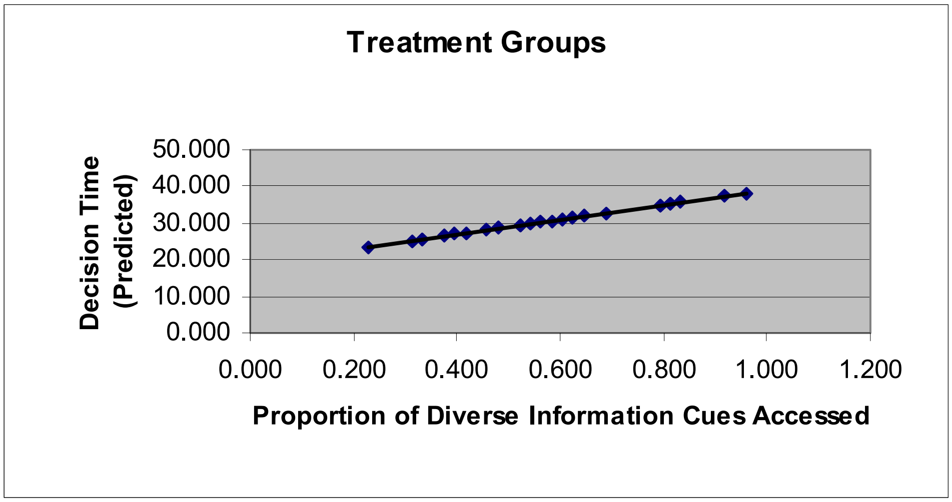

Figure 2B. Proportion of Diverse Information Cues Accessed vs. Predicted Decision Time [Treatment Groups]

H2: Degree of repetitiveness of information cues accessed and decision time

Regression analyses were performed separately on the data from control and treatment groups. The result of the regression analysis is presented in Tables 2A and 2B. The analysis demonstrates a statistically significant relationship between decision time and degree of repetitiveness of information cues accessed by the participants of both control and treatment groups. Figures 3A & 3B show the plots of the dependent and regressor variables for the control and treatment groups respectively.

Table 2A. Regression Results for Decision Time – Hypothesis 2 [Control Groups]

Source of Variation	SS	Df	F	Significance
Degree of repetitiveness of information cues accessed	524.766	1	3.99	0.0567
Model	524.766	1	3.99	0.0567
Error	3287.234	25		
R Square = 0.1377				

Table 2B. Regression Results for Decision Time – Hypothesis 2 [Treatment Groups]

Source of Variation	SS	Df	F	Significance
Degree of repetitiveness of information cues accessed	1735.121	1	24.06	0.0001
Model	1735.121	1	24.06	0.0001
Error	1802.731	25		
R Square = 0.4904				

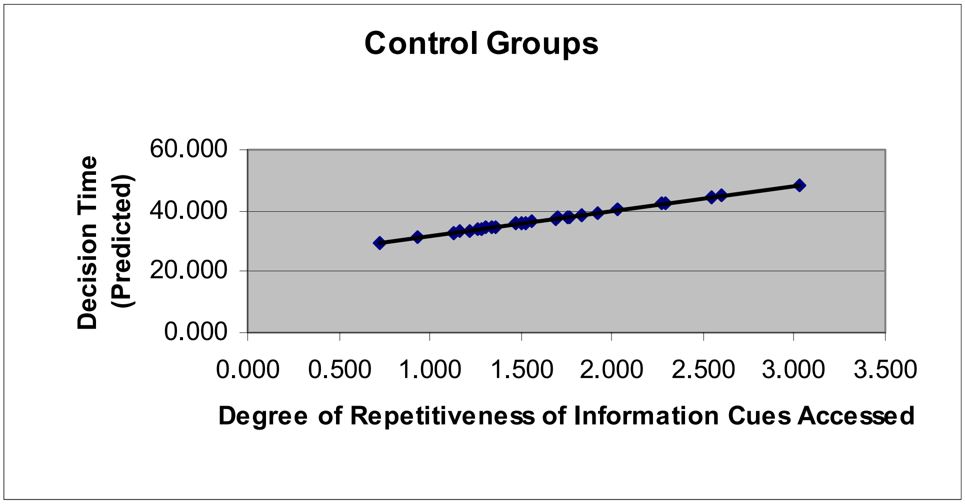

Figure 3A. Degree of Repetitiveness of Information Cues Accessed vs. Predicted Decision Time [Control Groups]

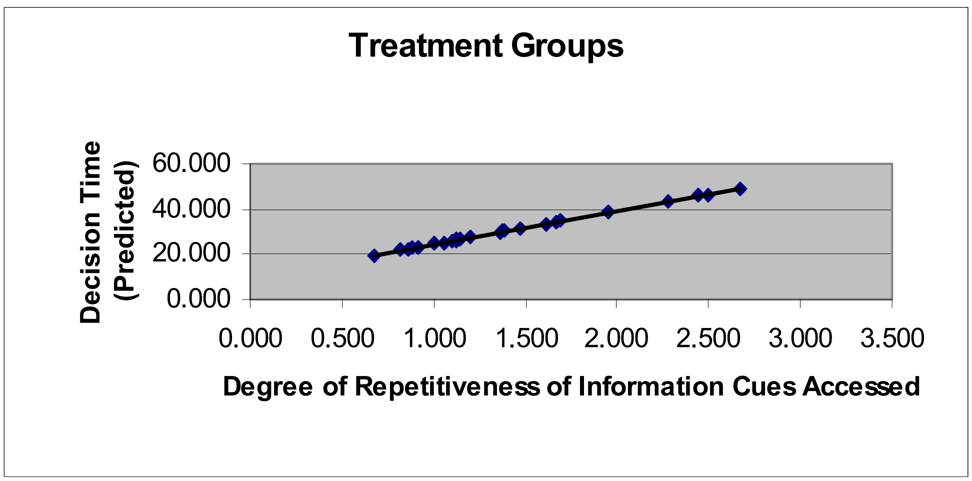

Figure 3B. Degree of Repetitiveness of Information Cues Accessed vs. Predicted Decision Time [Treatment Groups]

H3: Proportion of diverse information cues accessed
The results of the t-test (table 3) reveal weak support for the hypothesis 3. The use of collective memory seems to have resulted in lower proportion of diverse information cues accessed by the participants.

H4: Degree of repetitiveness of the information cues accessed
The results of the t-test (table 3) do not demonstrate any support for the hypothesis 4. The use of collective memory does not seem to have any influence on the repetitiveness of the information cues accessed by the participants. In fact, the degree of repetitiveness has decreased for the treatment groups, which is in contrary to the hypothesis 4.

Table 3. t-Test Results for Hypotheses 3 and 4

Dependent Variable	Mean (Std. Deviation)		t-Statistic		Hypothesis Support
	Control Groups	Treatment Groups	df=52	Significance Level	
Proportion of diverse information cues accessed	0.661 (0.132)	0.582 (0.196)	1.7389	0.088	H1: No (Weak Support)
Repetitiveness of information cues	1.642 (0.543)	1.437 (0.555)	1.3732	0.176	H2: No

Conclusion

The study results reported in this paper demonstrate that both information diversity and information repetitiveness can have negative effects on decision time in cognitive conflict tasks. The results of the study provide motivation for more thorough investigation of the effects of information diversity and repetitiveness on the other performance variables of cognitive conflict tasks, such as *group consensus and perceived decision quality*. The use of a collective memory support provides the study participants with a schema that may facilitate task learning and enable them to make decisions without accessing too many diverse information cues.

The information dimension (diversity and repetitiveness) seems to have significant influence on the performance collaborative group works. From a practical perspective, both diversity and repetitiveness of information cues provide a useful framework for assessing information overload problems in various types of collaborative information systems. Higher information diversity and repetitiveness have resulted in increased decision time. Information systems developed for group decision makers should incorporate optimum levels of diverse and repeated information cues so that decision makers can concentrate on the relevant aspects of the decision problem without wasting time in accessing unnecessary pieces of information.

References

Chewning, E. Jr and Harrell, A. "The effect of information load on decision makers' cue utilization levels and decision quality in a financial distress decision task, *Accounting, Organizations and Society* (15), 1990, 527-542.

Churchman, C.W. and Ackoff, R.L. "An Approximate Measure of Value," *Journal of Operations Research Society of America* (2:2), 1954, 172-187.

Cyert, R.M. and Goodman, P.S. "Creating Effective University-Industry Alliances: An Organizational Perspective," *Organizational Dynamics*, Spring 1997, 45-57.

Halbwachs, M. *Collective Memory*, Harper and Row, New York, 1950.

Halbwachs, M. *On Collective Memory*, University of Chicago Press, Chicago, 1992.

Hedberg, B. "How Organizations Learn and Unlearn," in: Nystrom, P. and Starbuck, W. Eds., *Handbook of Organizational Design*, Oxford University Press, New York, 1981, 1-27.

Hwang, M.I. and Lin, J.W. "Information dimension, information overload and decision quality," *Journal of Information Science* (25:3), 1999, 213-218.

Hwang, C. and Yoon, K. *Multiple Attribute Decision-making*, Springer-Verlag, New York, 1981.

Iselin, E.R. "The effects of information load and information diversity on decision quality in structured decision task," *Accounting, Organization and Society*, 1988, 147-164.

Iselin, E. "The impact of information diversity on information overload effects in unstructured managerial decision making," *Journal of Information Science* (15), 1989, 163-173.

Jessup, L.M. and Valacich, J.S. *Group Support Systems*, Macmillan Publishing, New York, 1993.

MacCrimmon, K.R. *Decision-Making Among Multiple-Attribute Alternatives: A Survey and Consolidated Approach*, RAND Memorandum, RM-4823-ARPA, 1968.

McGrath, J.E. *Groups: Interaction and Performance*, Prentice Hall, Englewood Cliffs, NJ, 1984.

Moorman, C. and Miner, A.S. "The Impact of Organizational Memory on New Product Performance and Creativity," *Journal of Marketing Research* (34), 1997, 91-104.

Nunamaker, J.F. Jr., Dennis, A.R. and Valacich, J.S. "Electronic Meeting Systems to Support Group Work, *Communications of the ACM* (34:7), 1991, 40-61.
Pennebaker, J.W. and Banasik, B.L. "On the Creation and Maintenance of Collective Memories: History as Social Psychology," in: Pennebaker, J.W., Paez, D. and Rime, B. Eds., *Collective memory of political events : social psychological perspectives*, Lawrence Erlbaum Associates, Publishers, New Jersey, 1997.
Schroder, H.M., Driver, M.J. and Streufert, S. *Human Information Processing*, Holt, Rinehart and Winston, New York, 1967.
Schwartz, B. "Collective Memory and History: How Abraham Lincoln Became a Symbol of Racial Equality," *The Sociological Quarterly* (38:3), 1997, 469-496.
Stein, E.W. and Zwass, V. "Actualizing Organizational Memory with Information Systems," *Information Systems Research* (6:2), 1995, 85-117.
Starbuck, W.H. "Organizations as action generators," *American Sociological Review* (48), 1983, 91-102.
Streufert, S. "Complexity and complex decision making," *Journal of Experimental Social Psychology* (8), 1970, 494-509.
Streufert, S.C. "Effects of information relevance on decision making in complex environments, *Memory and Cognition* (3), 1973, 224-228.
Turban, E. and Aronson, J.E. *Decision Support Systems and Intelligent Systems*, Prentice Hall, New Jersey, 2001.
Walsh, J.P. and Ungson, G.R. "Organizational Memory," *Academy of Management Review* (16:1), 1991, 57-91.
Weick, K.E. *The social psychology of organizing*, Addison-Wesley, Reading, MA, 1979.
Weiser, M. and Morrison, J. "Project Memory: Information Management for Project Teams," *Journal of Management Information Systems* (14:4), 1998, 149-166.
Zarecka, I.I. *Frames of Remembrance: The Dynamics of Collective Memory*, Transaction Publishers, New Brunswick, 1994.
Zigurs, I. and Buckland, B.K. "A Theory of Task/Technology Fit and Group Support Systems Effectiveness," *MIS Quarterly* (22), 1998, 313-334.

Appendix 1
List of Attributes for MBA Admission (as Used in the Prototype)

1. AACSB accreditation
2. Average age
3. Average starting salary
4. Closeness to hometown
5. Executive MBA program
6. Minimum months to degree
7. Non tuition fees
8. Part-time MBA program
9. PhD program
10. Percentage of applicants admitted to the program
11. Percentage of international students
12. Percentage of minority students
13. Percentage of students receiving aid
14. Percentage of women students
15. Tuition fees
16. Typical GMAT score
17. Typical undergraduate GPA
18. Typical work experience