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Assessing the Current State of Intellectual Relationships Between the Decision Support Systems Area and Academic Disciplines

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ASSESSING THE CURRENT STATE OF INTELLECTUAL RELATIONSHIPS BETWEEN THE DECISION SUPPORT SYSTEMS AREA AND ACADEMIC DISCIPLINES

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Abstract

This research has identified the roots of decision support systems (DSS) research and empirically investigated the intellectual relationship between the DSS subspecialties and the reference disciplines, using cluster analysis of an author cocitation frequency matrix derived from a comprehensive database of the DSS literature over the period of 1970 through 1995. This research has traced a uni-directional flow of intellectual materials to the DSS area from its reference disciplines to probe how concepts and findings by researchers in the contributing disciplines have been picked up by DSS researchers to be applied, extended, and refined in the development of DSS research subspecialties. Cluster analysis uncovered six major areas of DSS research (group DSS, foundations, model management, user interfaces, implementation, and multiple criteria DSS) and six contributing disciplines (multiple criteria decision making, cognitive science, organization science, artificial intelligence, psychology, communication theory, and systems science).

Keywords: Decision support systems, empirical research, cocitation analysis, cluster analysis, diffusion of research, reference disciplines

1. INTRODUCTION

The area of decision support systems has made meaningful progress over the past two decades and is in the process of solidifying its domain and demarcating its reference disciplines. Few empirical studies have been conducted to provide concrete evidence concerning the bidirectional flow of intellectual materials between the DSS area and its reference disciplines. This research focuses on identifying the roots of DSS research and empirically investigating the intellectual relationship between the DSS subspecialties and the reference disciplines to facilitate the development of articulated theory in the field. This study builds on a previous study (Eom 1996) and traces how concepts and findings by researchers in the contributing disciplines have been picked up by DSS researchers to be applied, extended, and refined in the development of DSS research subspecialties. Studying the reference disciplines improves DSS research as researchers adopt their theories, methodologies, philosophical bases, and assumptions as well as assess what these theories imply for DSS research (Goul et al. 1992; Keen 1980).

2. DATA AND RESEARCH METHODOLOGY

A database file was created consisting of a total of 31,938 *cited* reference records taken from the 1,189 *citing* articles in the DSS area over the past 25 years (1971-1995). A citing article is selected if (1) it discussed the development, implementation, operation, use, or impact of DSS or DSS components or, (2) for DSS articles related to contributing disciplines, they were explicitly related to the development, implementation, operation, use, or impact of DSS or DSS components.

This study uses author cocitation analysis (ACA). ACA is the principal bibliometric tool to establish *relationships* among authors in an academic field and thus can identify subspecialties of a field and how closely each subgroup is related to each of the other subgroups. The final author set of 146 was chosen by applying the overall cocitation frequency over 25 with himself/herself.[1] The cocitation matrix generation system developed for this research gives access to cited coauthors as well as first authors. The raw cocitation matrix of 146 authors is converted to the correlation coefficient matrix. The matrix is further analyzed by the cluster analysis program of SAS (a hierarchical agglomerative clustering program with Ward's trace option).

3. RESULTS

The cluster analysis resulted in a dendrogram (tree graph), which illustrates hierarchical clustering (Figures 1 and 2). The dendrogram shows that the DSS tree consists of two main branches (clusters 2 and 6). The first branch of the DSS tree represents all DSS subspecialties and related references disciplines excluding group decision support systems (GDSS) and their reference disciplines. The first branch holds five reference disciplines: artificial intelligence (AI), cognitive science, multiple criteria decision making (MCDM), systems science, and organization science. It also includes six major areas of DSS research: foundations, implementation, individual differences/user interfaces, model management, multiple criteria/negotiation DSS, and GDSS. The second branch consists of GDSS and related reference disciplines (communication theory, organization science, psychology, and artificial intelligence).

3.1 The Intellectual Relationship between the DSS Subspecialties and Other Disciplines within the Business School.

3.1.1 An Overview of Contributions to DSS Areas from Organization Science

DSS Design and Organization Science: Detailed understanding of individual, group, and organizational decision processes is a prerequisite for effective DSS design. DSS researchers have developed several development methodologies such as a decision centered approach (Gerrity 1971), an organizational change process approach (Keen and Scott Morton 1978), the ROMC (Representation, Operations, Memory Aids, and Control Mechanisms) approach (Sprague and Carlson 1982), and a systems-oriented approach (Ariav and Ginzberg 1985). The organizational change process approach of Keen and Scott Morton necessitates understanding both the normative decision process that the system is intended to generate and the actual decision process that exists. Organizational decision making models such as (1) the rational model, (2) the organizational process model, and (3) the satisficing model have contributed to the development of the DSS design methodologies.

Another group of organization scientists, including Daft and Lengel (1986), has sought to answer the question, "Why do organizations process information?" Daft and Lengel's study of organizational information requirements and the hierarchy of media richness has been widely cited to justify the implementation of GDSS as a tool that conveys the richest information. Daft and Lengel proposed that organizations can be structured to provide correct and sufficient information to reduce uncertainty and provide information of suitable richness (defined as the ability of information to change understanding within a time interval) to reduce equivocality as well.

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[1]See McCain (1990) for a detailed discussion of several different approaches to compiling a list of authors.

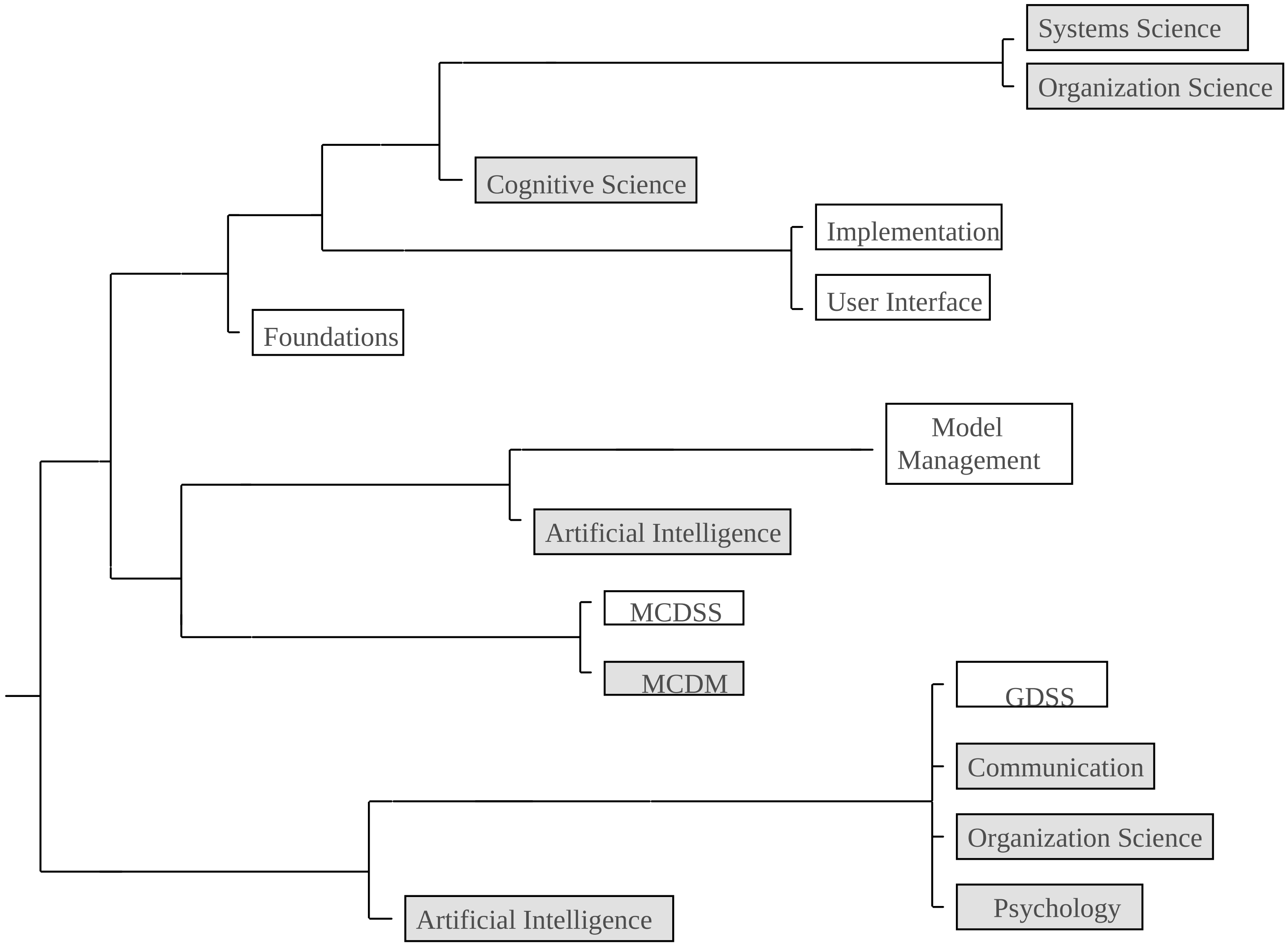

Figure 1. Dendogram Illustrating Hierarchical Clustering.
The dendogram illustrates hierarchical clustering of six DSS research subspecialities (white rectangles) and eight reference disciplines (shaded rectangles). It also shows external heterogeneity between clusters.

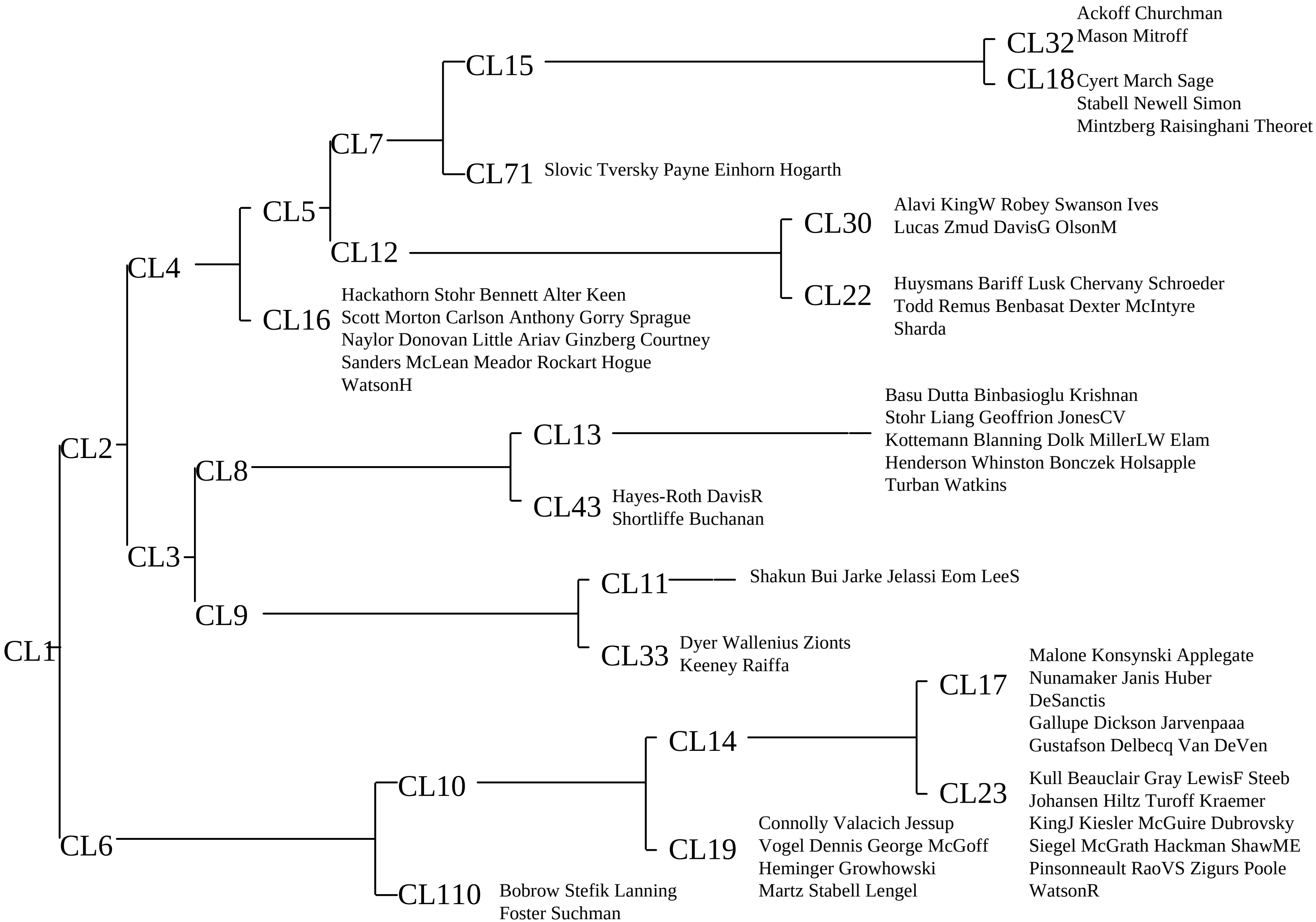

Figure 2. Dendogram Depicting Cluster Structure and Joining Sequences

The dendogram depicts both the cluster structure and the joining sequences to show how each of the authors is combined into a new aggregate cluster until all authors are grouped into the final one cluster (CL1).

User Interfaces and Organization Science: Newell and Simon (1972) pointed out that, for the individual to be equipped to make the correct decisions, the organization must place him in a psychological environment that will adapt his decisions to the organization's objectives and that will provide the individual with the information needed to make decisions correctly. Mason and Mitroff (1973) extended the work of Newell and Simon and hypothesized that "the designers of information systems should not force all psychological types to conform to one type of information system, rather each psychological type should be given the kind of information to which he is psychologically attuned and uses most effectively" (p. 478). The seminal work of Mason and Mitroff propelled the emergence of the individual differences research subspecialty in management information systems (MIS)/DSS, which had persisted for nearly two decades during the 1970s and 1980s.

GDSS and Organization Science: Delbecq, Van de Ven, and Gustafson (1975) experimentally compared three alternative methods for group decision making: the conventional interacting (discussion) group, the nominal group technique, and the Delphi technique. Many of these techniques and ideas, such as silent and independent idea generation, presenting each idea in a round-robin procedure, silent independent voting, etc., were successfully utilized in the development of GDSS in the 1980s.

3.1.2 An Overview of Contributions to Multiple Criteria DSS from MCDM

MCDM deals with a general class of problems that involve multiple attributes, objectives, and goals (Zeleny 1982). By its nature, usually there are numerous nondominated solutions in MCDM problems. To single out a decision alternative, Geoffrion, Dyer, and Feinberg (1972) suggested interactive procedures for multiple criteria optimization. Keeney and Raiffa (1976) developed the theory and methods of quantifying preferences over multiple objectives to help an individual decision maker structure multiple objective problems and make a choice among a set of pre-specified alternatives. An array of diverse MCDM techniques provided decision makers with more powerful means to solve ill-structured problems through direct interaction with analytical models. The MCDM algorithms/techniques include ordinal comparisons, pairwise alternative comparisons, implicit utility functions, goal programming and analytical hierarchical process, and others.

Zeleny challenges the reader with the following statement: "No decision making occurs unless at least two criteria are present. If only one criterion exists, mere measurement and search suffice for making a choice" (p. 74). An important reason for the emergence of MCDM model-embedded decision support systems (MCDSS) is that MCDM complements DSS and vice versa due to the differences in underlying philosophies, objectives, support mechanisms, and relative support roles (Nazareth 1993).

3.1.3 An Overview of Contributions to DSS Areas from Other Disciplines within the Business School

Although the following disciplines are not included in Figures 1 and 2 because the cocitation frequency of authors in these disciplines was less than the cut-off criterion (cocitation frequency of over 25), it was very close to the cut-off threshold.

Accounting: To most decision makers, including accountants, maintaining consistency of judgement is critically important. Libby (1981) demonstrated how behavioral decision theory developed by cognitive scientists enriches the understanding of accounting problems with an ultimate goal of decision improvement through the improvement of the consistency of judgment. His research focused on the examinations of the effects of heuristics on the accuracy of judgement using a statistical decision theory model, such as Bayes's theorem, as a criterion for evaluating intuitive or probabilistic judgements. These approaches provided a theoretical foundation for developing DSS and expert systems to estimate probability of bankruptcy, predict fraud, evaluate sample evidence and make sample-size choice in audit settings, rank importance of materiality factors, and make many other judgements of probability.

Economics: GDSS researchers have referenced the economic theory of teams to explain various issues in designing and implementing GDSS. Especially, the theory of games (von Neumann and Morgenstern 1953) is concerned with providing strategies for the games, both zero-sum and non-zero-sum, played by two or more persons with different interests and constrained by different rules of the game. On the other hand, the economic theory of teams (Marschak and Radner 1972) is concerned with the case of several persons who have common interests making decisions. That theory aimed at finding economic (optimal and efficient) means of providing information and of allocating it among the decision makers of a team, so that the best results could be achieved with respect to common interests of the members of a team.

Management Science: Management science (MS)/operations research (OR) models have been essential elements of DSSs. As shown in the previous survey of DSS applications (Eom and Lee 1990), forecasting and statistical models, simulation, integer programming, linear programming, and network models have been powerful MS/OR tools that have been increasingly embedded in the model base of DSSs. A follow-up survey found that use of deterministic models such as linear programming and integer programming is increasing (Eom et al. 1997). New advances in algorithms, such as the large-scale primal transshipment algorithm (Bradley et al. 1977), developed by management scientists make it possible for unsophisticated users to obtain readily understandable outputs (Nemhauser 1993). Advanced implementations of algorithms, such as simplex methods, the new interior point, and branch-and-bound algorithms, have been incorporated in commercial software such as Excel.

Strategic Management: Porter's work (1980, 1985) on tools and techniques for analyzing industries and competitors and creating and sustaining superior performance, as well as the multidimensional framework of Fredericks and Venkatraman (1988) has provided an impetus and theoretical basis for developing DSS for analyzing external environment and industry trends, mergers and acquisitions, and product/market position, and for strategic planning at various levels (corporate, division, department) and with various functions, selecting grand strategy, managing a portfolio of new product development research projects, evaluating strategy, supporting the integrated strategic planning process, and managing organizational crisis (Eom et al. 1997).

3.2 The Intellectual Relationship between the DSS Subspecialties and Other Disciplines outside the Business School

3.2.1 An Overview of Contributions to DSS Areas from Systems Science

Systems science originated from the experimental sciences, general systems theory, and cybernetics, and it has evolved into a distinct area for the development of systems theory to explain the structure and behavior of various systems. Systems approach is the application of systems theory and systems thinking to real world systems and aims at better understanding the organization as a system and at predicting future states of the organization through model building. The essence of the systems approach is explained by Ackoff (1975, p. viii):

> A system is a whole that cannot be taken apart without loss of its essential characteristics, and hence it must be studied as a whole. Now, instead of explaining a whole in terms of its parts, parts began to be explained in terms of the whole.

Systems Science and Implementation: Over the last two decades (the 1970s and 1980s), a great deal of information systems research was motivated by the belief that the user's cognitive style should be considered as an important factor in the design of MIS/DSS and that decisions seem to be a function of the decision maker's cognitive makeup, which differs for different psychological types. Researchers in this area focused on (1) useful classification of behavioral variables for attaining successful MIS/DSS design, (2) consideration of the system user's cognitive style/psychological type in the design and implementation of the successful information system (Mason and Mitroff 1973; Zmud 1979), and (3) the evaluation of graphical and color enhanced information presentation and other presentation formats (Dickson, et al. 1977).

Churchman and Schainblatt (1965) laid out a matrix that explains the types of confrontation between the manager and the scientist which may cause the implementation problem. The implementation matrix was further extended by Huysmans (1970) and Doktor and Hamilton (1973) to conclude that the cognitive styles of users/managers did affect the chances of implementation. Subsequently, the majority of researchers on DSS implementation research have expanded the implementation success factors to include, in addition to cognitive styles, other user-related factors such as personality, demographics, and user-situational variables, and have focused on the empirical examination of the relationship between the user-related factor and implementation success (Alavi and Joachimsthaler 1992).

Systems Science and DSS Design: Churchman (1971) developed the theory of designing inquiring systems, which defined a set of necessary conditions for conceiving a system. The set of conditions provides the system designer with a set of precepts for building an integral system. Ariav and Ginzberg applied his theory of design integrity to designing effective DSS. They asserted that effective DSS design must explicitly consider a common set of DSS elements simultaneously including DSS environment, task characteristics, access pattern, DSS roles and function, and DSS components, strongly reflecting Churchman's view that "all systems are design nonseparable" (Churchman 1971, p. 62). Attempts are being made to apply his theory of designing inquiring systems to collaborative, human-computer problem solving to enhance creativity (Angehrn 1993).

3.2.2 An Overview of Contributions to DSS Areas from Cognitive Science

The central component of cognitive science is the study of the human adult's normal, typical cognitive activities such as language understanding, thinking, visual cognition, and action by drawing on a number of disciplines such as linguistics, AI, philosophy, cognitive psychology, neuroscience, and cognitive anthropology (Von Eckardt 1993). Of these numerous contributing disciplines, cognitive psychology has been especially influential in the development of individual differences/user interface, implementation, and foundation subspecialties (see the dendrogram). Cognitive psychology deals with the study of visual information processing; neuroscience and neural networks; cognitive skills in problem solving; reasoning, including reasoning about probability; judgment and choice; recognizing pattern, speech sounds, word, and shape; representing declarative and procedural knowledge; learning and memory; and structure and meaning of languages including morphology and phonology.

Cognitive Science and Foundation: Tversky and Kahneman (1974) described an aspect of human cognitive limitation—cognitive biases that arise from the reliance on judgmental heuristics. They showed that people rely on several heuristic principles in making judgements under uncertainty (representativeness, availability of instances, and adjustment from an anchor), which are usually effective, but lead to systematic and predictable errors. Einhorn and Hogarth (1981) reviewed behavioral decision theory to place it within a broad psychological context. In so doing, they emphasized the importance of attention, memory, cognitive representation, conflict, learning, feedback to elucidate the basic psychological processes underlying judgement, and choice. They concluded that decision makers use different decision processes for different tasks. The decision processes are sensitive to seemingly minor changes in the task-related factors.

Cognitive Science and User Interfaces: The theory of problem solving (Newell and Simon 1972) recognized many of the dimensions along which the total human system can vary (e.g., tasks, time scale, phylogenetic scale), although the theory was not directly concerned with personality variables (individual differences). The limitations of the human information processing system (a relatively slow serial processor with small short-term memory [Newell and Simon 1972]) and the study of cognitive biases (Tversky and Kahneman 1974) contributed to the development of the ROMC approach to the user interface design (Sprague and Carlson 1982). The ROMC approach emphasizes that a focus for user interface design is to provide users with familiar representations (graphs, plots, maps, charts, etc.) in order to communicate some aspect of the decision to other persons and that several types of memory aids should be provided to extend the users' limited memory.

Cognitive psychology (Einhorn and Hogarth 1981; Tversky and Kahneman 1974; Winograd and Flores 1988), imagery theory, dual coding theory, structured modeling, and the theory of problem solving (Newell and Simon 1972) have made important contributions toward a better understanding of the relationship between the effectiveness of problem structuring and an individual's general thinking skills. Loy (1991) found that the user's ability to create and use visual images is positively related to better problem-solving and problem-structuring performance. His findings imply that further DSS research is necessary to develop interactive graphics-based problem-structuring aids that can provide effective support for decision makers who do not possess highly developed visual thinking skills.

Cognitive Science and Implementation: Newell and Simon's theory of problem solving was applied to understand the relationship between problem presentation to the decision maker and successful implementation of DSS. The organization of the problem representation significantly influences the structure of the problem space and the problem-solving processes decision makers use. Therefore, when their problem-solving processes are adapted to the problem representation, decision makers make effective decisions and this will lead to successful implementation of DSS.

3.2.3 An Overview of Contributions to Model Management from Artificial Intelligence

Since 1975, model management has been researched to encompass several central topics such as model construction, model base structure and representation, and model base processing (Blanning 1993). AI, as depicted in Figures 1 and 2, has strongly influenced the development of model management subspecialties. The concept of knowledge-based model management systems was introduced to support tasks of formulating a new decision model and/or choosing an existing model from the model base, analyzing the model, and interpreting the model's result (Elam et al. 1980; Elam and Konsynski 1987). Other researchers presented the use of artificial techniques for determining how models and data should be integrated and for representing models and developing mechanical methods for automatic selection, synthesis, and sequencing of models in response to a user query (Blanning 1982; Bonczek, et al. 1981; Dutta and Basu 1984).[2]

Goul et al. (1992, p. 1268) asserted that "future DSS research must reflect the reality from AI that machine-based intelligence has become an important aspect of computer-based support for humans" and addressed a need for revising the definition and focus of DSS to include the idea that selected tasks, in limited domains, involving human decision makers' judgment and intuition can be performed by computer-based intelligent agents as well as humans. Some DSS applications demonstrate that knowledge-based DSSs are indeed replacing human decision makers' judgements (Eom et al. 1997). Intelligent agents (known also as intelligent interfaces or adaptive interfaces) research is an emerging interdisciplinary research area involving researchers from such fields as expert systems, decision

[2]For a thorough review of the application of AI to enhance the capabilities of model management systems, see Elam et al. (1980) and Elam and Konsynski (1987).

support systems, cognitive science, psychology, and databases. According to Riecken (1994, p. 20), the primary purpose of agent research is to "develop software systems which *engage and help* all types of end users" in order to reduce work and information overload, teach, learn, and perform tasks for the user. In the 1992 Franz Edelman DSS prize-winning paper, Angehrn introduced the conversational framework for decision support as a basis of a new generation of active and intelligent DSS and executive information systems. The active DSS will be equipped with the tools (stimulus agents) that will act as experts, servants, or mentors to decide when and how to provide advice and criticism to the user, while the user formulates and inquires about his or her problems under the continuous stimulus of electronic agents.

3.2.4 An Overview of Contributions to GDSS from Psychology

Psychology appears to be one of the major disciplines that has greatly influenced the development of GDSS. Psychology is a diverse field with many branches such as cognitive psychology (as discussed earlier), industrial and organizational psychology, and social and behavioral psychology. Social psychology applies the scientific method of systematic observation, description, and measurement to the study of human social behavior: how human individuals behave, feel, and interact, and how they influence, think, and feel about one another (Brehm and Kassin 1990). The social behavior of the individual can be analyzed with a focus on one person, dyads of two people, and groups of three or more people. It seeks to discover how people are influenced, why they accept influence, and what variables increase or decrease the effectiveness of social influence (Aronson 1988). It studies human behaviors such as aggression, attraction, prejudice, conformity, self-justification, and interpersonal communications.

An important issue in the study of group DSS is to minimize the dysfunctions of the group interaction process such as evaluation apprehension, cognitive inertia, and domination by a few individuals. In designing GDSS to minimize the dysfunctions, GDSS researchers have sought to build on/extend the research results of group dynamics, which seeks the answer to the following question: "How is behavior influenced by others *in a group*?" In the area of group dynamics, Shaw (1981) and McGrath (1984) provided an integrative conceptual framework for synthesizing the voluminous body of group research and presented approaches to the study of groups. They examined factors that facilitate/inhibit group behavior and problem solving as an interrelated process of social interaction. The factors include the physical environment of groups, personal characteristics of group members, group composition, group structure, leadership, and group tasks and goals. According to McGrath, all groups can be classified as vehicles for delivering social influence, as structures for patterning social interaction, or as task performances systems. He focused on the nature, the causes, and the consequences of "group interaction process" defined as "dynamic interplay of individual and collective behavior of group members."

A series of experiments by psychologists such as Diehl and Stroebe (1987) concluded that "individuals brainstorming alone and later pooling produce more ideas, of a quality at least as high, as do the same number of people brainstorming in a group" due to several possible reasons such as evaluation apprehension, free riding, and production blocking. A significant finding of the Diehl and Strobe experiments was their recognition of the magnitude of the impacts of production blocking on the productivity loss of brainstorming groups. By manipulating blocking directly, Diehl and Strobe were able to determine that production blocking accounted for most of the productivity loss of real brainstorming groups. Therefore, their findings suggest that it might be more effective to ask group members first to develop their ideas in individual sessions; then these ideas could be discussed and evaluated in a group session.

Siegel et al. (1986) investigated the behavioral and social implications of computer-mediated communications and sought to answer the question: "Do computer-mediated communications change group decision making?" The results of their experiments suggest that simultaneous computer-mediated communication significantly affected efficiency, member participation, interpersonal behavior, and group choice, when compared to the face-to-face meeting. Using computerized communication, it took more time for group consensus and fewer remarks were exchanged. However, more decision proposals were introduced. Communication via the computer showed more equal participation of group members and more uninhibited communication; in addition, decisions deviated further from initial individual opinions. These results suggest computer-mediated communication is somewhat inefficient compared to face-to-face communication. Distraction and frustration in having to read and type messages simultaneously could provoke more uninhibited behavior.

Janis and Mann (1977) analyzed psychological processes involved in conflict, choices, commitment, and consequential outcomes and provided a descriptive conflict theory. Their theory is concerned with “when, how, and why psychological stress generated by decisional conflict imposes on the rationality of a person’s decisions” and how people actually cope with the stresses of decisional conflicts. Based on the theoretical assumptions derived from extensive research on the psychology of stress, Janis and Mann provided a general theoretical framework for integrating diverse findings from psychological/behavioral science research and reviewed the main body of psychological/behavioral science research concerning the determinants of decisional conflicts.

Osborn is another psychologist whose work has influenced greatly the development of GDSS subspecialties. He argued that most human mental capacities such as absorption, retention, and reasoning can be performed by computers with the exception of the creative ability to generate ideas, and that nearly all humans have some imaginative talent. Osborn identified two broad classes of imagination (controllable and uncontrollable by the will of the individual) (Osborn 1963). GDSS researchers have focused on extending his idea concerning how human imagination that can be driven at the will of the individual can be further developed by GDSS.

3.2.5 An Overview of Contributions to GDSS from Communication Theory

The study of human communication is an interdisciplinary field investigating communication processes of symbolic interaction (Littlejohn 1982). The field of human communication is broadly divided into interpersonal, group, organization, and mass communication. Communication theory researcher (Fisher 1970, 1980) has addressed questions of group decision making such as “How do groups affect individuals?” and “What factors contribute to task output?”

Coordination theory by the human communication school of thought has been proposed as a guiding set of principles for development and evaluation of GDSS. The coordination theory concerns the analysis of different kinds of dependencies among activities and the identification and management of the coordination processes (Malone and Crowston 1994). Research in the interdisciplinary study of coordination is grounded in several disciplines such as computer science, organization science, management science, economics, psychology, and systems science. General systems theory in particular provides cybernetic models of the interplay between computers, group members, goals, etc. (Churchman 1971, 1979).

3.2.6 An Overview of Contributions to the DSS Areas from Other Disciplines

Computer Science: A significant influence of database (Chen 1976; Maier 1983; Ullman 1982) can be found on the model management area. The structured modeling approach by Geoffrion (1987) has advanced the model representation area of model management, which is an extension of the entity-relationship data model and a necessary step for advancing to the next stage of model management (i.e., model manipulation). In the model processing area, Blanning (1982) investigated important issues in the design of relational model bases and presented a framework for the development of a relational algebra for the specification of join implementation in model bases. Dolk and Konsynski (1984) developed the model abstraction structure for representing models as a feasible basis for developing model management systems. Dolk and Kottemann (1993) attempted to connect both AI and database management systems to evolve a theory of model management via model integration that relies heavily upon the relational database theory. They believe that the emergence of a theory of model management is imminent. In addition to database management, computer scientists such as Shneiderman (1993) have influenced the development of the user interface research subspecialties.

4. CONCLUSION

A large proportion of DSS researchers have focused on researching GDSS and model management. Especially, the Group DSS area has been strengthened significantly since 1990s and has become the predominant area of DSS research. The areas of design and implementation are emerging, whereas the foundation and individual differences areas seem to be no longer active. The focus of DSS research appears to be shifting from the study of DSS components (data, model, individual differences of decision makers) during the period 1970 through 1990 to the design, implementation, and user-interface management, to provide useful guiding principles for practitioners in the integrated processes of design, implementation, and evaluation of decision support systems. For an extended discussion of implications and directions for future DSS research, see Eom (1996).

To build a coherent field of study, the intellectual development of the decision support systems area as an interdisciplinary field has been examined in an historical context. As examined, decision making has been a universal subject of research in many disciplines. This research has recognized that DSS research stems from the work of many disciplines within the business school including organization science, MCDM and management science, accounting, and strategic management, as well as many disciplines outside the business school such as AI, systems science, psychology, cognitive science, computer science, and communication theory. By a thorough examination of the intellectual relationships between DSS research subspecialties and contributing disciplines, several patterns of positive and constructive interactions between these two areas have been uncovered. First, the ideas, concepts, and terms such as electronic meeting, groupware, and teleconferencing, are coined by the researchers in many diverse academic disciplines. Second, research findings in the reference disciplines such as AI and MCDM have been applied to forge new research subspecialties such as knowledge-based decision support systems and multiple criteria decision support systems. Third, reference disciplines such as database management have been applied and extended in the management of models in DSS to build a theory of models. Research based on the well-established reference disciplines with abundant theories is most likely to lead to the development of new theories. Dolk and Kottemann believe that the emergence of a theory of model is imminent, and the current model integration research is projected as "the springboard for building a theory of models equivalent in power to relational theory in the database community" (p. 51). However, there is also a danger in extending ideas from other disciplines. More than a decade of intense research on cognitive styles and individual difference research, extending the ideas and work of Newell and Simon to derive operational information systems design principles appears to have come to an end. Huber (1983) concluded that the accumulated research findings as well as further cognitive style research are unlikely to lead to operational guidelines for DSS designs. Many ideas developed from psychologists, communication theorists, organization scientists, and computer scientists have positively contributed to the emergence of the new research area of GDSS.

5. REFERENCES

Ackoff, R. L. "Foreword," in *Management Systems: Conceptual Consideration*s, P. Schoderbek, C. Schoderbek, and A. Kefalas (eds.), Business Publications Inc., Dallas, TX, 1975, p. viii.

Alavi, M., and Joachimsthaler, E. A. "Revisiting DSS Implementation Research: A Meta-Analysis of the Literature and Suggestions for Researchers," *MIS Quarterly* (16:1), March 1992, pp. 95-116.

Angehrn, A. A. "Computers That Criticize You: Stimulus-Based Decision Support Systems," *Interfaces* (23:3), May-June 1993, pp. 3-16.

Ariav, G., and Ginzberg, M. J. "DSS Design: A Systemic View of Decision Support," *Communications of the ACM* (28:10), October 1985, pp. 1045-1052.

Aronson, E. *The Social Animal*, 5th ed., W. H. Freeman and Company, New York, 1988.

Blanning, R. W. "A Relational Framework for Model Management in Decision Support Systems," in *Transactions of the Second International Conference on Decision Support Systems* (*DSS-82)*, G. W. Dickson (ed.), June 1982, pp. 16-28.

Blanning, R. W. "Model Management Systems: An Overview," *Decision Support Systems* (9:1), January 1993, pp. 9-18.

Bonczek, R. H.; Holsapple, C. W.; and Whinston, A. B. "A Generalized Decision Support System Using Predicate Calculus and Network Data Base Management," *Operations Research* (29:2), March-April 1981, pp. 263-281.

Bradley, G. H.; Brown, G. G.; and Graves, G. W. "Design and Implementation of Large-Scale Primal Transhipment Algorithms," *Management Science* (24:1), September 1977, pp. 1-34.

Brehm, S. S. ,and Kassin, S. M. *Social Psychology*, Houghton Miffin Company, Boston, 1990.

Chen, P. "The Entity-Relationship Model: Toward a Unified View of Data," *ACM Transactions on Database Systems* (1:1), March 1976, pp. 9-36.

Churchman, C. W. *The Design of Inquiring Systems: Basic Concepts of Systems and Organizations,* Basic Books, New York, 1971.

Churchman, C. W. *The System Approach* (revised and updated ed.), Dell Publishing, New York, 1979.

Churchman, C. W., and Schainblatt, A. H. "The Researcher and the Manager: A Dialectic of Implementation," *Management Science* (11:4), February 1965, pp. 69-73.

Daft, R. L., and Lengel, R. H. "Organizational Information Requirements, Media Richness, and Structural Designs," *Management Science* (32:5), May 1986, pp. 554-571.

Delbecq, A. L.; Van de Ven, A. H.; and Gustafson, D. H. *Group Techniques for Program Planning: A Guide to Nominal Group and Delphi Processes,* Scott, Foresman and Company, Glenview, IL, 1975.

Dickson, G. W.; Senn, J. A.; and Chervany, N. L. "Research in Management Information Systems: The Minnesota Experiments," *Management Science* (23:9), May 1977, pp. 913-923.

Diehl, M., and Stroebe, W. "Productivity Loss in Brainstorming Groups: Toward the Solution of a Riddle," *Journal of Personality and Social Psychology* (53:3), September 1987, pp. 497-509.

Doktor, R. H., and Hamilton, W. F. "Cognitive Style and the Acceptance of Management Science Recommendations," *Management Science* (19:8), April 1973, pp. 884-894.

Dolk, D. R., and Konsynski, B. R. "Knowledge Representation for Model Management Systems," *IEEE Transactions on Software Engineering* (SE-10:6), November 1984, pp. 619-628.

Dolk, D. R., and Kottemann, J. E. "Model Integration and A Theory of Models," *Decision Support Systems* (9:1), January 1993, pp. 51-63.

Dutta, A., and Basu, A. "An Artificial Intelligence Approach to Model Management in Decision Support Systems," *IEEE Computer* (17:9), September 1984, 89-97.

Einhorn, H. J., and Hogarth, R. M. "Behavioral Decision Theory: Processes of Judgment and Choice," *Annual Review of Psychology* (32), 1981, pp. 53-88.

Elam, J. J.; Henderson, J. C.; and Miller, L. W. "Model Management Systems: An Approach to Decision Support in Complex Organizations," *Proceedings of the First International Conference on Information Systems*, E. R. McLean (ed.), Philadelphia, PA, December 1980, pp. 98-110.

Elam, J. J., and Konsynski, B. R. "Using Artificial Intelligence Techniques to Enhance the Capabilities of Model Management Systems," *Decision Sciences* (18:3), Summer 1987, pp. 487-502.

Eom, H. B., and Lee, S. M. "A Survey of Decision Support System Applications (1971-April 1988)," *Interfaces*, (20:3), May-June 1990, pp. 65-79.

Eom, S. B. "Mapping the Intellectual Structure of Research in Decision Support Systems Through Author Cocitation Analysis (1971-1993)," *Decision Support Systems* (16:4), April 1996, pp. 315-338.

Eom, S. B.; Lee, S. M.; Somarajan, C.; and Kim, E. "Decision Support Systems Applications Research: A Bibliography (April 1988-1994)," *O.R. Insight* (10:2), April-June 1997, pp. 18-32.

Fisher, B. A. "Decision Emergence: Phases in Group Decision Making," *Speech Monographs* (37), 1970, pp. 53-66.

Fisher, B. A. *Small Group Decision Making*, 2nd ed., McGraw-Hill, New York, 1980.

Fredericks, P., and Venkatraman, N. "The Rise of Strategy Support Systems," *Sloan Management Review* (29:3), Spring 1988, pp. 47-54.

Geoffrion, A. M. "An Introduction to Structured Modeling," *Management Science* (33:5), May 1987, pp. 547-589.

Geoffrion, A. M.; Dyer, J. S.; and Feinberg, A. "An Interactive Approach for Multi-Criteria Optimization with an Application to the Operation of an Academic Department," *Management Science* (19:4), December 1972, pp. 357-368.

Gerrity Jr., T. P. "Design of Man-Machine Decision Systems: An Application to Portfolio Management," *Sloan Management Review* (12:2), Winter 1971, pp. 59-75.

Goul, M.; Henderson, J. C.; and Tonge, F. M. "The Emergence of Artificial Intelligence as a Reference Discipline for Decision Support Systems Research," *Decision Sciences* (23:6), November-December 1992, pp. 1263-1276.

Henderson, J. C. "Finding Synergy Between Decision Support Systems and Expert Systems Research," *Decision Sciences* (18:3), Summer 1987, pp. 333-349.

Huber, G. P. "Cognitive Style as a Basis for MIS and DSS Design: Much Ado About Nothing?" *Management Science* (29:5), May 1983, pp. 567-579.

Huysmans, J. H. B. M. *The Implementation of Operations Research*, Wiley-Interscience, New York, 1970.

Janis, I. L., and Mann, L. *Decision Making: A Psychological Analysis of Conflict, Choice, and Commitment*, Free Press, New York, 1977.

Keen, P. G. W. "MIS Research: Reference Disciplines and a Cumulative Tradition," in *Proceedings of the First International Conference on Information Systems*, E. R. McLean (ed.), Philadelphia, PA, December 1980, pp. 9-18.

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

Keeney, R. L., and Raiffa, H. *Decisions with Multiple Objectives: Preferences and Value Tradeoffs*, John Wiley and Sons, New York, 1976.

Libby, R. *Accounting and Human Information Processing: Theory and Applications*, Prentice-Hall, Englewood Cliffs, NJ, 1981.

Littlejohn, S. W. "An Overview of Contributions to Human Communication Theory from Other Disciplines," in *Human Communication Theory: Comparative Essays*, Frank E. X. Dance (ed.), Harper & Row Publishers, New York, 1982, pp. 243-285.

Loy, S. L. "The Interaction Effects Between General Thinking Skills and An Interactive Graphics-Based DSS to Support Problem Structuring," *Decision Sciences* (22:4), September-October 1991, pp. 846-868.

Maier, D. *The Theory of Relational Databases*, Computer Science Press, Rockville, MD, 1983.

Malone, T. W., and Crowston, K. "The Interdisciplinary Study of Coordination," *ACM Computing Surveys* (26:1), March 1994, pp. 87-119.

Marschak, J., and Radner, R. *Economic Theory of Teams*, Cowles Foundations for Research in Economics at Yale University Monograph 22, Yale University Press, New Haven, CT, 1972.

Mason, R. O., and Mitroff, I. I. "A Program for Research on Management Information Systems," *Management Science* (19:5), January 1973, pp. 475-487.

McCain, K. W. "Mapping Authors in Intellectual Space: A Technical Overview," *Journal of the American Society for Information Science* (41:6), September 1990, pp. 351-359.

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

Nazareth, D. L. "Integrating MCDM and DSS: Barriers and Counter Strategies," *INFOR* (31:1), February 1993, pp. 1-15.

Nemhauser, G. L. "The Age of Optimization: Solving Large-Scale Real World Problems," The 1993 Phillip McCord Morse Lecture, TIMS/ORSA Joint National Meeting, Chicago, IL, May 1993.

Newell, A., and Simon, H. A. *Human Problem Solving*, Prentice-Hall, Englewood Cliffs, NJ, 1972.

Osborn, A. F. *Applied Imagination: Principles and Procedures of Creative Problem-Solving*, Charles Scribner's Sons, New York, 1963.

Porter, M. E. *Competitive Strategy: Techniques for Analyzing Industries and Competitors*, The Free Press, New York, 1980.

Porter, M. E. *Competitive Advantage: Creating and Sustaining Superior Performance*, The Free Press, New York, 1985.

Riecken, D. "Introduction to Special Issue on Intelligent Agents," *Communications of the ACM* (37:7), July 1994, pp. 18-21.

Shortliffe, E. H. *Computer Based Medical Consultations: MYCIN*, American Elsevier, New York, 1976.

Shaw, M. E. *Group Dynamics: The Psychology of Small Group Behavior*, 3rd ed., McGraw-Hill, New York, 1981.

Shneiderman, B. *Designing the User Interface: Strategies for Effective Human-Computer Interaction*, Addison-Wesley, Reading, MA, 1992.

Siegel, J.; Dubrovsky, V.; Kiesler, S.; and McGuire, T. W. "Group Processes in Computer-Mediated Communication," *Organizational Behavior & Human Decision Processes* (37:2), April 1986, pp. 157-187.

Sprague Jr., R. H., and Carlson, E. D. *Building Effective Decision Support Systems*, Prentice-Hall, Englewood Cliffs, NJ, 1982.

Tversky, A., and Kahneman, D. "Judgment Under Uncertainty: Heuristics and Biases," *Science* (185), 1974, pp. 1124-1131.

Ullman, J. D. *Principles of Data Base Systems*, Computer Science Press, New York, 1982.

Von Eckardt, B. *What is Cognitive Science?* The MIT Press, Cambridge, MA, 1993.

von Neumann, J., and Morgenstern, O. *The Theory of Games and Economic Behavior*, 3rd ed. Princeton University Press, Princeton, NJ, 1953.

Winograd, T., and Flores, F. *Understanding Computers and Cognition: A New Foundations for Design*, Ablex Publishing, Nordwood, NJ, 1988.

Zeleny, M. *Multiple Criteria Decision Making*, McGraw-Hill, New York, 1982.

Zmud, R. W. "Individual Differences and MIS Success: A Review of the Empirical Literature," *Management Science* (25:10), October 1979, pp. 966-979.