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INTELLECTUAL RELATIONSHIPS BETWEEN DECISION SUPPORT SYSTEMS AND PSYCHOLOGY

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Abstract

This paper discusses the intellectual relationships between decision support systems (DSS) and psychology and examined the contributions of psychology to the development of the DSS areas. The fundamental factor distinguishing DSS from any other computer-based information systems is the use of judgment in every stage of decision making process. The crucial part of cognitive psychology is the study of internal mental processes, mental limitations, and the impacts that the limitations have on the mental processes, such as revealing judgmental heuristics and exploring their impacts on decision making. Cognitive scientists emphasized that judgmental biases can occur at every stage of information processing and that judgments are the result of interaction between the structure of tasks and the nature of human information processing systems. Decision aids are necessary in structuring the problem and assessing consequences, since intuitive judgment is inevitably deficient. We have traced how concepts/theories in psychology have been further extended and refined in the development of information systems theories and concepts.

Introduction

Psychology is the scientific study of the mind, mental processes, and behavior of living organisms in order to understand, predict, control, and explain these aspects. A large number of psychologists appear to agree that there is no universal definition of psychology and that most likely, one will never exist. Psychology is a diverse field with many branches, including cognitive psychology, industrial and organizational psychology, social and behavioral psychology, experimental psychology, biological psychology, developmental psychology, clinical psychology, educational psychology, counseling psychology, rehabilitation psychology, philosophical psychology, community psychology, humanistic psychology, population/environmental psychology, health psychology, etc. All these diversified fields of psychology are interested in studying environmental forces, genetic forces, mental processes, and the free will enacting on the minds of living organisms. This paper discusses the intellectual relationship between the decision support systems subareas and psychology

Like many academic disciplines, the study of information systems is a multidisciplinary (or interdisciplinary) field. There has been a two way flow of intellectual materials between the MIS area and other academic disciplines, such as management science/operations research, psychology, systems science, cognitive science, communications science, economics, accounting, etc. This article examines the contributions of psychology to the development of DSS subspecialties.

Despite psychology being a field with many diverse branches, including the aforementioned, all branches are concerned with studying the forces of environment, genetics, mental processes, and free will on the human mind. Of these numerous branches of psychology, cognitive psychology and social psychology are found to be the two most influential fields that have affected the establishment of DSS/ESS as an academic discipline.

Contributions of Psychology to the Development of Information Systems Subareas

The information systems area is a relatively young field of study as compared to, for example, economics, physics, philosophy, organizational behavior, etc. As a field of study continues to grow and become coherent, study of the intellectual development of the field is important. In a relatively new field, understanding the process of intellectual development and evolution of thought is even more beneficial because it identifies the basic commitments that will serve as the foundations of the field as it matures.

Contributions to Information Systems Design/user Interfaces from Psychology

The cost-benefit framework discussed above has been widely accepted by DSS researchers to assess the impact of decision aids used on effort expenditure by decision makers. Todd and Benbasat (1991) conducted numerous laboratory experiments to conclude that the use of a decision aid may result in effort savings, but not improved decision performance. In other words, DSS may aid the decision maker to be more efficient, but not to be more effective. Therefore, they suggested that DSS designers must consider the decision maker's trade-off between improving decision quality and conserving effort. Cost-benefit theory views problem solving in general as a trade-off between the effort to make a decision and the accuracy of the outcome, regardless of the characteristics of the tasks that must be performed.

Cognitive fit theory developed by Vessey (1991) and Vessey and Galletta (1991) can provide a useful guideline specifically for the designers of DSS for the tasks involving graphical and/or tabular representation of data in the decision making process. Vessey and Galletta (1991) argue that supporting the task to be accomplished with the appropriate display format leads to minimization of both effort and error. Therefore, system designers should concentrate on determining the characteristics of the tasks that problem solvers must address, and supporting those tasks with the appropriate problem representation and support tools. 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.

An applied information-processing psychology project team at the Xerox Palo Alto Research Center conducted requisite basic psychological research to generate a set of design principles which aid in the design of computer systems for human-computer interaction (Card et al. 1983). Their framework for applying psychology to computer system design consists of:

(1) the structure and performance of the human-computer system
(2) performance of models for predicting the performance of the human-computer system, and
(3) design functions for using the performance models in the design process.

Card et al (1983) viewed that the role of an applied psychology is to supply performance models for the designer. The performance (independent variable) of a human-computer system can be specified as being determined by its structural (dependent) variables (task, user, and computer).

Contributions to Implementation from Cognitive Psychology

Researchers in the DSS implementation area have attempted to systematically identify the implementation success factors and the relationship between user-related factors (cognitive style, personality, demographics, and user-situational variables) and implementation success. The majority of DSS implementation researchers have expanded the implementation success factors to include other user-related factors, such as personality, demographics, and user-situational variables, in addition to cognitive styles. They asserted that the cognitive style of users/managers did affect the chances of implementations

A theory of problem solving by Newell and Simon (1972) described the cognitive mechanisms and the nature of human information-processing systems. A theory of problem solving sheds some light on understanding how intelligent adults solve short (half-hour), moderately difficult problems of a symbolic nature, such as those in chess, symbolic logic, and algebra-like puzzles. According to their theory, 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, which leads to successful implementation of DSS.

Contributions to GSS from Psychology

Group idea generation is an important part of GSS activities. Osborn (1963) 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). GSS 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 GSS. Brain storming is one of the most widely known approaches to idea generation. Osborn improved a traditional, unstructured process of group idea generation technique and provided a set of systematic rules for brain storming groups to overcome several social psychological factors that usually inhibit the generation of ideas.

Numerous research has shown that nominal groups of non-interacting individuals have outperformed verbally brainstorming groups (Nagasundaram and Dennis 1993). Many psychologists investigated the most likely causes of productivity losses of brainstorming groups (production blocking, free riding, evaluation apprehension, etc.). A series of experiments by psychologists Diehl and Stroebe (1987) concluded that "individuals brainstorming alone, then pooling afterwards produces 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 Diehl and Strobe's experiments was their recognition of the magnitude of the impacts that production blocking has on the productivity loss of brainstorming groups. By manipulating blocking directly, Diehl and Strobe (1987) 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.

Several studies conducted in the early 1990s showed that electronically brainstorming groups produced superior results to verbally brainstorming groups and non-electronic nominal groups in terms of number of unique ideas generated (Gallupe et al. 1991). GSS researchers tried to answer the question of why electronically brainstorming groups generated a higher number of unique ideas, adopting the numerous research results of cognitive scientists. Nagasundaram and Dennis (1993) argued that "a large part of idea-generation behavior in electronic brainstorming (EBS) can be explained by viewing EBS as an individual, cognitive (rather than social) phenomenon from the human information processing system perspective." 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 (1977) 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.

An important goal in the study of group DSS is to minimize the dysfunctions of the group interaction process, such as evaluation apprehension, cognitive inertia, domination by a few individuals, etc. 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 inter-related process of social interaction. The factors include the physical environment of groups, personal characteristics of group members, group composition, group structure, leadership, group tasks and goals, etc. According to McGrath (1984), all groups can be classified as: vehicles for delivering social influence, structures for patterning social interaction, or task performances systems. He focused on the nature, the causes, and the consequences of "group interaction processes," defined as "dynamic interplay of individual and collective behavior of group members."

Siegel and others (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.

Contributions to Model Management from Cognitive Psychology

Since 1975, model management has been determined to encompass several central topics, such as model base structure and representation, model base processing, and application of artificial intelligence to model integration, construction, and interpretation.

A group of DSS researchers are continuing to build DSS to support the problem structuring phase (Loy 1991; Pracht and Courtney 1988). In this line of research, while building toward an interactive graphics-based problem-structuring aid, such as the Graphical Interactive Structural Modeling Option (GISMO), cognitive scientists have made important contributions in developing imagery theory, dual coding theory, and a theory of problem solving. According to Anderson (1985), there are two competing theories of memories-- propositional vs. dual-code. The dual-code theorists believe that although other codes exist for other modalities, such as touch, taste, and smell, all memory is tied to a particular sensory modality, with the verbal and visual codes being the dominant ones stored in long-term memory. On the other hand, the propositional code theorists claim that representations in memory are abstract, and therefore, are not tied to a particular sensory modality.

Using GISMO, 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 DSS tools which can provide effective support for decision makers who do not possess highly developed visual thinking skills.

In the same line of research, graph-based modeling is an emerging research area. Jones (1995) presented NETWORKS, a prototype system of graph-based modeling which allows the user to represent a wide variety of decision problems in a graphical form, such as bar chart, decision tree, decision network, etc. Further, the users manipulate the models (e.g., deleting/adding subtrees for decision trees) using a graph-grammar by applying a set of operations (or productions).

Contributions to Intelligent Information Systems/DSS from Cognitive Psychology

A significant contribution from cognitive psychology is the development of artificial neural networks. This area of research is often called connectionism, parallel distributed processing, or neurocomputing. Numerous individuals have contributed to the advancement of neural network systems. Among them, Rumelhart, McCleland, and the PDP research group (the research group formed to understand the nature of cooperative computation and to develop “neurally inspired” computational architectures) have been most influential in providing foundational concepts for the development of neural networks (Rumelhart and McClelland 1986).

One of the essential study questions the cognitive scientists had in mind is to study the architecture of mind. Comparatively, the human brain works slowly, as it contains billions of brain cells. In addition, the brain must deploy the processing elements in the brain cooperatively and in parallel to carry out its activities. Human brains have the capability to think in parallel and in serial for any task requiring attention. Today, intelligent DSS combines traditional quantitative DSS tools with neural networks. Such DSS combined with neural networks produce synergistic impacts in improving the effectiveness of decision making activities via enhancing the cognitive support for the user.

As reviewed, cognitive psychologists identified the cognitive limitations and biases associated with presenting data to a decision-maker and within information processing. To overcome these human limitations, many DSS researchers suggested an expert system with embedded DSS to ameliorate these cognitive limitations.

Intelligent agents (known also as intelligent interfaces, adaptive interfaces) research is an emerging interdisciplinary research area involving researchers from such fields as ES, DSS, cognitive psychology, computer science, etc. According to Riecken (1994), 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 (1993) introduced the conversational framework for decision support as a basis of a new generation of active and intelligent DSS and EIS. 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.

Summary and Conclusion

We have discussed the intellectual relationships between the decision support systems subarea and examined the contributions of psychology to the development of the MIS areas. The fundamental factor distinguishing DSS from any other computer-based information systems is the use of judgment in every stage of decision making process. The crucial part of cognitive psychology is the study of internal mental processes, mental limitations, and the impacts that the limitations have on the mental processes, such as revealing judgmental heuristics and exploring their impacts on decision making. Cognitive scientists emphasized that judgmental biases can occur at every stage of information processing and that judgments are the result of interaction between the structure of tasks and the nature of human information processing systems. Decision aids are necessary in structuring the problem and assessing consequences, since intuitive judgment is inevitably deficient. We have traced how concepts/theories in psychology have been further extended and refined in the development of information systems theories and concepts.

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