The Impact of Executive Information Systems on Organizational Design, Intelligence, and Decision Making

Dorothy E. Leidner • Joyce J. Elam
Hankamer School of Business, Baylor University, Waco, Texas 76798
College of Business, Florida International University, Miami, Florida 33199

This study examines the impact of executive information systems on organizations in light of George Huber's (1990) theory of advanced information technologies. The hypotheses and method are very traditional, but the results shed light on a fairly new class of information systems that, unlike traditional systems, target the highest levels of organizational decision making. The results suggest some of the positive impacts of these new systems and also raise questions about their long-term value. Most importantly, the study verifies and enhances some of Huber's important tenets.

Gerardine DeSanctis

Abstract

Managerial decision making is regarded as among the most important functions of senior managers. The presence of easily accessible, reliable information contributes to effective decision making. Sources of information may be oral, written, or computer-based. The computer-based information sources remain the least studied in the context of executive decision making because executives have tended to use other managers and their own intuition as their primary information sources. Recently though, computer-based information systems directly tailored for use by executives have begun to be implemented within organizations. Such systems, referred to as Executive Information Systems, may help executives make faster and higher quality decisions, an increasingly important requirement for executives given such trends as globalization and heightened competition. This study uses survey responses of 91 high level managers to empirically examine the relationship of executive information system use by managers with decision making speed, problem identification speed, information availability, and the involvement of subordinates in decision making.

The study found that when used frequently and over time, executive information systems are positively related to perceived problem identification and decision making speed for senior and middle managers. Whether such effects lead to higher quality decisions are topics for further study. In addition, the frequency of use of executive information systems is shown to be related to a perceived increase in information availability although the length of time the system is in use is not related to perceived information availability. This suggests that the information needs of senior and middle managers is malleable and systems designed to support the decision making of managers need to be flexible to adapt to changing information needs. Lastly, the study found that the use of executive information systems does not reduce the reliance of senior or middle managers on their subordinates to help in decision making. This may be because the involvement of subordinates does not necessarily connote a consistent positive or negative behavior among American managers, whereas speed and information are consistently considered as positive. The implications of the results for a previously developed theory of the effects of advanced information technology on organizational design, intelligence, and decision making are discussed.

(*Executive Information Systems*; *Management Decision Making*; *Organization Theory*; *Executive Support Systems*; *Information Systems*)

Introduction

The presence of easily accessible, reliable information contributes to effective decision making. Sources of information may be oral such as meetings, written such as printed reports and letters, or computer-based such as electronic mail, on-line management information systems (MIS) or decision support systems (DSS) (Jones

1047-7039/95/0606/0645/$01.25

and McLeod 1986). The computer-based information sources remain the least studied in the context of executive decision making because executives have tended to use other managers and their own intuition as their primary information sources (Jones and McLeod 1986). Recently though, computer-based information systems directly tailored for use by executives have begun to be implemented within organizations. Such systems, hereafter referred to as Executive Information Systems (EIS), may help executives make faster and higher quality decisions, an increasingly important requirement for executives given such trends as globalization and heightened competition (Huber 1984, Eisenhardt 1989).

Case studies of selected organizations have shown that EIS are credited with improving organizational intelligence and decision making activities. Executive users of EIS perceive such benefits as increased understanding of the business, more comprehensive analysis, greater confidence, and a more complete mental model, and ultimately faster and higher quality decisions (Rockart and DeLong 1988). Other case studies show the role of EIS in supporting the changed decision making environment that results when an organization must deal with reduced staff levels (Applegate and Osborn 1988). Yet despite many case study descriptions of the impact of EIS use, there has been little research that synthesizes and integrates these findings or that provides theoretical explanations for the effects found. With the growth in the number of organizations adopting EIS, there now exists both the opportunity and the need to undertake more rigorous, theory-guided studies of the organizational effects of EIS use.

This paper reports the results of such a study. The paper is organized as follows. The next section provides the theoretical foundation for the study and states the hypotheses to be tested. The third section describes the methodology used in conducting the study. The fourth section presents the results of the study and the last section discusses the implication of the results for a theory on the organizational effects of advanced information technologies like EIS.

Theoretical Foundations and Hypotheses

Huber (1990) proposes a theory concerning the effects that advanced information technologies have on organizational design, intelligence, and decision making. Advanced information technologies are defined to include computer-assisted communication technologies (e.g., electronic mail, computer conferencing, and video conferencing) as well as computer-assisted decision-support technologies (e.g., expert systems, decision-support systems, and executive information systems). This theory was constructed by first developing a set of propositions drawn from organizational communication and information systems research. These propositions possess as an independent variable, computer-assisted decision and/or communication-aiding technologies. The dependent variables include performance variables related to organizational intelligence and decision making (e.g., timeliness and quality) and design variables related to technology-prompted changes in organizational design. These design variables are conceptualized at the subunit level (e.g., size of decision units), the organizational level (e.g., centralization of decision making), and in terms of organizational memory (e.g., development and use of computer-resident in-house expert systems). The propositions are then used to build a conceptual theory that links together five constructs: availability of advanced information technologies, use of advanced information technologies, increased information accessibility, changes in organizational design, and improvements in effectiveness of intelligence development and decision making. This conceptual model along with the propositions that are related to decision-support technologies is shown in Figure 1.

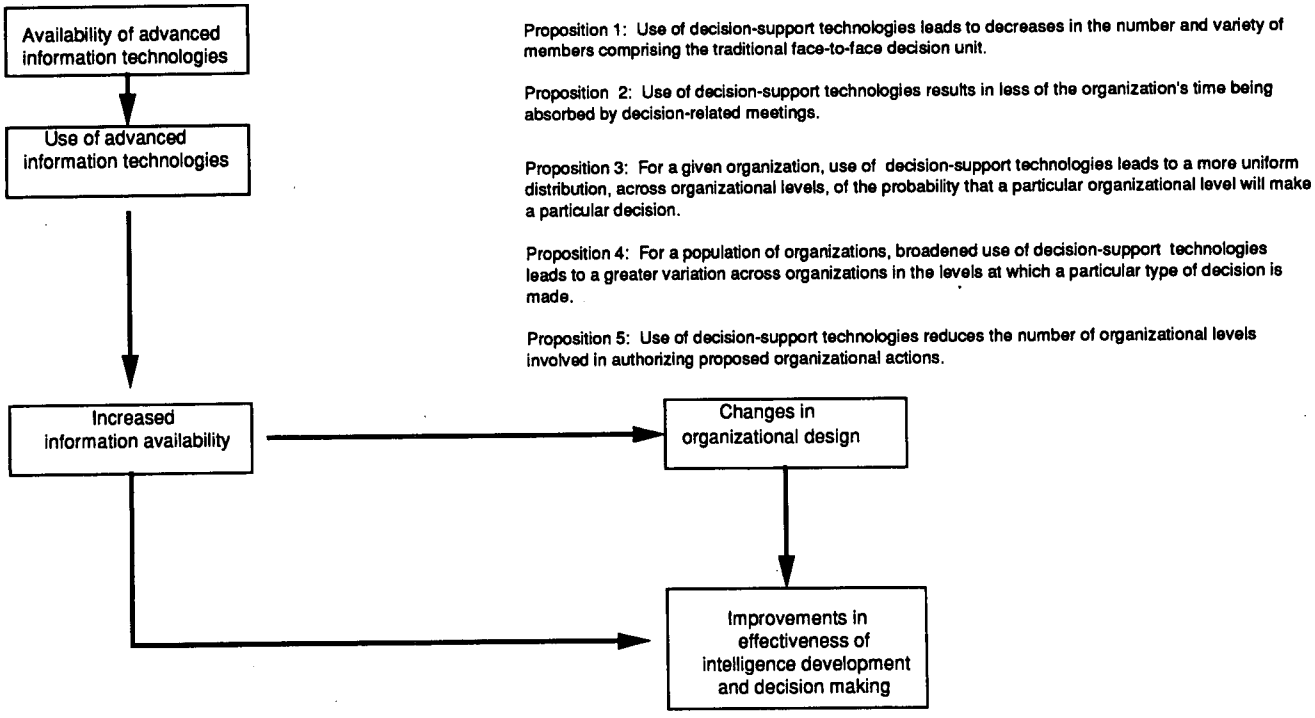
The propositions and the conceptual theory (hereafter, referred to simply as the theory) provide a good starting point for empirical work on the effects that EIS have on organizations. In this study, we construct a research model from four constructs included in this theory: use of advanced information technologies, increased information accessibility, changes in organization design, and improvements in effectiveness of intelligence development and decision making. In building a research model that specifically focuses on EIS, some clarification and refinements of the constructs as originally defined in the theory were required as described below.

We begin this section by providing a definition of EIS. This is followed by a description of the research model and the hypotheses to be tested. The operationalization of the variables included in the hypotheses will be presented in the methodology section.

Executive Information Systems

Huber (1990) defines an advanced information system to be a "device that (1) transmits, manipulates, analyzes, or exploits information, (2) in which a digital computer processes information integral to the user's communication or decision task, and (3) that has either

Figure 1 Conceptual Theory and Propositions Related to Decision-support Technologies from Huber (1990)



made its appearance since 1970 or exists in a form that aids in communication or decision tasks to a significantly greater degree than did pre-1971 form." While EIS safety these requirements, a more specific definition of EIS that identifies the intended users and the common features may be useful in understanding the potential effects of EIS on organizational design, intelligence, and decision making.

The original definitions of EIS emphasized senior managers as the ultimate user: Rockart and DeLong (1988) defined EIS as "the routine use of a computer terminal by either the CEO or a member of the senior management team reporting directly to him" and Turban and Schaeffer (1987) defined EIS as "a computer-based system specifically designed to meet the needs of top executives and to eliminate the need for intermediaries." Recognizing that EIS use has spread below the top management level in many organizations, more recent definitions specify the intended users only as managers (Watson et al. 1991). Existing research on EIS frequently has included general managers and vice presidents in the term "executive user" (Bergeron et al. 1991) and EIS developers claim to target vice presidents and above as potential users (Rinehart 1986). This research will therefore define EIS to include both senior and middle management users.

Carlisle and Aladmeddine (1990) argue that for a computer-based information system to be considered an EIS it must have all of the following features: office support such as electronic mail and a calendar system, analytical support such as spreadsheets, customization capabilities such as the ability to design specific icons for a screen, graphical capabilities, and planning tools such as project management. This is, however, a very strict definition that few of the systems in use in organizations today that are widely recognized as EIS could satisfy. Watson et al. (1991) offer a much less restrictive definition. They define EIS as "a computerized system that provides executives with easy access to

Table 1 Definition of EIS

	EIS Definition
Purpose:	Meet the information needs of managers by providing timely access to information relevant to their activities
Intended users:	Senior and Middle Managers
Features:	Single database of internal and / or external information
	Drill-down analysis capabilities
	Trend analysis capabilities
	Ability to obtain data originating from multiple sources
	Highlighting of critical information

internal and external information that is relevant to their critical success factors." This definition, however, fails to identify the common features that are most typically included in EIS.

For purposes of this research, we will define EIS to be computer-based systems that include most, but not necessarily all, of the following features: a single database where all internal financial and operational data as well as external data can be found, a user-friendly interface (e.g., non-keyboard interface, use of icons in interfaces), drill-down analysis capabilities (e.g., the incremental examination of data at different levels of detail),[1] trend analysis capabilities (the examination of data across desired time intervals), exception reporting, and the highlighting of information an executive feels is critical (Schade 1988). A summary of the definition of EIS used in this research is shown in Table 1.

EIS Use

Common to all of the propositions in Figure 1 is the independent variable, the use of decision-support technologies. Implicit in these propositions is the assumption that the organization is the unit of analysis. However, when focusing on EIS, measuring use at the organizational level is not very meaningful for three major reasons. First, since EIS are targeted to individuals in the middle and upper management ranks, there is usually only a small number of potential users in any organization. Second, since EIS use is discretionary, there may only be a small subset of targeted individuals who actually use EIS at all; and within this set of individuals, the extent of use is likely to vary substantially. Third, EIS are a new technology and their use has not become institutionalized in many organizations. Until EIS become widespread throughout organizations, the effects on organizational design, intelligence, and decision making are likely to be seen only in those parts of the organizations where EIS use is strong. Aggregating responses of individuals within an organization is inappropriate when the technology under study has not become institutionalized. For these reasons, the individual EIS user will be the unit of analysis and EIS use will be measured at the individual level. It should be noted that Huber's theory was not intended for the individual level; this research thus represents an adaptation and testing of the theory to a different level of analysis rather than a direct testing of it. The results can therefore not be construed as confirming or refuting the theory at the organizational level.

It is important to note that EIS are designed for use by individuals who have overall responsibilities for developing, recommending, and selecting courses of actions for either the organization as a whole or for individual organizational subunits. Thus, although use is measured at an individual level, EIS use may have organizational consequences and thus affect organizational decision making. The extent of these effects may vary depending upon whether the user is a senior or middle manager. To account for this possibility, management level will be included in the testing of hypotheses.

It is unclear whether the propositions given in Figure 1 intend use to mean "any use" as opposed to "no use" or whether the propositions intend use to mean "degree of usage." Because EIS can be considered as one of many information sources available to managers to support their decision making, it is expected that there will be variations in the extent to which managers use this source. As Huber (1990) points out, when organizational participants perceive that their use of an advanced information technology leads to an increase in their effectiveness in fulfilling organizational goals, their use of the advanced information technology will be reinforced. This reinforcement in turn leads to more frequent use of the advanced information technology. Therefore this research will conceptualize EIS use in terms of the frequency of use.

EIS use will also be conceptualized in terms of the length of time that an individual has used an EIS. It is important to examine the effects of long-term use of EIS as well as the frequency of EIS use for two major reasons. First, given that EIS is a relatively new advanced information technology in most organizations, it may take time before the impacts of EIS are realized or noticed, even in those parts of the organization

where EIS use is frequent. In addition, over time, managers may develop optimal ways of using EIS that require less frequent interactions than was the case when they first began to use EIS.

EIS Use and Improvements in Organizational Intelligence and Decision Making

Huber (1990) develops three propositions concerning the effect of decision-support technologies on the quality and speed of organizational decision making as shown in Figure 1. In Huber's theory, communication technologies, not decision-support technologies, are seen as contributing to the effectiveness, quality, or timeliness of organizational intelligence. Organizational intelligence is defined to be the output or product of an organization's efforts to acquire, process, and interpret information external to the organization and is an input to the organization's decision makers. Thus, organizational intelligence is seen as separate from organizational decision making.

We view organizational intelligence in a more general way as including any problem identification activity. Given that problem identification is generally accepted to be the beginning stage of the decision making process (Witte 1972, Brim et al. 1962, Mintzberg et al. 1976, Simon 1977), all organizational decision making involves some level of organizational intelligence. If EIS affect the timeliness and quality of decisions, it is reasonable to assume that they affect the timeliness and quality of the beginning stage of the decision making process.

Internal monitoring and environmental scanning are key activities of senior managers (Keegan 1974): such activities provide "early warning indicators" which enable executives to identify and react faster to problems and to competitive trends and product changes (Stanat 1986). By allowing quicker access to both internal and external information, EIS enable faster scanning and monitoring (Rockart and DeLong 1988). Effectively employed, EIS can give managers a needed increase in reaction speed (Stephenson 1986). The use of EIS may also reduce the time needed for problem identification by allowing managers to identify problems themselves rather than relying on subordinates to identify problems for them. For these reasons, the more frequent the use of EIS, the more likely problems will be identified faster. The longer the EIS has been in use, the more adept the manager will be in interpreting the information and determining where problems exist. It is thus hypothesized:

HYPOTHESIS 1a. *The more frequent the manager's use of EIS, the faster the speed of problem identification.*

HYPOTHESIS 1b. *The longer the length of the manager's use of EIS, the faster the speed of problem identification.*

Arguing that the aspects of the decision making process following problem or opportunity recognition might be more effective when using advanced information technology, Huber (1990) suggests that the use of advanced information technologies will allow decision makers or their assistants to analyze information quickly and thus reduce the time required to make decisions. The time frame of decision making has not been studied extensively (Mintzberg et al. 1976) although speed is considered particularly important in highly uncertain, dynamic or "high-velocity" environments (Eisenhardt 1989). Eisenhardt (1989) found that effective firms in such environments make strategic decisions quickly. The availability of real-time information was seen as an important factor in reducing the time frame for making decisions. In addition, the decisions were faster because real-time information was used and multiple alternatives were considered simultaneously. EIS can provide such real-time information. The provision of real-time, accurate, and easily accessible information should allow managers to make decisions more quickly. As will be discussed below, decreased reliance on subordinates for analysis may also reduce the time required to make a decision. Those managers who use EIS the most frequently should notice the largest increase in their decision making speed; likewise, those who have used the systems the longest will be accustomed to quickly assessing their business environment and acting quickly. Thus, it is hypothesized:

HYPOTHESIS 2a. *The more frequent the manager's use of EIS, the faster the speed of the decision making process.*

HYPOTHESES 2b. *The longer the length of the manager's use of EIS, the faster the speed of the decision making process.*

EIS Use and Increased Information Availability and Accuracy

Jones and McLeod's (1986) research on executives' use of information from various sources discovered a heavy reliance on informal, verbal sources and little use of computer-based sources. Similarly, Jarvenpaa and Ives (1990) found that 41% of the executives in their study had no involvement with the computer and only two executives in Mittman and Moore's (1984) study of 18

executives used a DSS at least weekly. Another study found that only 28 out of 153 senior managers used a computer (Bergeron et al. 1991). One of the reasons for these findings at the senior management level may be that senior managers do not perceive existing information systems (e.g., MIS and DSS) as providing pertinent and reliable information.

EIS are intended to provide such pertinent and reliable information by incorporating six types of essential information needed by management (Kogan 1986): key problem narratives, highlights charts, top-level financials, key factors, detailed key performance indicators, and responsibility reports. Having needed information cleanly packaged and available in a timely manner may lead managers to perceive an increase in information availability. Huber proposes such a relationship in his conceptual theory although he offered no specific proposition (see Figure 1).

In addition to increasing information availability, EIS can also be expected to increase information accuracy. In developing EIS, organizations often uncover major inconsistencies in accounting policies and reporting systems. Since EIS are based upon a single database, these inconsistencies must be resolved. For example, Applegate (1987) cites the example of the use of the word "sign up" at Lockheed Georgia. To the legal department, a sign up signifies that a signed contract to purchase a plane was received; to finance; the word implies that a down payment for a new plane has been received; to marketing, the word suggests that a customer has agreed to make a purchase. These differences in specific definitions led to timing differences as to when the sign-up was recorded and hence to different impressions of the organization's performance among top managers. EIS force such inconsistencies to be resolved.

EIS should lead to more available and more accurate information for its users. Perceived availability and accuracy should increase with both the frequency of use as well as the length of use. It is therefore hypothesized:

HYPOTHESIS 3a. *The more frequent the manager's use of EIS, the greater the perceived information availability.*

HYPOTHESIS 3b. *The longer the length of the manager's EIS use, the greater the perceived information availability.*

HYPOTHESIS 4a. *The more frequent the manager's use of EIS, the greater the perceived information accuracy.*

HYPOTHESIS 4b. *The longer the length of the manager's EIS use, the greater the perceived information accuracy.*[2]

EIS Use and Changes in Organization Design

Huber (1990) develops five propositions concerning the effect of decision-support technologies on organizational design as shown in Figure 1. The first two propositions deal with variables—size and heterogeneity of decision units and frequency and duration of meetings—generally thought of in the context of organizational subunits. The last three propositions deal with variables—centralization of decision making and number of organizational levels involved in authorization—generally associated with the organization as a whole. In this study, we focused on the effects of EIS at the organizational subunit or decision unit level since we felt that the use of EIS has not become widespread enough or institutionalized to the degree necessary for effects on design at the organizational level to have materialized. At the organizational subunit level, we focused on the size and heterogeneity of decision units.[3]

Huber (1990) suggests that the accessibility of information made possible by decision-support technologies can help decision units to become relatively smaller and more homogeneous. These units may become smaller because experts in the decision unit are replaced by expert systems. Decision units might also become smaller if the role that subordinates have traditionally played in decision making activities changes.

Traditionally, subordinates have played an important role in problem identification. Wilensky (1967) noticed the low proportion of problems which experts originate (pose the initial problem) and Blankenship and Miles (1964) noticed that although upper levels enjoyed considerable independence and discretion upwards, they relied heavily on subordinates to bring problems to their attention and to provide recommendations for solving problems. Upper-level managers also tended to involve their subordinates in the decision making process to a greater degree than managers at lower levels.

There are indications that the use of EIS may lessen the role played by subordinates in decision making. In fact, many managers interviewed by Rockart and DeLong (1988) were pleased with their EIS because they lowered the extent of their reliance on subordinates for problem identification and analysis. Exception reporting and trend analysis help in problem detection and may cause managers to rely less on subordinates to initiate problems. The ability to monitor

information on a daily basis may also reduce their reliance on subordinates for the identification of problems. The more frequent managers' use of EIS, the more likely they will notice problems themselves without the help of subordinates. The longer the system has been in use, the more the manager will rely on the system rather than subordinates for problem identification. It is thus hypothesized:

HYPOTHESIS 5a. *The more frequent the manager's use of EIS, the less the manager's involvement of subordinates in problem identification.*

HYPOTHESIS 5b. *The longer the length of the manager's use of EIS, the less the manager's involvement of subordinates in problem identification.*

If a senior manager is able to get trusted information quickly from a single source, such as an EIS, less reliance on a formal or informal network of people to analyze information may result and participants previously responsible for analyzing and interpreting information may no longer be needed. Decision-support technologies allowing managers to obtain and analyze reliable information may reduce the managers' reliance on lower levels for decision analysis and allow them to analyze and make decisions they may have otherwise left to lower levels.

By providing detailed operational data for performance monitoring, drill-down analysis, and trend analysis, EIS may allow senior managers to analyze problems and evaluate alternatives themselves. EIS use could thus result in less management reliance on subordinates during analysis. In addition, the setting of triggers by managers can allow larger amounts of detail to be tracked on an automated basis using exception reports. This may allow a manager to become more involved in operational decisions which were previously decentralized and may make them more autocratic in terms of decision making. Thus, less involvement of subordinates in decision making analysis by managers who use EIS is expected. The more frequent the use, the more pronounced should be the manager's self-reliance; the longer the system has been used, the less the manager will find it necessary to consult with subordinates. It is therefore hypothesized:

HYPOTHESIS 6a. *The more frequent the manager's use of EIS, the less the involvement of subordinates in the decision making analysis.*

HYPOTHESIS 6b. *The longer the length of the manager's use of EIS, the less the involvement of subordinates in the decision making analysis.*

Methodology

A survey instrument was used to gather data to test the relationships expressed in the hypotheses. The survey collected information on personal decision making styles, the use of an EIS, and the user's perceptions of the benefits gained from using an EIS. The survey included multi-item scales for all variables in the research model. The survey was pilot tested by three executives from a large financial institution with an EIS and reviewed by a panel of three colleagues with research backgrounds in management decision making and/or decision support systems. Suggestions were incorporated into a second version which was piloted by two more executives: one president from a different financial institution and one president of a small company with intensive computer usage. One additional suggestion was made and incorporated into the final version. Such a piloting process helps establish content validity (Straub 1989). Bias in response from misinterpretation of the instrument should therefore be reduced.

Operationalization of Variables

In order to build upon previous research, a review of instruments used in other studies examining information technology and/or decision making processes was undertaken. Based on this review, certain items were derived from previous research. Other items were created by the authors. The definition of each variable used to test the hypotheses and the items associated with each are given below.

Independent Variables. EIS use is measured according to its frequency of use by the respondent and according to the length of time it has been used by the respondent. Frequency of EIS use was measured on a five point scale consisting of infrequently, monthly, 1 to 4 times per week, daily, and several times per day. It was not possible to derive a linear scale to measure EIS frequency of use (for example, how much time each week) because this would necessitate access to monitoring systems that kept track of each minute the user spent on the system. None of the systems in this study was equipped with such monitoring devices. To determine the length of time the EIS had been used by the individual, the individual was asked the month/day/year when he/she began using the EIS.

Dependent Variables. The speed of problem identification is the time elapsed between when the signs of a problem first originate and when they are first

detected. The respondents were asked to assess the degree to which EIS had helped them to identify potential problems faster, sense key factors impacting their area of responsibility, and notice potential problems before they became crises. Speed of decision making is the span of time beginning with problem identification and ending with choice. Ideas were borrowed from Huber (1990), who helped define and clarify the speed of decision making. To measure the speed of decision making, respondents were asked the degree to which the EIS had helped them make decisions quicker, shorten the time frame for making decisions, and spend less time in meetings. We choose to include time spent in meetings as a part of decision making speed rather than as a dependent variable in itself because we felt that "time spent in meetings" reflects a value judgment that less time is desirable: the more time spent, the longer the time to make the decision. On the positive side, meetings are a forum for information sharing among participants in a decision making process; however, this information sharing component is implicit in the "size and heterogeneity of the decision unit" variable of Huber (1990). Therefore, the speed component of "time spent in meetings" is incorporated into the variable associated with decision making speed.

Information availability is the presence of and access to needed information. Availability is high if the data are available at the time when needed (Gifford et al. 1979) and are easily accessible. The EIS users were asked if information was available on the EIS that was previously unavailable except as a special report, if information was now available in a more timely manner, and if information was available from a single source (the EIS). Information accuracy is measured in terms of the consistency of information across departments, the perceived degree of accuracy, and the degree to which the information received is the information desired. No prior surveys were found that measured these two constructs so the wording of each item was determined by the authors.

Participation in problem identification is the extent to which managers rely on subordinates to identify problems. Participation in decision making is the extent to which managers rely on subordinates to perform analysis in decision making. Blankenship and Miles (1964) measured decision maker behavior by measuring the extent of personal initiation, autonomy from superior, perceived influence on superior, reliance on subordinates, and final choice. Our survey borrows and expands two of these items: extent of personal initiation and reliance on subordinates. To assess the participation of subordinates in problem identification, the respondents were asked the degree to which they personally identified most problems in their area of responsibility, the degree to which problems were brought to their attention by subordinates, and the degree to which they relied on subordinates to keep them informed of daily problems. To measure the participation of subordinates in decision making, the respondents were asked the degree to which they made informal decisions that did not involve their subordinates, the degree to which they involved subordinates in decision processes, and the degree to which they involved subordinates in identifying and/or deciding upon courses of action.

All dependent variables were measured on a five-point scale with 1 representing "To No Extent" and 5 representing "To a Great Extent."

Selection of Respondents

Through an extensive review of business, trade, and academic journals, and through contacting the major suppliers of EIS development shells and consultants for EIS development, the researchers identified approximately 100 companies in the U.S. that had developed or were developing EIS. Since EIS have not yet been categorized into meaningful types, no attempt was made to control for a particular type of EIS.[4]

A contact person was identified in each company and interviewed over the phone. The contact person was typically from the information systems department and had an important role in designing, developing, and/or maintaining the EIS. The contacts were asked about the major system features, the spread of the system in the organization, and their perceptions of the EIS's benefits. In addition, several contacts arranged for on-site visits with EIS users in their organizations. In total, 26 telephone interviews of developers were conducted, and six on-site interviews of users were conducted. Three senior managers and three middle managers were interviewed during the site visits. Where appropriate, insights from the interviews are used to interpret the results of the survey.

The contact person was given a set of surveys to distribute to EIS users. If the number of users was less than ten, we requested that all EIS users be given a survey. If there were more than ten EIS users, we requested that the contact person randomly distribute the surveys to users in proportion to their management level (i.e., if 30% of the total EIS users were top managers and 70% middle managers, then 30% of the respondents were upper managers and 70% were middle managers).

As mentioned previously, although executive policy makers were originally intended to be the users of EIS, these systems are now frequently used at lower management levels (Watson et al. 1991). It was therefore desirable to include senior and middle management respondents in order to determine if the hypotheses held for both levels of users. Past research helps in the classification of senior and middle managers. Mittman and Moore (1984) defined executives to be those with a title of vice president and above. Sixty-four percent of their respondents were vice presidents. Isenberg (1985) defined a senior manager to be at the level of general manager or above. Both consultants and developers of EIS have included vice presidents as "senior manager" or "executive" (Kogan 1986, Stanat 1986). Others have called top management the president and one level below the president, while middle management is two levels below the president (Zaki and Hoffman 1988). The term senior manager in this research will refer to a manager reporting no more than two levels below the president or CEO. A middle manager will refer to a manager who reports more than two levels below the president.

Analysis and Results

In total, 29 contacts agreed during phone conversations to distribute surveys. Responses were returned from 22 organizations for an organizational response rate of 75.8%. In total, 303 surveys were sent to the 29 organizations. Of these, 97 were returned for a response rate of 32% for total surveys sent. There were a total of 91 usable surveys equally split between senior and middle managers (45 senior managers and 46 middle managers). Table 2 presents the profiles of the participating organizations. Nonresponse bias was assessed by comparing the average revenues and size of the responding organizations with the revenues and size of the seven nonresponding organizations. The revenues and size of the nonresponding organizations were well within the ranges of figures represented by the responding sample. In addition, the nonrespondents represented roughly the same industry mix as the responding sample.

Construct Validity and Reliability

Construct validity addresses the question of whether the measures are true constructs describing the event or merely artifacts of the methodology (Straub 1989). Because items were included in the survey that were not related to Huber's theory, there were fewer than the desirable ten respondents per item. Unstable solutions may result from having insufficient observations per item (Tabachnick and Fidell 1989). To compensate for such instability, the entire pool of items was split into a priori scales and several runs of factor analysis were performed by running items for two scales at a time. Such an iterative approach to factor analysis is discussed in Seashore (1983) and Van de Ven and Ferry (1980) and is common for large surveys (Busch et al. 1991). The factors should be correlated since they are almost all dealing with some aspect of organizational intelligence and decision making. For this reason, an oblique rather than orthogonal rotation was used (Tabachnick and Fidell 1989). Eigenvalues greater than 1 and scree plots were used in determining the number of factors. For an item to be considered in the composition of a variable, it had to have a loading of at least 0.5 on the factor, with no loading exceeding 0.3 on another factor, had to conform to a priori assignments, and had to add to the variable's reliability.

The mean of the items in each scale was used to combine the items into a variable score. Cronbach's

Table 2 Profiles of Sample Organizations

Industry	Number	Average Revenues 000s	Average No. Employees	Average No. EIS Users
Financial Services	4	$ 7,780	25,980	21
Consumer Products	3	$21,231	75,667	21
Manufacturing	3	$12,884	79,100	26
Utilities	3	$23,740	108,203	8
Computer Services	1	$ 7,000	60,681	9
Transportation	2	$ 2,539	22,400	10
Petroleum	1	$15,800	19,000	100
Professional Services	1	n/a	92	6
Aerospace	1	$16,000	30,000	15

alpha was used to assess the inter-item reliability of the final, multi-item scales. While a reliability score of 0.6 is usually considered acceptable (Nunally 1967), all of the variables' reliability scores exceed 0.8 except for one. The exception was the involvement of subordinates in decision making with a reliability of 0.68. The factor loadings and the reliability scores for each variable are provided in Table 3.

In general, factor analysis supported the proposed scales. Major exceptions were that no information accuracy variable could be extracted and no separation between involvement of subordinates in problem identification versus involvement of subordinates in decision analysis was detected. This resulted in several items being eliminated from further analysis. It also resulted in being unable to test Hypothesis 4 concerning information accuracy. Hypotheses 5 and 6 concerning the involvement of subordinates in problem identification and analysis, respectively, were combined into a single testable hypothesis (Hypothesis 7). The final set of hypotheses to be tested are shown in Table 4. Table 5 presents the descriptive statistics for each variable.

Table 3 Factor Loadings and Reliability

	Cronbach's Alpha	Factor Loading
Factor 1: Problem Identification Speed	0.89	
Sense key factors impacting my area of responsibility		0.55
Notice potential problems before they become serious crises		0.84
Factor 2: Decision Making Speed	0.92	
Make decisions quicker		0.56
Shortened the time frame for making decisions		0.67
Factor 3: Information Availability	0.90	
Availability of information that was previously unavailable except as a special request		0.60
Information available in a more timely manner		0.84
A single delivery source of important, frequently used information		0.79
Factor 4: Involvement of Subordinates In Decision Making	0.68	
Many problems requiring organizational action are brought to my attention by subordinates		0.51
I rely on subordinates to keep me informed of daily problems		0.61
I make many informal decisions not involving my subordinates*		0.52
I frequently involve subordinates in decision processes		0.59
I frequently involve subordinates in identifying and / or deciding upon courses of action		0.56

*Reverse Scored

Normality, Linearity, and Homoscedasticity

Normality is the assumption that each variable is normally distributed. SAS mean and univariate procedures were used to diagnose the normality of the data by examining the residuals and getting skewness and kurtosis figures for each item. None of the items were significantly skewed and only one item had significant kurtosis. Because only one item was nonnormal, transformation of the data was deemed unnecessary.

The assumption of linearity is that there is linearity between all pairs of variables. Nonlinearity was diagnosed from bivariate scatterplots between pairs of variables. The assumption of linearity appeared to be met based on examinations of the scatterplots. Homoscedasticity was also checked by examining the bivariate scatterplots. The assumption of homoscedasticity is that the variability in score for one variable is roughly the same at all values of the other variable. The bivariate scatterplot should be roughly the same width all over if homoscedasticity is present. Again the scatterplots did not yield evidence of a need to transform the data.

Table 4 Testable Hypotheses

H1a:	The more frequent the manager's use of EIS, the faster the manager's problem identification speed.
H1b:	The longer the manager's use of EIS, the faster the manager's problem identification speed.
H2a:	The more frequent the manager's use of EIS, the faster the manager's decision making speed.
H2b:	The longer the manager's use of EIS, the faster the manager's decision making speed.
H3a:	The more frequent the manager's use of EIS, the greater the perceived information availability.
H3b:	The longer the manager's use of EIS, the greater the perceived information availability.
H7a:	The more frequent the manager's use of EIS, the less the involvement of subordinates in organizational intelligence and decision making.
H7b:	The longer the manager's use of EIS, the less the involvement of subordinates in organizational intelligence and decision making.

Statistical Analysis Performed

MANOVA was run to test if there was an overall organization effect. There was a significant organization effect ($F = 2.3$, $p = 0.0001$). This suggests that the organizations differed significantly in some aspects that affected the way EIS were used. However, while this suggests that responses could be aggregated to an organization level, we elect not to do so because we do not believe, for the reasons stated earlier, that an organizational measure of EIS use is very meaningful at this time. As revealed in Table 2, the number of users per organization represented is extremely small compared to the overall number of employees in the organization. In over half the organizations, the number of EIS users was less than 10. It is therefore dubious to treat the individuals as representing the views of the entire organization. Furthermore, several of the organizations had fewer than five respondents.[9] This research will therefore examine individual responses rather than aggregating responses of individuals within a company.

Correlation

Table 6 presents the correlations of the variables with each other. As would be expected, most of the decision making variables are highly correlated with one another. This would be expected given that variables were purposely chosen that were thought to characterize decision making. However, in interpreting the correlations, one must keep in mind that two variables may be correlated with each other only because they share correlation with a common other variable.

Table 5 Descriptive Statistics

Variable	N	Mean	St Dev	Min	Max
Frequency of EIS Use	91	3.3	1.2	1	5
Length of Time of EIS Use (months)	91	28.8	25.5	2	99
Problem Identification Speed	89	2.5	1.1	1	5
Decision Making Speed	89	2.3	1.1	1	5
Information Availability	88	3.5	1.2	1	5
Involvement of Subordinates in Organizational Intelligence, and Decision Making	87	3.7	0.5	2.2	4.6

Table 6 Correlations

Variable	Frequency of EIS Use	Length of EIS Use	Information Availability	Problem Identification Speed	Decision Making Speed
Frequency of Use					
Length of Use	0.21 0.0375				
Information Availability	0.32 0.0017	0.13 0.2300			
Problem Identification Speed	0.37 0.0002	0.32 0.0024	0.62 0.0001		
Decision Making Speed	0.35 0.0004	0.365 0.0004	0.65 0.0001	0.76 0.0001	
Involvement of Subordinates	-0.79 0.4500	0.14 0.2050	0.15 0.1500	0.02 0.8400	0.11 0.2900

Two-Way ANOVAs

Table 7 presents the two-way ANOVAs using management level and frequency of use as the categorical variables and the length of use as a covariate. Included in Table 7 is the regression coefficient for the length of use, the adjusted $R2$, the t-value, and the probability of significance. The ANOVAs indicate that there is a main effect for all of the dependent variables. For problem identification speed, decision making speed, and information availability, there is no level effect nor any level by frequency interaction effect. There are, however, significant frequency and length of use effects on these variables. For the involvement of subordinates in decision making, there is a main effect and a significant level effect, but no effect due to frequency or length of EIS use, nor any interaction between frequency and level.

Hypotheses Testing

Hypothesis 1a predicted that the more frequent the use of EIS, the faster the users would notice problems. The ANOVA for problem identification speed indicated that the frequency of EIS use was significant ($F = 4.36$, $p = 0.003$) and that there was no level effect ($F = 0.03$; $p = 0.860$) nor any interaction effect ($F = 0.23$, $p = 0.923$). The correlations indicate that the relationship is positive ($r = 0.37$, $p = 0.0002$). This hypothesis was therefore supported with no difference between senior and middle managers. Hypothesis 1b predicted that the longer the EIS had been used, the faster the problem identification would occur. Length of time of EIS use was significant ($F = 8.82$, $p = 0.0004$). The coefficient of length of time is positive ($b = 0.013$) and significant ($T = 3.045$, $p = 0.003$).

Hypothesis 2a predicted that frequent use of EIS would increase the speed of the decision making process. This hypothesis was supported. The ANOVA for decision making speed indicated that the frequency of EIS use was significant ($F = 2.67$, $p = 0.038$) and that there was no level effect ($F = 0.16$, $p = 0.691$) nor any interaction effect ($F = 0.06$, $p = 0.994$). Frequency of EIS use was positively and significantly correlated with

Table 7 Two-Way Anovas and Regression

	Two-Way ANOVAs			Regression			
	MS	F(df)	P > F	Coeff.	Adj. R2	T	P > T
Problem Identification Speed							
Main Effect	29.186	4.54 (6)	0.001				
Level	0.034	0.03 (1)	0.860				
Frequency of EIS Use	18.670	4.36 (4)	0.003				
Length of Time of EIS Use (cov)	9.440	8.82 (1)	0.004	0.013	0.123	3.045	0.003
Level X Frequency	0.972	0.23 (4)	0.923				
Decision Making Speed							
Main Effect	24.107	3.98 (6)	0.002				
Level	0.160	0.16 (1)	0.691				
Frequency of EIS Use	1.077	2.67 (4)	0.038				
Length of Time of EIS Use (cov)	9.923	9.82 (1)	0.002	0.014	0.122	3.648	0.001
Level X Frequency	0.235	0.06 (4)	0.994				
Information Availability							
Main Effect	24.320	3.21 (6)	0.007				
Level	0.225	0.18 (1)	0.675				
Frequency of EIS Use	21.270	4.20 (4)	0.004				
Length of Time of EIS Use (cov)	2.480	1.96 (1)	0.166	0.007	0.015	1.515	0.133
Level X Frequency	0.742	0.15 (4)	0.964				
Involvement of Subordinates							
Main Effect	3.656	2.52 (6)	0.028				
Level	1.878	7.77 (1)	0.007				
Frequency of EIS Use	1.383	1.43 (4)	0.232				
Length of Time of EIS Use (cov)	0.430	1.79 (1)	0.187	0.003	0.001	1.622	0.109
Level X Frequency	0.356	0.37 (4)	0.830				

decision making speed ($r = 0.35$, $p = 0.0004$). Hypothesis 2b predicted that the longer the EIS had been in use, the faster would be the decision making process. This hypothesis was likewise supported. The length of time of EIS use was significantly related to decision making speed ($F = 9.82$, $p = 0.002$). The coefficient of length of time is positive ($b = 0.014$) and significant ($T = 3.648$, $p = 0.001$).

Hypothesis 3a suggests that the more frequent the manager's use of EIS, the greater the perceived availability of information. The ANOVA for information availability indicated that the frequency of EIS use was significant ($F = 4.20$, $p = 0.004$) and that there was no level effect ($F = 0.18$, $p = 0.675$) or interaction effect ($F = 0.15$, $p = 0.964$). Frequency of EIS use was positively and significantly associated with information availability ($r = 0.32$, $p = 0.0017$). H3b predicted that the length of EIS use would be related to perceived information availability. There is no significant length effect ($F = 1.96$, $p = 0.166$). Therefore Hypothesis 3b is rejected. There is no significant relationship between the length of EIS use and perceived information availability.

Hypothesis 7a predicted that there would be a negative association between the frequency of EIS use and the involvement of subordinates in decision making. This hypothesis was not supported. There was no frequency effect ($F = 1.43$, $p = 0.232$). Hypothesis 7b predicted a negative association between the length of time of EIS use and the involvement of subordinates in the decision making process. This hypothesis was not supported either ($F = 0.179$, $p = 0.187$). However, there was a level effect ($F = 7.77$, $p = 0.007$). T-tests indicate that senior managers involve subordinates to a significantly greater degree than do middle managers ($T = -2.74$, $p = 0.008$).

Table 8 summarizes the results of hypothesis testing.

Table 8 Support for Hypotheses

	Senior	Middle
H1a: The more frequent the manager's use of EIS, the faster the problem identification speed.	YES	YES
H1b: The longer the manager's use of EIS, the faster the problem identification speed.	YES	YES
H2a: The more frequent the manager's use of EIS, the faster the decision making speed.	YES	YES
H2b: The longer the manager's use of EIS, the faster the decision making speed.	YES	YES
H3a: The more frequent the manager's use of EIS, the greater the perceived information availability.	YES	YES
H3b: The longer the manager's use of EIS, greater the perceived information availability.	NO	NO
H7a: The more frequent the manager's use of EIS, the less the involvement of subordinates in organizational intelligence and decision making.	NO	NO
H7b: The longer the manager's use of EIS, the less the involvement of subordinates in organizational intelligence and decision making.	NO	NO

Implications and Research Directions

Discussion of Findings

The findings suggest that both the frequency and the length of EIS use are positively associated with faster problem identification and faster decision making. One senior vice president characterized the business environment facing executives as an "increasingly hostile environment with government deregulation, increased competition, pressure on margins, and reduced time to make decisions." This study suggests that EIS help reduce the time to identify problems and make decisions. Given that senior rather than middle managers are typically considered the individuals faced with the most time pressure to respond quickly to situations, it is surprising that with respect to the relationship of EIS use and problem identification and decision making speed, there is no difference between senior and middle managers. The findings suggest that middle managers are also faced with environments demanding fast response and up-to-date information.

Another finding is that senior and middle managers do perceive information to be more available if they are using EIS frequently than if they are not using EIS frequently. It is again noteworthy that middle managers and senior managers do not vary on this response. Because EIS are not likely to be tailored for middle managers as they are for senior managers, middle managers would not necessarily be expected to be able to access the information they need. In addition, middle managers may have used other computer-based information sources and not see the unique value of EIS. As one middle manager reported, the

EIS was not detailed enough for his major roles, but rather was an "historical back end." He had two other decision support systems that he used more extensively for planning, decision making and market analysis. He used the EIS to keep himself informed of the information that the senior managers were using to build judgments of organizational performance. Nevertheless, overall middle managers report increased information availability. One might argue that the information is perceived as more available, but perhaps it is not necessarily relevant. However, if the information contained in the EIS were irrelevant to the managers, the managers should not also have perceived greater problem identification and decision making speed as a result of using the EIS.

Although frequency of EIS use was related to perceived information availability, length of time of EIS use was not. This is a surprising result since an established EIS would have been expected to have been modified and refined over time to provide the information needed by managers. One possible explanation for frequency but not length of use being related to information availability is that over time users forget what their information environment was before the EIS was put in place. This suggests that over time users of the EIS lose their ability to compare the current information availability to what it was before the EIS was in place. Another explanation is that over time information needs change and if the systems are not flexible to adapt to changing information needs, the availability of needed information declines. The latter interpretation is consistent with the views of the IS directors interviewed who reported the need to keep abreast of changing information requirements as an important success factor.

The most surprising finding was that the extent of involvement of subordinates in problem identification and decision making was unrelated to EIS use for senior and middle managers. This runs counter to the prediction that the use of EIS would lead to the reduction of intermediaries and possibly threaten the jobs of middle managers. One CFO in an interview suggested, "my using the EIS frees middle managers up to manage instead of massaging numbers." He stated that middle managers could spend more time on analysis. Thus, rather than decreasing the participation of subordinates in problem identification and decision making, the use of EIS by senior managers may only change the nature of their participation.

There was a level effect on the involvement of subordinates with *t*-tests indicating that senior managers involve subordinates in decision making to a significantly greater degree than do middle managers ($T = 2.74$, $p = 0.0008$). This is consistent with Blankenship and Miles (1964) finding that senior managers involve subordinates to a greater degree than do middle managers. Thus, in the case of middle managers, one explanation for middle managers not involving subordinates more or less as a result of using EIS is that subordinates may already play a relatively small role in these activities.

Another possible explanation for the failure to find the predicted less involvement of subordinates in decision making by senior or middle managers is that, unlike speed which is widely regarded as desirable as is information availability, involvement does not necessarily connote a consistent positive or negative behavior among American managers. Managers valuing subordinate involvement might use technology to actually increase involvement whereas managers valuing independence could use technology to promote less involvement. Hence, information technology may be used to reinforce a given and accepted organizational design rather than to change it. This would suggest that Huber's theory lacks explanatory variables to suggest why the relationships proposed in the theory should occur, especially given that the same information technology can be used to accomplish different outcomes depending on the value attributed to the outcome.

The study also highlighted several interesting facts about the dissemination of EIS in organizations. As stated earlier, EIS were originally targeted for senior managers. However, since half of our respondents were middle managers, the use of EIS has clearly spread down to middle management ranks. There appeared to be several reasons for such spread. In one company where an on-site visit was made, the middle managers felt extreme pressure to use the EIS because the CEO would call unexpectedly wanting explanations for discrepancies in daily performance measures. Other organizations had begun targeting middle managers rather than senior managers with EIS. Several companies indicated that they were beginning to target middle managers for all future EIS development because they felt that these were the managers most likely to benefit from EIS. One director of MIS said that their EIS development effort focused first on executives, but they soon realized that they really needed to transform it into a tool for middle managers because the senior executives at this company were using the EIS only for historical data. The IS director felt that the real benefit of EIS was when EIS was used to look forward, to model, and to plan, activities he felt the middle managers would be more prone to conduct on a computer-

based system. Thus, possible explanations for the spread of EIS downward in the organization include: (1) the comfort factor in middle managers wanting access to information senior managers access, (2) the ease factor in middle managers wanting a graphical user interface to information they would otherwise have to retrieve from paper reports, (3) the threat factor of middle managers feeling they will be judged by information they are unaware of, and (4) the targeting of middle managers by developers.

It is interesting that there was not more of a difference between senior and middle management responses on the variables. The only significant difference was in the involvement of subordinates in decision making, with senior managers involving subordinates more than middle managers; yet this was the variable that was unrelated to frequency of EIS use and length of time of EIS use. The fact that a class of systems has been developed for "executives" and labeled "executive information systems" seemed to imply that executive's information needs were somehow unique and unserviceable with current systems. However, Rockart and DeLong (1988) questioned whether the roles of senior and middle managers were different enough to justify a separate class of systems. This study indicates that in terms of decision making, perhaps they are not. The rapid spread of the system to middle managers suggests that middle managers may have more similar information needs to senior managers than typically believed. An alternate explanation of the failure to find large differences between senior and middle managers' use of EIS might be that the type of information readily available on EIS—internal operational and financial information—is equally important to both. The difference between the levels might remain pronounced in terms of the need for external and soft information which EIS have still largely failed to incorporate. Few systems actually incorporate external information with the exception of the Dow Jones News Service. Thus while the internal information needs of senior and middle managers proved similar, their external needs may nevertheless vary considerably. Because EIS have largely failed to address the external, strategic information, such differences between senior and middle managers would not be apparent.

Huber's Theory Revisited

This study found support for the propositions put forth by Huber that the use of decision support technologies can lead to improved organizational intelligence and decision making outcomes. Part of the theoretical explanation as to why these results occur can be attributed to higher levels of perceived information availability. However, given the individual unit of analysis in this study, it is possible that an additional explanation for the relationship between decision-support technologies and improved organizational intelligence and decision making outcomes can be found in the area of managerial cognition. While there is no well-accepted cognitive view of management, two cognitive perspectives have been identified that are useful in understanding why EIS may affect decision making outcomes: the "Manager as Decision Maker" and "Manager as Sensemaker" (Rockart and DeLong 1988). EIS may support the role of manager as decision maker by providing an environment that facilitates more analysis, the reflective thought and deliberation given to a problem and the array of proposed responses. With their ability to facilitate the analysis of problems with drill-down and trend-finding capabilities, EIS may significantly increase the extent of analysis performed by their users. It has long been argued that decision support technologies offer data access and modeling capabilities to their users. Increased information availability is made possible by data access capabilities and greater extent of analysis is made possible by modeling capabilities.

The notion of sensemaking focuses on how managers impose cognitive structures, commonly referred to as mental models, on their environments. Mental models are seen as the vehicles through which experience is structured and information acquisition facilitated (Johnson-Laird 1983, Norman 1983). Through the use of mental models, individuals understand phenomena, make inferences and predictions, and decide on what action to take. A mental model captures the cause and effect relationships which a manager believes to underlie his/her business environment. In spite of the difficulties in actually measuring one's mental model, researchers on executive work have used the concept of mental models to understand and to explain how executives deal with the complexity inherent in their jobs (Mintzberg 1973, Kotter 1982, Jacques 1976, Isenberg 1985). The effectiveness of a manager's decisions is seen as being dependent upon the quality of his/her mental models (Mintzberg 1973).

EIS have several features that should aid in the enhancement of mental models (Rockart and DeLong 1988). Since executives can quickly access external data themselves through an EIS rather than relying on a staff member, they have the opportunity to directly filter a much greater amount of external data through their mental models. This forces executives to test the accuracy of their mental models. The EIS's ability to

combine data from multiple sources allows executives to identify and explore new relationships. These newly discovered relationships get incorporated into their mental models. By presenting data in more meaningful formats, an EIS encourages them to think about important aspects of their business in different ways. This can serve to challenge the assumptions that underlie these mental models and cause modifications to occur.

The reasoning above would suggest that an examination of the extent of analysis in decision making and enhancement of a manager's mental model are important constructs to consider in a study of the impacts of EIS. Items were included in our survey to measure these constructs despite their not being included in Huber's theory. As mentioned in the methodology section, not all of the variables we thought were important to investigate in the context of EIS were captured by Huber's theory. The specific items measuring the extent of analysis and mental model enhancement are given in Table 1 in the Appendix.[5]

The correlations of the variables with the frequency of EIS and the length of time of EIS use are shown in Table 9. The two-way ANOVAs are shown in Table 10.

For the variable "Extent of Analysis," there is a significant frequency effect ($F = 4.64$, $p = 0.002$), a significant length of use effect ($F = 8.31$, $p = 0.005$); there is no level or interaction effect. The more frequent the use of EIS, the greater the extent of analysis performed by the decision maker ($r = 0.44$, $p = 0.0001$). Likewise, the longer the user had been using the EIS, the more pronounced the effect ($b = 0.01$, $T = 3.461$, $p = 0.0008$). For the variable "Mental Model Enhancement," there is a significant frequency of use effect ($F = 2.28$, $p = 0.068$), significant length effect ($F = 11.031$, $p = 0.001$) and no level or interaction effect. The relationships between frequency of use and a manager's mental model is positive and significant ($r = 0.29$, $p = 0.002$). The relationship with length of use is also positive ($b = 0.014$) and significant ($T = 3.567$, $p = 0.0006$). While it has been suggested that there are two approaches to decision making: intuitive and analytic (Howard 1981), EIS is apparently beneficial to both. Not only was EIS use significantly related to a manager's greater extent of analysis (the analytic aspect), EIS use was also significantly related to the enhancement of managers' mental models (the intuitive aspect).

This post-hoc, exploratory analysis suggests that these two variables can enhance Huber's theory by providing a more complete explanation as to "why" the effects he proposes should occur. Increased information availability can provide a stimulus to enhance one's mental model. In addition, an executive's mental model can

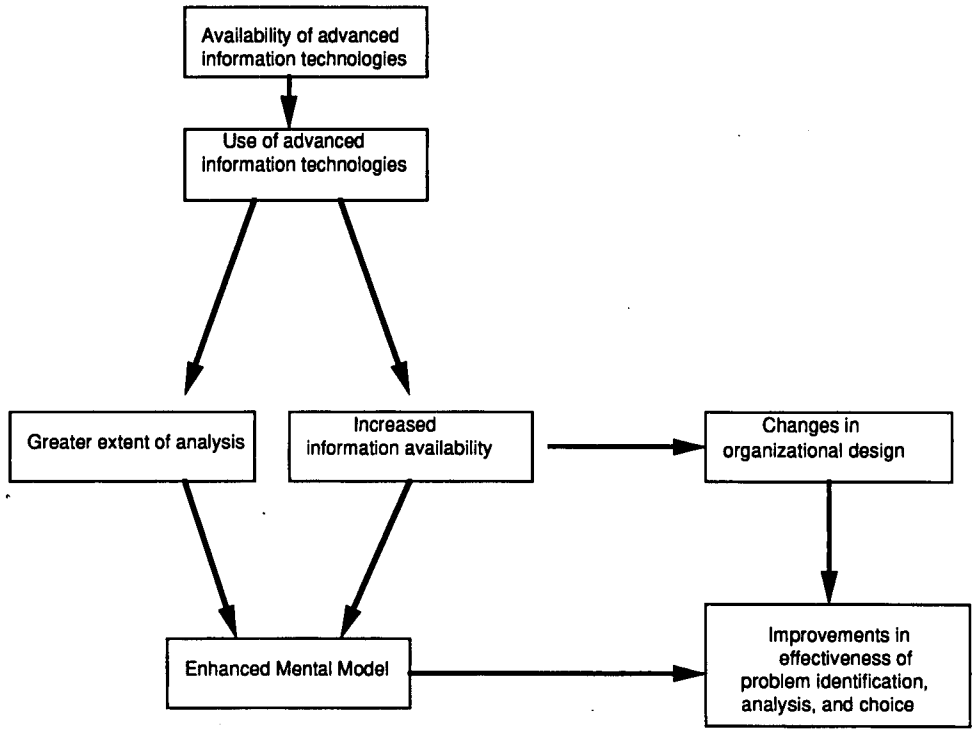
Table 9 Correlation of EIS with Managerial Cognition Variables

	Frequency of EIS Use	Length of Time of EIS Use
Extent of Analysis		
r	0.4366	0.3102
p	0.0001	0.0010
Mental Model Enhancement		
r	0.2948	0.3359
p	0.0020	0.0010

Table 10 Two-Way Anovas and Regression

	Two-Way ANOVAs			Regression			
	MS	F	P > F	Coeff.	Adj. R2	T	P > T
Extent of Analysis							
Main Effect	23.536	5.57 (6)	0.000				
Level	1.471	2.09 (1)	0.152				
Frequency of EIS Use	13.071	4.64 (4)	0.002				
Length of Time of EIS Use (cov)	5.851	8.31 (1)	0.005	0.010	0.110	3.461	0.0008
Level X Frequency	0.166	0.06 (4)	0.993				
Mental Model							
Main Effect	20.820	3.59 (6)	0.003				
Level	0.141	0.15 (1)	0.704				
Frequency of EIS Use	8.795	2.28 (4)	0.068				
Length of Time of EIS Use (cov)	10.690	11.03 (1)	0.001	0.014	0.116	3.567	0.0006
Level X Frequency	0.231	0.06 (4)	0.993				

Figure 2 Revised Conceptual Theory



also be enhanced by analyzing more fully the information that is now available with the tools provided by the EIS. Thus, we recommend a modification of Huber's theory which incorporates the constructs—greater extent of analysis and enhanced mental models—as depicted in Figure 2.

In addition to the modifications described above, further refinement of Huber's theory may be needed to take into account different classes of advanced information technologies. In this study, we focused only on that portion of the theory that was related to one particular type of decision-support technologies: EIS. The modification to the theory proposed above only applies to this class of advanced information technologies.

Although a specific theory may be desirable for studying the effects of a particular class of advanced information technologies, it is important to recognize that these technologies do not exist in isolation in organizations. For example, how will results be different for managers using both communication and decision-support technologies? In this study, we focused only on EIS. But supposing that some executives might also have been using communication technologies, there would have been competing technologies in place that might have influenced some of the results. This points out the need for a theory that examines the interaction of these advanced information technologies as well as theories that examine each technology individually.

Finally, when examining the effects of decision-support technologies, we found it more useful to consider organizational intelligence as part of the decision making process rather than as a separate activity. EIS are not used by organizational units to whom environmental scanning activities have been delegated; rather they are used by individuals who do scanning as part of their broader decision making responsibilities. The decision making process is commonly viewed as consisting as several stages, the most simple being Simon's intelligence, design, choice model (1977). Recognizing that EIS use may affect each of these stages differently, we explicitly examined the effect of EIS use on problem identification activities separate from the decision making process as a whole. Where appropriate the theory should recognize the possibility of different effects on different stages of the decision making process.

Limitations

There are several limitations to the study that warrant mention. First, the study addressed only users of EIS at

the point in time the survey was administered and the interviews were conducted. It is very likely that there were previous users of the system in each organization who, for various reasons, had discontinued use of the system. Their opinions of the system were not tapped. The results must be interpreted to suggest that EIS can be related to decision making behavior, but may not always be. Secondly, it is inappropriate to make causal deductions. Although from a theoretical and intuitive standpoint, the direction of the hypotheses were argued, the research method did not test for directionality. Therefore, the results must be interpreted in terms of association rather than causality. Lastly, perceptual measures were used for all variables except length of EIS use. The respondents were acting as informants of their own behavior. The use of perceptual measures need not be considered a weakness, but does suggest that the respondents' perceptions of the impacts of EIS use might not necessarily coincide exactly with reality. Le Blanc and Kozar (1990) found in one case that the perception of DSS success was low although objective measures indicated it was in reality high. Thus, the results must be interpreted within the context that perceptual measures were used. However, the perception of benefits through system usage may be sufficient justification in managers' minds for the system.

Conclusions and Future Research

The purpose of this study was to empirically examine the relationship of EIS use to organizational intelligence and decision making and to empirically explore why such a relationship might exist. The research used results of a survey of 91 EIS users across 22 organizations to test hypotheses concerning the relationship of the frequency and length of time of EIS use with information availability, timeliness of problem identification and decision making, and participation of subordinates in decision making. Eight hypotheses were tested separately for middle managers and senior managers. A post-hoc, exploratory analysis suggested that the greater extent of analysis in decision making and enhanced mental models were important constructs to add to Huber's theory in order to better explain the relationship between EIS use and improved organizational intelligence and decision making outcomes.

The importance of managerial decision making has never been challenged. How to assist and improve managerial decision making has remained an elusive challenge. Computer-based information systems designed to provide senior managers access to information relevant to their management activities—Executive Information Systems—when used frequently and over time are shown in this study be positively related to perceived problem identification and decision making speed for senior and middle managers. Whether such effects lead to higher quality decision as suggested by Huber (1990) are topics for further study.

This study only examined the relationship of EIS use on one particular design variable at the subunit level (reliance on subordinates) and one performance variable (speed of problem identification and decision making). This study found that EIS use by either senior managers or middle managers did not affect the level of subordinate involvement. Further research is needed to determine whether the nature of this involvement is changed when an EIS is used. Further research is also needed to examine the relationship between EIS use and other subunit organizational design variables in addition to those suggested by Huber (1990). As EIS become more institutionalized in organizations, research is needed to examine how the use of EIS impacts design variables at the organizational level.

Chen (1991) found that the length of time an information system is in use does not affect a user's overall satisfaction with the system. This study provides some insights into why this may occur. In particular, this study found that one variable (speed of organizational intelligence and decision making) was positively related to the length of time that an EIS had been in use. However, another variable (information availability) was not positively related to the length of time that an EIS had been in use. Future research is needed to track EIS use over time in order to understand the benefits that users obtain at various points in time and how these benefits change over time. This study examined the effects of EIS use on management decision making at an individual level. Future research is needed to examine effects at the organizational level once EIS has become institutionalized inside an organization. Such research could compare the organizational effects of EIS use at organizations that have adopted an EIS to those that have not.

Endnotes

[1]The analysis features are often defined in advance and built into the system in order to keep the system speed acceptable although ad hoc analysis may also be allowed.

[2]Arguments can also be made for the reverse of these hypotheses: that perceived availability and accuracy lead to increased usage. In fact, the relationship is probably complex and circular; this paper chooses to argue all hypotheses in the direction of EIS contributing to a perceived change in some aspect of organizational intelligence and decision making. While it is probable that managers choose an information source because they perceive it to provide available

information, by using the source they may begin to perceive information to be even more available than they anticipated. The current research examines this post-system use aspect of information availability. The effect of expectations on post-system use perceptions is beyond the domain of the current research.

[3]Information on whether EIS users spent less time in meetings was gathered and used in developing a measure for speed of decision making. This is described in the methodology section.

[4]All of the EIS in the present study were developed using a software shell; typically these shells provide easy ways to develop graphical user interfaces, charts and graphs. Each of the EIS contains a subset of the features listed in Table 1.

[5]The appendix is available upon request from the authors or from the *Organization Science* editorial office at INFORMS, 290 Westminster Street, Providence, RI 02903.

References

Applegate, Lynda M. (1987), "Lockheed-Georgia Company: Executive Information Systems," *Harvard Case* (9-187-147), Boston, MA: Harvard Business School.

____ and Charles S. Osborn (1988), "Phillips 66 Company: Executive Information Systems," *Harvard Case* (9-189-006), Boston, MA: Harvard Business School.

Bergeron, François, Louis Raymond and Martin Lagorge (1991), "Top Managers Evaluate the Attributes of EIS," in Ilze Zigurs (Ed.), *DSS-91 Transactions* 6-14.

Blankenship, L. Vaughn and Raymond E. Miles (1964), "Organizational Structure and Managerial Decision Behavior," *Administrative Science Quarterly*, 106-120.

Brim, Orville G., Jr., David C. Glass, David E. Lavin and Norman E. Goodman (1962), *Personality and Decision Processes: Studies in the Social Psychology of Thinking*, Stanford, CA: Stanford University Press.

Busch, Elizabeth A., Sirkka L. Jarvenpaa, Noam Tractinsky and William H. Glick (1991), "External Versus Internal Perspectives in Determining Firm's Progressive Use of Information Technology," *Proceedings of the Twelfth International Conference on Information Systems*, 239-250.

Carlisle, Judith P. and Kimberly D. Aladmeddine (1990), "A Study Evaluating Existing Executive Information Systems Products," in Jay F. Nunamaker, Jr. (Ed.), *Proceedings of the Twenty-Third Annual Hawaii International Conference on System Sciences*, Vol. III, 160-169.

Chen, Helen (1991), "Executive Computing Usage, Payoff and Satisfaction: Summary Results of an End-user Survey," in Ilze Zigurs (Ed.), *DSS-91 Transactions*, 16-27.

Eisenhardt, Kathleen M. (1989), "Making Fast Strategic Decisions in High-Velocity Environments," *Academy of Management Journal*, 32, 3, 543-576.

Gifford, William E., H. Randolph Bobbitt and John W. Slocum, Jr. (1979), "Message Characteristics and Perceptions of Uncertainty by Organizational Decision Makers," *Academy of Management Journal*, 22, 3, 458-481.

Howard, Ronald A. (1981), "An Assessment of Decision Analysis," *Operations Research*, 28, 1, 4-27.

Huber, George P. (1984), "The Nature and Design of Post-Industrial Organizations," *Management Science*, 30, 928-951.

____ (1990), "A Theory of the Effects of Advanced Information Technologies on Organizational Design, Intelligence, and Decision Making," *Academy of Management Review*, 15, 1, 47-71.

Isenberg, Daniel J. (1985), "Research on How Senior Managers Think: Implications for Designing Executive Support Systems," in Joyce Elam (Ed.), *DSS-85 Transactions*, 64-66.

Jacques, Elliott (1976), *A General Theory of Bureaucracy*, Hampshire, England: Gower Publishing Co.

Jarvenpaa, Sirkka L. and Blake Ives (1990), "IT and Corporate Strategy: A View from the Top," *Information Systems Research*, 1, 4, 351-376.

Johnson-Laird, P. N. (1983), *Mental Models*, Cambridge, MA: Harvard University Press.

Jones, Jack William and Raymond McLeod, Jr. (1986), "The Structure of Executive Information Systems: An Exploratory Analysis," *Decision Sciences*, 17, 220-248.

Keegan, Warren J. (1974), "Multinational Scanning: A Study of the Information Sources Utilized by Headquarters Executives in Multinational Companies," *Administrative Science Quarterly*, 411-421.

Kogan, John N. (1986), "Information for Motivation: A Key to Executive Information Systems That Translate Strategy into Results for Management," in Jane Fedorowicz (Ed.), *DSS-86 Transactions*, 6-13.

Kotter, John P. (1982), *The General Managers*, New York: Free Press.

Le Blanc, Louis A. and Kenneth A. Kozar (1990), "An Empirical Investigation of the Relationship between DSS Usage and System Performance: A Case Study of a Navigation Support System," *MIS Quarterly*, 263-277.

Mintzberg, H., D. Raisinghani and A. Thêorêt (1976), "The Structure of 'Unstructured' Decision Processes," *Administrative Science Quarterly*, 21, 246-275.

Mintzberg, Henry (1973), *The Nature of Managerial Work*, New York: Harper & Row.

Mittman, Brian S. and Jeffrey H. Moore (1984), "Senior Management Computer Use: Implications for DSS Designs and Goals," in Robert W. Zmud (Ed.), *DSS-84 Transactions*, 42-49.

Norman, Donald A. (1983), "Some Observations on Mental Models," in D. Gentner and A. L. Stevens (Eds.), *Mental Models*, Hillsdale, NJ: Erlbaum.

Nunally, J. C. (1967), *Psychometric Theory*, New York: McGraw-Hill.

Rinehart, Gary D. (1986), "EIS In A Public Utility," in Jane Fedorowicz (Ed.), *DSS-86 Transactions*, 65-69.

Rockart, John and David DeLong (1988), *Executive Support Systems: The Emergence of Top Management Computer Use*, Burr Ridge, IL: Dow-Jones-Irwin.

Schade, Mimi (1988), "The First Boston Executive Workstation," *July 1988 EIS Conference Report*, 1, 4, 4-5.

Seashore, S. E., E. E. Lawler, P. H. Mirvis and C. Camman (1983), *Assessing Organizational Change: A Guide to Methods, Measures, and Practices*, New York: Wiley.

Simon, H. A. (1977), *The New Science of Management Decision*, Englewood Cliffs, NJ: Prentice Hall.

Stanat, Ruth (1986), "Building a Document-Based Competitive Intelligence System," in Jane Fedorowicz (Ed.), *DSS-86 Transactions*, 60-64.

Stephenson, Blair Y. (1986), "Information: A Strategic Business Weapon," in Jane Fedorowicz (Ed.), *DSS-86 Transactions*, 24–34.

Straub, Detmar W. (1989), "Validating Instruments in MIS Research," *MIS Quarterly*, 13, 2, 147–170.

Tabachnick, Barbara G. and Linda S. Fidell (1989), *Using Multivariate Statistics*, 2nd ed., New York: Harper & Row.

Turban, Efraim and Donna M. Schaeffer (1987), "A Comparative Study of Executive Information Systems," in Omar A. El Sawy (Ed.), *DSS-87 Transactions*, 139–148.

Van de Ven, A. H. and D. L. Ferry (1980), *Measuring and Assessing Organizations*, New York: Wiley.

Watson, Hugh J., Kelly Rainer and Chang Koh (1991), "Executive Information Systems: A Framework for Development and A Survey of Current Practices," *MIS Quarterly*, 13–30.

Wilensky, Harold J. (1967), *Organizational Intelligence*, New York: Basic Books Inc.

Witte, Eberhard (1972), "Field Research in Complex Decision-Making Processes—The Phase Theorem," *ISMO*, 156–182.

Zaki, Ahmed S. and Richard C. Hoffman (1988), "Information Type and Its Impact on Information Dissemination," *Journal of Information Systems Management*, 5, 2, 71–82.

Accepted by Gerardine DeSanctis; received November 1992. *This paper has been with the authors for three revisions.*