NORTH-HOLLAND

International Journal of Accounting Information Systems
1 (2000) 178–203

INTERNATIONAL JOURNAL OF
ACCOUNTING
INFORMATION
SYSTEMS

How information systems influence user decisions: a research framework and literature review

Ed O'Donnell*, Julie Smith David

School of Accountancy, Arizona State University, Box 873606, Tempe, AZ 85287, USA

Received 1 September 1998; received in revised form 1 February 2000; accepted 1 February 2000

Abstract

Technology has created new information alternatives that may influence the way information system users make decisions. This paper proposes a research framework for examining how features of an information system affect the decision-making process. The framework is synthesized by merging frameworks from the accounting information systems (AIS) literature and the human information processing (HIP) literature. The framework is then used to organize a literature review of 15 journals from 1987 through mid-1999, which identified 57 decision-making studies. Findings indicate that a wide range of opportunities is available for information systems research on issues of contemporary importance. This discussion includes changes in the decision process initiated by implementing enterprise resource planning (ERP) systems, data warehouses, electronic commerce, virtual organizations, on-line financial reporting, and disaggregated financial statement information.

Keywords: Human information processing; Accounting information systems; Judgement and decision making

Accounting information systems (AIS) provide input for decision making. Technology has availed many new information alternatives, i.e. presentation features that could change the way decisions are made, but AIS research has only begun to examine these contemporary issues (Sutton and Arnold, 1995). For example, access to a database of basic transaction information makes it possible to acquire detailed accounting data and aggregate it differently for each decision situation. Real-time financial reporting, made feasible by the World Wide Web, could provide daily rather than quarterly decision information. Systems can now provide flexible, interactive user interfaces that immediately respond to a myriad of

* Corresponding author. Tel.: +1-480-965-3631; fax: +1-480-965-8392.
E-mail addresses: ed.odonnell@asu.edu (E. O'Donnell), julie.smith.david@asu.edu (J.S. David).

1467-0895/00/$ – see front matter
PII: S1467-0895(00)00009-9

information requests. How do these AIS innovations impact user decisions? Do disaggregated accounting reports, real-time financial information, and interactive interfaces improve the decisions they help to make? Advances in technology have made questions like these important issues for AIS professionals and academics alike.

The need for research that examines how information system characteristics influence user decisions has been recognized by both research scholars (e.g. Reneau and Grabski, 1987; Cushing, 1990; Stone, 1990; Benbasat and Todd, 1996) and editors of prominent AIS journals (e.g. Borthick, 1992; McCarthy, 1987; Sutton, 1992, 1996). To help focus future research in this area, this paper makes three contributions toward research programs that examine how characteristics of an information system can influence judgment and decision making (JDM). First, we provide a research framework that specifies how information systems interact with other variables of the JDM process. Second, we present findings of a literature review that summarizes research on the association between information system features and decision making. Third, we suggest specific research topics that are of contemporary interest but have not been examined in the information systems literature.

The remainder of this paper is organized into three sections. Section 1 presents a research framework that we synthesized by merging an AIS research framework with a descriptive framework for human information processing (HIP) research. The second section presents a literature review organized around the variables specified by our framework. The literature review identifies studies that provide empirical evidence about how information system features can influence user decisions and how those features interact with other JDM variables. The third section identifies unexplored associations between system features and other decision variables that could provide fruitful areas for future research.

1. Research framework

Although AIS research has been a distinct academic discipline for several decades, a unifying framework has not formally been articulated until recently. David et al. (1999) use a framework from computer science and philosophy to describe relationships among business events, AIS, and individual interpretation. Their framework describes how people assign meaning to business transactions but does not address the decision-making process. Simultaneously, Mauldin and Ruchala (1999) developed a meta-theory for information systems that recognizes the importance of task characteristics to system design and task performance. Their framework also explicates three levels of analysis that can be performed within AIS research: cognitive, technical, and organizational. McCarthy (1987) suggests that, as a discipline, AIS research can benefit from borrowing and transferring the theoretical foundations used by better-established JDM paradigms. Following his prescription, this paper further refines the cognitive portion of the Mauldin and Ruchala meta-theory by synthesizing the David et al. framework and the JDM paradigm. As a result, we develop a framework for information systems research that is grounded in the extensive decision-making literature that has been conducted under the HIP paradigm (Newell and Simon, 1972).

David et al. (1999) suggest that AIS create an interface through which three distinct, but related variables can influence organizational behavior. AIS capture and provide information

about economic events that decision-makers use for planning, monitoring, and controlling their organizations. The information from AIS, which are instantiations of a symbolic representation of reality, also influences manager's perceptions of reality. These mental concepts give meaning to economic events. This process is a function the (1) objects, (2) concepts, and (3) symbols that influence the search for meaning as well as the AIS through which knowledge is acquired. Objects are the reality (people, things, and events) of the physical space in which the enterprise operates. Concepts are perceptions of reality, which are embodied by mental representations in a person's neural space. Symbols are the formalized design documentation of physical reality that are used to design AIS. These symbols in semantic space can influence the mental concepts people develop about physical objects.

David et al. (1999) diagram the role of AIS using a pyramid where symbols, objects, and concepts contribute a three-sided triangular base that provides an understanding (meaning) of economic transactions. AIS form the apex of the pyramid because AIS provide an interface between the variables that influence meaning and the information needed for knowledge development. Fig. 1 presents a diagram of associations among these variables that was adapted from David et al.

The HIP paradigm, which has evolved through a substantial body of generic JDM research, recognizes two general categories of decision variables: (1) differences between decision environments and (2) differences among decision-makers (Simon, 1990). Based on this framework, Payne et al. (1993) describe decision making as a function of the context, the problem, and the person. Context variables recognize differences in the decision environment (e.g. accountability, group membership) that could influence how a decision-maker interprets the elements and demands of the decision task. Problem variables include differences in decision attributes (e.g. number and similarity of decision alternatives; reference point and framing effects) and differences in decision cues (e.g. information display; presentation

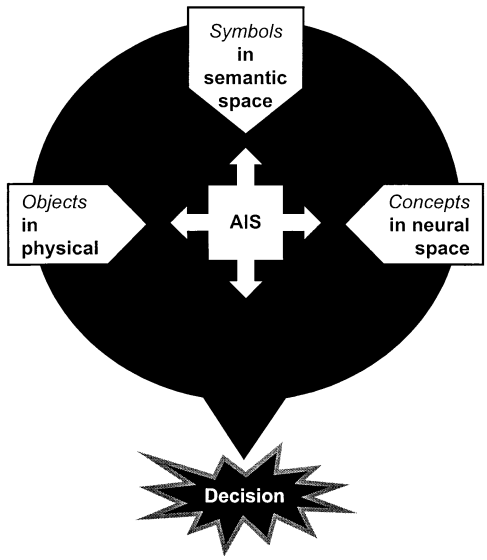

Fig. 1. AIS research framework (adapted from David et al.1999).

order). Person variables represent differences in decision-making skills associated with different levels of task knowledge and problem-solving ability. These variables interact to determine the strategy used for making a decision. The decision strategy is executed by processing information in a mental problem space where meaning is assigned to decision cues and the relative value of each cue is determined (Newell and Simon, 1972). Fig. 2 presents a diagram of associations among decision variables adapted from the HIP processing framework proposed by Payne et al.

Consider how these two frameworks overlap. Both recognize the influence of information systems. The AIS framework recognizes the symbols used to represent reality and other characteristics of the information system as variables in the understanding process. The HIP framework recognizes characteristics of decision cues (information system) as a distinct component of the problem. Both frameworks recognize the influence of constraints imposed by the task environment where meaning evolves and decisions are made. In the AIS framework, objects from physical reality define the parameters of a decision task. In the HIP framework, attributes of the decision task and the context in which the decision is made will each influence the decision process. Both frameworks also recognize the influence of differences in the mental concepts and the decision-making skills a person brings to the task. The AIS framework recognizes that a person's mindset and mental concepts influence meaning and the HIP framework recognizes that the knowledge and ability a person brings to the task will influence the decision process.

While the AIS framework focuses on how people participate in economic events, the HIP framework goes a step farther by focusing on how people use meaning to make decisions. Consequently, the HIP framework recognizes another variable, decision strategy, which is a function of the three variables discussed above. Finally, both frameworks recognize that all

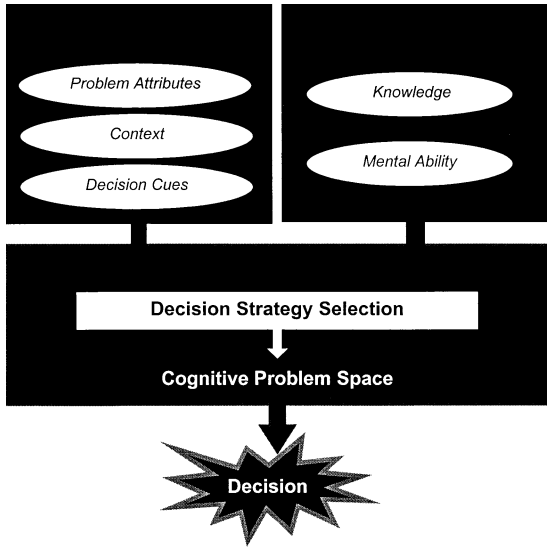

Fig. 2. HIP research framework (adapted from Payne et al., 1993).

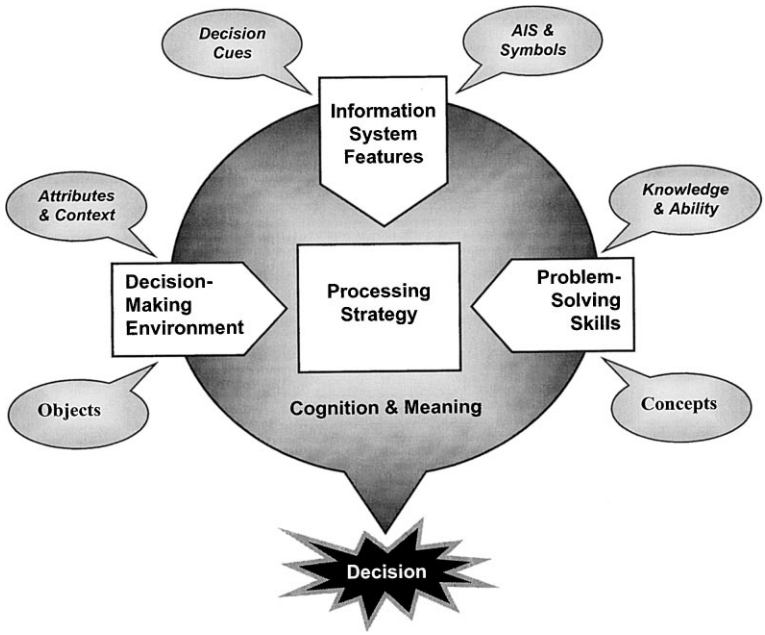

Fig. 3. Decision-making framework for information systems.

variables interact in the mind of the decision-maker and involve mental processes that cannot be measured directly or scrutinized through observation.

Synthesizing the AIS and HIP frameworks produces a decision-making framework for information systems research. This framework describes JDM as a function of three exogenous variables, including (1) information system features, (2) the decision-making environment, and (3) problem-solving skills, as well as processing strategy (an endogenous variable). Through cognition, these variables interact to produce decisions. We used this framework, which is diagrammed in Fig. 3, as the basis for organizing a review of the information systems literature.

2. Literature review

Our goal for this literature review is to provide published evidence describing how different information system features can influence user decision making, either directly as a main effect or indirectly through an interaction with the other decision variables illustrated in Fig. 3. To meet this goal, we identified studies that examined variations in decision making as a dependent variable and at least one of the independent variables was a specific characteristic of the computerized information system used while making the decision. Studies meeting this criteria are most likely to have been published in journals from the accounting and AIS literature or in journals from the management information systems (MIS) literature. It is also possible that such studies might have been published in the literature on decision making and

experimental psychology, although these types of journals are not as likely to provide outlets for research on computerized information systems.

Our objective was to provide a comprehensive review within manageable parameters. As a result, we began with the listing of AIS and MIS journals reviewed by Poston and Grabski (2000), and added accounting journals listed by Arnold (1993) that, in our opinion, were likely to consider publishing information systems research. Fifteen journals were selected for review, including *Accounting Horizons*, *Accounting Management and Information Technologies*, *Accounting, Organizations and Society*, the *Accounting Review*, *Advances in Accounting Information Systems*, *Auditing: A Journal of Practice and Theory*, *Behavioral Research in Accounting*, *Decision Sciences*, *Decision Support Systems*, the *Journal of Information Systems*, the *Journal of Accounting Literature*, the *Journal of Management Information Systems*, *Information Systems Research*, *International Journal of Intelligent Systems in Accounting, Finance, and Management*, and *MIS Quarterly*. We did not include decision-making and psychology journals in our search; therefore, our findings, while reasonably comprehensive, are less than exhaustive.[1]

Given our specific objectives, a number of information systems research topics were outside the scope of the review conducted for this study. We did not examine an article if it did not focus on decision making by individual information system users. For example, we did not review the following streams of research: (a) learning as an artifact of decision support systems (DSS), (b) decisions about whether or not to use an information system, (c) group decision-making processes, (d) factors that influence successful systems implementation, (e) components of user satisfaction, (f) studies that only examined processing time (and not decision variation) as the dependent variable, and (g) auditing studies that examined decisions about the reliability of information provided by a system. There is also a vast literature in accounting that examines how different financial statement attributes (e.g. level of disclosure, amount of non-financial information, etc.) can change decision making. Although these studies could be construed as examining how the output from AIS influence decisions, we excluded them from the literature review.

2.1. Scope and methodology

Because information systems technology has evolved so rapidly, the window for "current" research is rather narrow. Technological advances that spawned many of the contemporary research questions noted above have largely transpired during the 1990s. Furthermore, between 1987 and 1991 there was a proliferation of articles reviewing the information system literature. As a consequence, the literature review conducted for this study spanned the period from 1987 through 1999, which includes all volumes of the two dominant AIS journals (the *Journal of Information Systems* and *Advances in Accounting Information Systems*).

To identify research that reported results targeted by this study, we reviewed the table of contents for every issue of the target journals published between 1987 and 1998, inclusive, and all 1999 journals that were available. If the title of an article implied that it might meet the criteria of this study, we examined the article. We also studied all theory development and

[1] Additionally, we included several important articles from other journals that were identified by the reviewers.

literature review articles encountered during this search to identify any articles that fell outside the parameters established for this study but should be included nonetheless. A listing of review and theory articles that we found, along with a brief summary of each one, is presented in Appendix A.

We evaluated each paper to determine whether a decision was being made or a procedural task was being performed. To make this distinction, we relied upon definitions from several sources that identified two important criteria. First, decisions do not generally have a right and wrong answer; rather, there is uncertainty involved, which precludes the decision-maker from drawing on existing knowledge to quickly and confidently solve the problem. For example, McGrath (1994) refers to solving problems with correct answers as "intellective tasks" while resolving problems without answers are "decision-making tasks." Second, decisions are made with the goal of positively influencing an uncertain, final outcome (Yates, 1990, p. 3; Payne et al., 1993, p. 10, for example). Finally, papers were eliminated from the study if the decision-making setting was very unlikely for accounting professionals. For example, we chose to remove a paper from our study in which the subjects decided how to enter query commands into a computer to generate query results (Suh and Jenkins, 1992). While we realize that accountants are likely to collect data from systems and might perform queries, this task was not categorized as a decision for two reasons. First, although there may be multiple ways to create a query in some systems, the authors were able to identify right and wrong ways to write the queries, given the languages they made available to the subjects. Second, and more importantly, for most accountants this would not be the final choice that they made with the goal of influencing their future. Rather, this task would be a step in the process that might help them make a decision, but writing the query is not the decision, in and of itself.

Our search identified 57 articles that reported empirical evidence of associations among decision outcome, information systems features, and in many cases, one of the other three decision variables illustrated in Fig. 3. A listing of these articles, grouped by the information system feature examined, is presented in Table 1. We highlight studies that include dimensions of the decision-making environment, problem-solving skills, or processing strategy in their analysis with check marks in the appropriate columns. Articles that only examine the main effects of information systems features on decisions are listed without any check marks.

2.2. Discussion of findings

All of the research presented in Table 1 provides empirical evidence of the effect that information systems characteristics have on decision making, and the associations examined by these studies map directly to our descriptive framework. These studies examined how a variety of information systems characteristics affected JDM. One of the major ways that researchers have hypothesized that information systems can influence decision making is through variation in presentation format. Seventeen (30%) articles investigate the most commonly studied variation in presentation mode: the impact of tabular versus graphical presentation of information. Nine (16%) more studies examined the influence of other presentation options. Other ways that information systems may influence decision making include the availability or use of a DSS (included in 14, or 25%, of the studies included in this

Table 1
Listing of articles by information systems feature examined and interactions explored

	Interaction(s) explored		
Information system features	Decision-making environment	Problem-solving skills	Processing strategy
Tables vs. graphs			
Blocker et al. (1986)	✓		
MacKay and Villarreal (1987)		✓	
Kaplan (1988)	✓		
Davis (1989)	✓		
DeSanctis and Jarvenpaa (1989)		✓	
Liberatore et al. (1989)	✓	✓	
Amer (1991)	✓		
Hard and Vanacek (1991)	✓		
Anderson and Kaplan (1992)	✓		
Anderson and Reckers (1992)			
Diamond and Lerch (1992)			✓
Umanath and Vessey (1994)			✓
Bricker and Nehmer (1995)			✓
Schulz and Booth (1995)			
Wright (1995)	✓		
Frownfelter-Lohrke (1998)	✓		
Tuttle and Kershaw (1998)	✓		✓
Other presentation modes			
Kasper and Morris (1988)			
Wilson and Zigurs (1999)	✓		
Clements and Wolfe (1997)			
Ramarapu et al. (1997)	✓		
Asahi et al. (1995)			
Galletta et al. (1996)			
Dennis and Carte (1998)			
Roy and Lerch (1996)	✓		
Lenard et al. (1998)			
Availability of DSS or ESS			
Applegate et al. (1987)			
Kotterman and Remus (1989)	✓	✓	
Chu (1991)	✓		✓
Eining and Dorr (1991)		✓	
Todd and Benbasat (1991)	✓		✓
MacKay et al. (1992)		✓	✓
Mackay and Elam (1992)			
Todd and Benbasat (1992)	✓		✓
Leidner and Elam (1993)			✓
Goodhue and Thompson (1995)	✓		
Swink (1995)		✓	
Vandenbosch and Higgens (1995)		✓	
Vandenbosch and Higgens (1996)			
Kim et al. (1997)			✓

(continued on next page)

Table 1 (*continued*)

Information system features	Interaction(s) explored		
	Decision-making environment	Problem-solving skills	Processing strategy
Aggregation and load			
Benbasat and Dexter (1979)		✓	
Iselin (1988)		✓	
Lederer and Smith (1988)		✓	✓
Chewning and Harrell (1990)		✓	
Goodhue et al. (1992)			
Gillett (1993)			
Mia and Chenhall (1994)	✓		
Stocks and Harrell (1995)			
Johnson and Kaplan (1996)			
Stocks and Tuttle (1998)		✓	
Interaction and feedback			
Ang et al. (1993)			
Santhanam and Sein (1994)			
Gibson (1994)			
Arunachalam and Daly (1995)			✓
Stone (1995)		✓	✓
Arunachalam and Daly (1996)			
Montazemi et al. (1996)	✓		

review), the effect of information aggregation and load (in 10 studies, or 18%), and the system's facility to provide interaction and feedback (in 7 studies, or 12%).

Over half of the studies (34) looked beyond the influence of a single information system feature to examine the interaction between a systems characteristic and one or more of the other three variables. Of those 34 studies, 20 (59%) examined interactions with the decision-making environment, 13 (38%) examined interactions with problem-solving skills, and 11 (32%) examined interactions with processing strategy. In the following sections we provide a summary discussion of results reported in these studies, organized by information system feature.

2.3. Tables vs. graphs

The effect of presenting accounting information in tabular versus graphical format has received significant research attention. Although early research hypothesized a direct relationship between presentation format and decision performance, studies have not provided consistent evidence that presentation format alone influences judgment in predictable ways. Of the 17 studies listed in Table 1 that examined tabular versus graphical presentation format, seven found main effects, seven found only interactive effects, and the other three, Kaplan (1988), Bricker and Nehmer (1995) and Frownfelter-Lohrke (1998), found that presentation format had no effect at all.

As our research framework suggests, the studies that provide evidence of the presentation mode's main effect on decision making controlled for other dimensions in the framework. For

example, one of the studies that found main effects also examined the effect of a decision-making environment characteristic. Specifically, Anderson and Kaplan (1992) found that the influence of presentation format remained constant as data variability increased.

There is also evidence that the main effect between presentation mode and decision performance is not always influenced by user problem-solving skills. For example, MacKay and Villarreal (1987) found that graphical presentation improved bankruptcy forecast accuracy but did not interact with experience. Similarly, DeSanctis and Jarvenpaa (1989) found that graphical presentation improved earnings forecast accuracy, and performance differences were not influenced by practice. Anderson and Reckers (1992) found that graphs consistently resulted in more accurate sales forecasts, although field independence also improved decision performance.

Three additional studies found presentation mode main effects while controlling for decision strategy. Diamond and Lerch (1992) and Umanath and Vessey (1994) found that graphical presentations reduced the negative influence of information load and changed decision strategy by altering the relative influence of decision cues. Schulz and Booth (1995) found that graphs produced more accurate correlation estimates and decreased time on task but did not influence decision confidence.

Although one study provided evidence of a presentation format main effect when controlling for decision-making environment, seven other studies found that the influence of presentation format interacts with characteristics of the environment. Several papers have examined the effect of varying decision complexity, along with presentation format, in decision making. Davis (1989) and Liberatore et al. (1989) found that tabular format was superior as the questions to be answered with decision cues became more complex. Similarly, Blocker et al. (1986) found that tabular presentation improved the accuracy of the auditors' risk assessments when decision cues were less consistent. However, Wright (1995) found auditors who used graphical presentations made more accurate loan collectibility predictions, a more complex task, but presentation had no influence on decision performance for financial trend and characteristic assessments, which are less complex tasks.

Because there is some inconsistency in whether complex tasks are aided by graphical or tabular formats, it is important to study other dimensions of the decision-making environment, such as was done in three additional studies in our review. Amer (1991) found that tabular presentation resulted in more accurate assessments of debt covenant violations in a selective task but had no effect on predictions of bond ratings during an integrative task. Hard and Vanacek (1991) found that financial predictions were more accurate for graphical presentations during an estimation task but more accurate for tabular presentations during an accumulation task. Tuttle and Kershaw (1998) found that graphs produced better performance evaluations under conditions that require holistic decision strategies but that presentation format did not influence decision performance when analytical strategies were mandated.

In total, this body of research suggests that the extent to which tables are superior to graphs, or vice-versa, depends in large part on the characteristics of the decision task. Additionally, the research that examines the effect of tabular and graphical presentation has been rigorous and has examined several dimensions within our research framework. As such, we believe that academics interested in other areas of judgment and decision-making research should follow these researchers' lead.

2.4. Other presentation formats

Comparing other variations in presentation format with tabular reports appears to have much the same effect on decision making as tabular versus graphical representations does. For example, the three studies in this review that examine the main effect between multimedia presentation modes and decision making report conflicting findings. Kasper and Morris (1988) found that textual information was better comprehended than other forms that did not require reading (such as audio or audio/video), but the communication media did not influence the users' perceptions of difficulty. On the other hand, Clements and Wolfe (1997) found that presenting multimedia decision information captures attention better and improves memory but has no measurable influence on decision performance. Additionally, Galletta et al. (1996) provide evidence that it may be important for users to read paper documents, rather than looking at computer screens.

In total, these papers provide some evidence that multimedia presentations may be less able to support decision making than originally expected. However, we believe that the proliferation of multimedia information from the Internet implies that businesses believe there is benefit from such presentation. Therefore, we recommend future research that explores the additional associations between multimedia format, decision-making environment, problem-solving skills, and processing strategies to determine if there are situations in which decision making is enhanced.

Several other presentation formats are being studied, including hypertext systems, geographical information systems (GIS), treemaps, and probability maps. Ramarapu et al. (1997) reported that hypertext presentations appear to improve decision quality for some types of tasks but not for others. GIS can be used to illustrate differences in organizational performances across regions, and simple versions of these tools are being included in common business software. However, similar to other graphical representations, using a GIS does not insure superior performance over using tabular representations of the data. Rather, task characteristics, explicitly situations in which adjacency relationships are critical, interact with presentation mode to influence performance (Dennis and Carte, 1998).

Treemaps can be used to display multiple dimensions of a problem in a two-dimensional space and have been shown to identify outliers and causal relationships in hierarchical data. Asahi et al. (1995) extend this work to provide interactive facilities that enabled users to re-specify decision weights. Users of the advanced system were able to select the appropriate tool to solve their problem and were satisfied with the system.

Probability maps divide the screen into cells representing a portion of the population. The cells are shaded to represent different characteristics within the population. This representation can be used to reduce user bias and ineffective mental models for better decision accuracy (Roy and Lerch, 1996).

Finally, because of the mixed results reported for presentation mode and performance, researchers are beginning to study whether user preferences for display type influence performance. Wilson and Zigurs (1999) found that subjects had no difference in task performance whether using their preferred display format or any other. However, when provided with theory-based format recommendations, their performance increased and they did not resist the recommendations.

2.5. Availability of DSS or ESS

Using a DSS, as opposed to unaided analysis of decision information, may improve decision performance, although Leidner and Elam (1993) provide the only evidence of such a main effect. In their study, problem identification, decision-making speed, and extent of analysis all increase with the frequency and duration of DSS[2] use. The remaining papers all examine interactions between DSS and the other variables that are hypothesized to influence decision making.

Several studies examine the association between problem-solving skills, DSS availability and JDM, with conflicting results. Mackay and Elam (1992) provide evidence that users must have sufficient training in the DSS or they will be unable to apply their functional knowledge to the task. Additionally, MacKay et al. (1992) found that the benefits of using a DSS can increase as task-specific experience increases (MacKay et al., 1992). On the other hand, those benefits apparently diminish as problem-solving ability increases (Swink, 1995), and they are apparently not influenced by feedback (Eining and Dorr, 1991).

Other studies have focused on effect of user's mental models (another component of problem-solving skills). Goodhue and Thompson (1995) found that decision performance may improve if the DSS matches well with the decision-maker's mental model of the task (Goodhue and Thompson, 1995). Additionally, Kotterman and Remus (1989) provide support for a three-way interaction in which the benefits from such a match increase as task complexity (a characteristic of decision-making environment) increases. A DSS can help users change their mental model to reflect new information (mental model building during DSS use rather than maintenance) if they scan through the system to help them think creatively, rather than performing a more focused search (Vandenbosch and Higgins, 1996). This could be a critical success factor as executives view DSS as leading to competitive performance only when they experience mental model building (Vandenbosch and Higgins, 1995).

A DSS can also influence the user's processing strategy and this influence may be affected by the user's decision-making environment. Evidently, using a DSS increases both the problem-finding and problem-solving components of a decision (MacKay et al., 1992), but performance benefits achieved during the design (problem-finding) phase diminish as complexity increases (Chu, 1991).

DSS users tend to adapt decision strategies from previous experience, and this tendency toward incremental decision processes is not sensitive to task complexity (Chu, 1991). Decision strategies inspired by the availability of a DSS tend to reduce processing effort (Todd and Benbasat, 1992) and, for the most part, can be effectively replicated with linear models (Kim et al., 1997). However, systems designers can create a DSS to lower the effort needed for a decision-maker to follow the preferred decision strategy to induce the preferred behavior (Todd and Benbasat, 1991).

---

[2] Executive information systems are a subset of decision support systems. Therefore, we will use the term "DSS" throughout this section of text although the authors may have referred to their systems as executive information systems.

2.6. Aggregation and load

Researchers have hypothesized that providing users with access to more data, both aggregated and disaggregated, will improve their decision making. Research looking at the simple association between this information system characteristic and JDM is mixed. Increasing the number of decision cues (information load) can lead to less consistent decisions (Chewning and Harrell, 1990, Stocks and Harrell, 1995), but providing the same type of disaggregated information throughout an organization can improve overall decision performance (Goodhue et al., 1992). Presenting information categorically rather than numerically can improve judgment quality by reducing the complexity of disaggregated data and these performance benefits are consistent across different levels of information load (Stocks and Tuttle, 1998). Gillett (1993) incorporated the concept of aggregation into information systems design research, and the resulting audit tool was used in a field setting.[3] Results help confirm the association between data aggregation and decision performance, which has implications for practice.

Other research has refined this evidence by examining how data aggregation and information load interacts with the other variables. Mia and Chenhall (1994) find that the benefits from providing access to disaggregated information are sensitive to the type of decision task the users are required to perform. Additionally, several studies examined the interaction with one's problem-solving skills. For example, decision performance evidently improves when disaggregation increases the number of dimensions (attributes) distinguished by the information system (Johnson and Kaplan, 1996), but these benefits diminish as task-specific experience increases (Iselin, 1988). More specifically, disaggregated accounting information can produce better decisions for decision-makers with more analytical ability (Benbasat and Dexter, 1979) and analytic planners (Lederer and Smith, 1988).

2.7. Interaction and feedback

The organizational behavior literature has hypothesized that providing employees with feedback will improve their performance (Montazemi et al., 1996). Research has shown, however, that not all types of feedback will produce positive results. For example, Stone (1995) found that providing outcome feedback was associated with higher accuracy, but providing process feedback only improved subjects' self-insight into the processes they performed. Similarly, the mode of feedback can influence productivity; audio feedback has yielded higher productivity than visual or audio–visual (Gibson, 1994). Interestingly, although feedback has been shown to increase performance, employees may not seek out feedback. However, if the feedback is computer-generated, rather than face-to-face, users are more likely to request feedback (Ang et al., 1993). Additionally, for both computer-generated and face-to-face feedback, if the feedback giver appears to be in a good mood, more feedback will be requested.

In addition to the association between feedback and decision-making performance, researchers have begun exploring the more complex interactions between the other concepts

[3] The discussion by Vasarhelyi (1993) provides more insight into this paper.

in our research framework. In this research, providing feedback as part of the decision information generated by a system can improve decision performance in some situations but not in others. Feedback can improve decision performance by altering decision strategy (Arunachalam and Daley, 1995) and the benefits of feedback increase as the decision-making environment becomes more complex (Montazemi et al., 1996). However, feedback may not be beneficial in diagnostic tasks when decision-makers have no task-specific experience (Eining and Dorr, 1991). Stone (1995) studied the interaction between users' problem-solving skills (their concepts would include their perceived difficulty of using the feedback tool), and the type of feedback they received. Those receiving process feedback who expected the feedback to be difficult to use were significantly less accurate in their decision making than other groups. Thus, he concludes that systems designers need to consider both the type of feedback their systems will provide and then manage users' expectations about how difficult the system will be to use.

2.8. Summary of findings

Taken as a whole, this literature review suggests that only three information systems features have been explored in much depth: (1) tabular versus graphical presentation format, (2) using versus not using DSS, and (3) differences in the amount of information (load) available. Table 1 illustrates that some complex interactions between DSS availability and the other three decision variables have been examined by more than one study. However, with the exception of decision-making environment, we believe that the interactions between other decision variables and either presentation format or information load have yet to be fully explored. Furthermore, some characteristics of decision information that could have a considerable impact on contemporary information systems design have received only limited attention or have not been examined at all. As a consequence, there appears to be considerable need for behavioral research on a number of information systems issues, which are summarized in the next section.

3. Directions for future research

Systems researchers interested in furthering our understanding of decision making are faced with two choices in identifying new, interesting projects. First, we can continue to refine our knowledge about how the already studied system features influence JDM. The second approach, which we believe will be much more fruitful, is to identify new dimensions in system features and the decision-making environment that would motivate research involving contemporary issues. This section describes both approaches and provides specific recommendations for extending research into these areas.

3.1. Extend the existing research

As discussed, the research to date has focused primarily on three system features. However, several areas of this research have been studied minimally or have mixed results

and further research is needed to resolve these findings. For example, researchers do not fully understand the interaction between presentation mode (tabular versus graphical) and the effect of multimedia presentations on decision making. We also do not have enough data about the other presentation modes to know when they will improve decision making in accounting situations.

Researchers interested in extending the literature should also consider the blanks in Table 1 that identify several interactive associations that have not been examined that may illuminate interesting extensions of existing research. The interactive influence of problem-solving skill and processing strategy has received little or no research attention beyond their interaction with DSS availability. Furthermore, other than level of complexity, the influence of decision-making environment variables has been explored only sparingly. The study of complexity could also be extended to more complex and realistic tasks (Vessey, 1991) and into the area of strategic (rather than operational) decision-making (Sabherwal and Grover, 1989).

Other useful extensions of existing literature might be accomplished through studies that examine (a) whether decision-makers with more problem-solving skills respond differently to changes in presentation format, (b) whether the influence of interactive system features changes as the level of complexity changes, (c) whether the information load imposed by an information system becomes more of a problem as tasks become more complex, and (d) whether decision strategy selection can mitigate the undesirable influence of information overload.[4]

3.2. Identify new characteristics to research

Another way to find fruitful areas for future research is to reconsider the constructs in the JDM model and identify new characteristics that have not yet been explored. We believe that both the system features and decision-making environment pose many areas for exploration. The following sections identify trends in today's IT environment that have implications for both researchers and academics.

3.2.1. Information system features

Information systems vary in many more dimensions than the few that have been explored in the literature. By immersing themselves in the current IT environment, researchers can identify characteristics that are of contemporary importance to information systems professionals and academics, but have not yet been explored with behavioral research.

Perhaps the most discussed change in information systems has been the move toward Enterprise Resource Planning (ERP) systems. Organizations are spending millions of dollars to implement these systems, but organizations have failed to use the data in the system to their advantage (Davenport, 1998a, 1998b). Additionally, ERP vendors are developing relationships with universities so their software products will be included in our classes. This

[4] Schick et al. (1990) review the literature on information load and advocate research that examines whether the phenomenon of information overload is a function of user attention and time pressure rather than an artifact of the (Vessey, 1991) decision information.

provides an opportunity for accounting researchers to perform JDM laboratory experiments using actual ERP systems.

ERP systems are reported to have many characteristics that likely influence a user's decision-making process. Table 2 lists potential features that could be included in future research. Each of these characteristics could become a rich area for exploration, just as the graphs versus tables research question has been. For example, ERP systems integrate data from across the organization and often make that data available to users through ad hoc reporting tools (Piturro, 1999). To date, however, only limited information systems research has studied how decisions change when the amount of information increases significantly,

Table 2
Sample information systems features for future JDM research

ERP systems
- Integrated databases
- Cross functional information availability issues:
  - Amount of data available for analysis
  - Data responsibility concerns
- Issues related to integrated organizational units:
  - Multi-national data in the system (language and currency issues)
  - Data responsibility concerns
- Complexity
- Real time availability
- Standardized procedures enforced throughout the organization
- Level of customization
- Ad hoc reporting capabilities
- Range financial and non-financial metrics available

Advanced planning systems
- Inter-organizational transfer of information
- Speed of order and planning reconfiguration

Data warehouses
- Integrated data
- Range of tools: query, report writers, OLAP
- Meta data availability
- "Cleaning" performed to increase data quality

Financial accounting standards
- Movement toward more frequent reporting demands

Electronic commerce
- Speed of change
- New business models
- Round the clock availability

Virtual organizations
- Minimal face-to-face communication
- Mode of communication (e-mail, phone, video, etc.)

and no research has examined the effect of the resulting increased complexity in the reporting environments. Are users able to create the necessary queries? Are they overly confident in their ability to extract the correct information to guide their decisions? Does the complexity improve or hamper their decision-making capabilities?

While Table 2 shows general characteristics of ERP systems, additional research is called for to evaluate the actual features of different systems environments. We must move beyond surface differences in the systems interface and environment and evaluate the underlying assumptions and structures in the systems. This research requires explication of the underlying systems designs, which will be necessary before such studies are performed. For example, if researchers hope to compare decision making in different ERP environments, they must identify what information systems features are critical to the decision, what data is available within each system, and how the systems vary along these dimensions. Because such research has not been performed, researchers should refer to the David et al. (1999) framework, and recall that the Symbol construct is a critical component in the systems environment. We believe that researchers referring to a system's documentation (its symbolic representation) will be able to more precisely design their experiments. Additionally, because they will know the key information systems features being studied, their work will be more generalizable to other systems that are also understood at the symbolic level.

There are several other systems innovations that may influence how users make decisions. For example, while ERP systems have integrated information within an organization, more dramatic changes occur when organizations implement interorganizational systems such as the advanced planning tools on the market today (such as i2 and Manugistics). These systems excel at consolidating data from multiple parties in a supply chain and applying statistical techniques to perform on-line real time rescheduling of the production and distribution functions (Berger, 1997, Gilbert and Sweat, 1999). Users of such systems must rely on data with two new characteristics: it is frequently from a foreign source that they cannot control or audit, and they must allow the systems to make decisions that had heretofore been in the human domain. Additionally, the speed in which decisions are made has continued to accelerate.

Finally, data warehousing is becoming a common technique in today's organizations. These systems, again, are characterized by integrated data, but there are at least two additional types of studies that would prove valuable. First, one strength of data warehouses is their ability to allow users to explore the data to either collect the data they need to support preconceived hypotheses, or to allow the data warehouse tools to spot new trends and relationships that lead to new hypotheses (David and Steinbart, 2000). To meet these objectives, analysts can be provided with a wide range of tools including query tools similar to the QBE interface in Microsoft Access, on-line analytical processing tools that enable multidimensional analysis without users needing to understand query language, and data mining tools. Similar to the tables-versus-graphs literature, research is needed to determine what type of tool is useful in different decision-making environments, and what problem-solving strategies users need to use these tools successfully.

Data warehousing also presents one of the best opportunities to study the relationship between symbolic systems representations and decision making. One of the key recommendations for successful data warehouses is that users are provided access to the meta data that

describes the elements in the system (Sachdeva, 1998). Decision making strategies and decision quality are likely to be influenced by different meta data representations. Therefore, performing research that studies the different meta data formats, along with users' problem-solving skills and decision environments will enhance the JDM literature and has implications for organizations with data warehouses.

3.2.2. Decision-making environment

There is a wide range of opportunities for research that explores other environmental characteristics. Changes in the decision-making environment may result in changes to systems, and changes in technological capabilities can change corporate environments. Little research has been performed to determine how these changes cascade into user decision making. For example, organizational culture and task programmability can influence how an AIS impacts decision performance (Dunk and Roohani, 1997), but these features have not been examined in behavioral studies.

Changes in demands for financial reports are an important area for information systems researchers to continue to study. Two new financial reporting features, where the new alternatives have been availed by technology, should be of particular contemporary interest, including reporting intervals (Sutton and Arnold, 1995) and the degree of aggregation imposed on the information provided by the system (Sutton, 1992, 1996). Internet access to database reporting systems has made it feasible to provide real-time access to disaggregated transaction information. Information systems research that examines these attributes could contribute to the standard-setting process and might also capture the interest of mainstream accounting academicians and journals.

While a reliable infrastructure for delivering real-time, disaggregated financial information has only recently become available, these issues have been around the AIS literature for some time. For example, Amer (1991) discusses the intersection between AIS and the measurement focus prescribed for financial reporting. Cushing (1989) examines the policy implications of providing disaggregated financial information. However, we believe that the level-of-aggregation issue has not been fully explored and this literature review turned up no articles dealing with the real-time reporting issue.[5]

The explosion of Internet usage for electronic commerce is resulting in critical changes to many dimensions of the decision-making environment (Gilbert and Sweat, 1999) (see Table 2). Web-based organizations face change at an incredible speed. They must be able to adapt to new situations and bear huge costs associated with being the third or fourth company to a new business opportunity rather than the first or second. Therefore, academic researchers should study the effect of time pressures on decision making.

Additionally, studying the new business models is critical to determine what decisions are necessary and how they can be supported. The general trend in today's organizations is to identify ways to eliminate "required" steps in businesses processes, frequently aided by technology. For example, Operations Resource Management (ORM) systems such as

[5] Research that examines these issues may have been published in the financial accounting and reporting literature but were not examined in conjunction with this literature review because no behavioral study was conducted or because the journal was not reviewed.

Ariba and PurchasePro are changing how non-inventory items are being purchased (Nee, 1997). Rather than having an employee complete a purchase requisition that is approved by a supervisor and translated into a vendor purchase order by a buyer, these systems reside on every employee's desktop and allow them to access on-line catalogs to place their orders directly. At least two broad research questions arise in this environment. First, how can system design provide sufficient data to these new buyers to help them make the best decisions for the organization? Second, when the business model changes, how can management evaluate performance in the new environment? Specific to the ORM example, how should management evaluate the purchasing function? How should they define the system parameters that enforce new controls? How do they evaluate the success of such systems? These types of decisions are likely to require different information, perhaps presented in new formats. For example, one technique would be for the system to generate exception reports of unusual buying patterns. How would management's decisions change when using exception reports compared to pre-scheduled reports or ad hoc queries?

Another change in the environment that can influence decisions is the growing occurrence of virtual organizations (Evans and Wurster, 1997; Magretta, 1998). In these firms, face to face communication is at a minimum and there are few if any long-term organizational hierarchies in place. In this environment, decisions will be made relying on information from relatively unknown sources through a wide range of media. Additionally, the systems must evolve as the organizations do. Research should be performed to determine how virtual firms are designing their systems. Once the researcher explicates the differences between systems supporting virtual and traditional (or between two different virtual organizations), characteristics of these environments should be studied to determine whether they hinder or enhance decision making.

3.3. Additional recommendations

The previous sections have described a wide range of opportunities for JDM researchers. However, as we move beyond experiments that examine only one aspect of how information systems present information to users, experimental design will be critical to success. Controlling for the influence of the different variables that influence JDM is an important component of rigorous behavioral research into the association between information system and decision-maker (Benbasat and Todd, 1996). When designing a research project, the variables specified in Fig. 3 should either be measured and controlled for or held constant by some feature of the experimental design. For example, in a study where the participants have different amounts of task-specific experience, the research design must measure and control for differences in problem-solving skill.

The dynamic nature of the three interaction variables illustrated in Fig. 3 has some interesting implications, particularly with respect to decision strategy and how it changes as decision-makers adapt to their task. A comprehensive descriptive framework must account for the influence of decision strategy (Benbasat and Todd, 1996). Furthermore, decision strategy can be influenced by decisional guidance features, such as menu structure and help messages (Silver, 1991). Decision strategy can also change as task knowledge changes

(Payne et al., 1993), which occurs as the decision-maker learns more about the decision task (DeSanctis and Jarvenpaa, 1989). More process-tracing research is needed to document the influence of decision strategy on decision performance (Benbasat and Nault, 1990).

4. Conclusion

We believe there is a huge opportunity to perform quality research related to how an information system affects JDM, and that the framework developed in this paper can provide two benefits to researchers in this area. First, as shown in the literature review, categorizing the current literature using our framework can help researchers identify new areas for exploration. Categorizing previous studies highlighted opportunities to extend the tables versus graphs literature and illuminated the need for new studies to include hypotheses about complex interactions among other variables, especially those involving decision strategy. Perhaps more importantly, the literature review unveiled several other presentation modes that have received much less attention, yet are likely to be more important in tomorrow's organizations. For example, ISSI/International Data believes that spatial information management (SIM) is likely to grow 25–30% in the business support systems segment (Sonnen, 2000). Such systems build upon GIS technologies to use the wealth of data in ERP systems or data warehouses to provide management with visual representations of key relationships in the environment. The goal of these systems, of course, is to improve business decision making. However, to date, we have not identified which techniques actually lead to better decision making. Thus, we believe that studying other presentation techniques offers more potential since there is so much less known about them.

Second, we believe that our framework can help researchers design new studies of heretofore unexplored areas. We strongly encourage our fellow AIS researchers to become intimately familiar with today's technological advancements to determine what AIS features are being introduced. Such features provide excellent areas for future research. In these kinds of studies, our framework will help researchers to explicitly define the AIS characteristics they want to examine and to identify other factors that must be controlled for or need further exploration. We believe that this approach will have many benefits for those who use it. By being familiar with advancements in technology, researchers who use this approach should provide timely insights about the rapidly changing business world. This understanding will also enable us to provide state-of-the-art training to our students, enriching their classroom experiences and better preparing them for careers in technology-rich environments.

The foregoing discussion only scratches the surface of research opportunities that are available and there may be other important issues that we have not mentioned. Hopefully, however, the descriptive framework and literature review presented herein will inspire research that expands what we know about how information systems influence user decisions. The result will be an academic discipline that evaluates the current environments and guides future developments through research findings and educational insights. We look forward to seeing new, exciting research that provides insights on key AIS characteristics, decision-making environment, problem-solving skills, and decision strategy.

Appendix A. Articles providing perspective on information systems research

Author (Date)	Description of article
Amer et al. (1987)	Review AIS literature that examines (1) associations between accounting measurement focus and system design, (2) EDP auditing, and (3) decision aids.
Benbasat and Nault (1990)	Review the literature in MIS. Stress the need for theory-based research that integrates findings into a comprehensive framework. Stress need for decision strategy research using processing tracing methods.
Benbasat and Todd (1996)	Discuss how developing a problem representation (model formulation) influences decision making when using decision aids. Consider the influence of decision information (types of aids), task environment (complexity), cognitive ability, task knowledge (experience), and decision strategy (effort).
Cushing (1989)	Discusses policy implications of using an events approach to financial reporting. Suggests that disaggregation would improve market efficiency by providing more flexibility for making decision strategies, thereby improving decisions.
Cushing (1990)	A paradigm for AIS research is still developing. More work is needed in the area of information presentation alternatives, cognitive ability (style), and human–computer interaction (interface).
Dunk and Roohani (1997)	Suggest that the extent to which information technology enhances firm performance is a function of amount of operational change, organizational culture, and task programmability.
Gerlach and Kuo (1991)	Review the literature on human–computer interaction. Suggest that designing effective interfaces begins by understanding interactions between user and task differences, and more research in this area is needed.
Kasper (1996)	Posits that if system design properties (expressiveness, visibility, and inquirability) and the design method are aligned during DSS development, then future DSS users will have accurate perceptions of their decision quality.
Kida and Smith (1995)	Discuss how presentation format, information load, and decision objectives influence decision making by changing memory processes.
March and Smith (1995)	Argue that research frameworks from the natural sciences can provide significant insight about how to develop an effective paradigm for information systems research. The key to motivating research is establishing that the output from an information system has utility for an important task.
Minch (1990)	Provides a framework for hypertext DSS including opportunities to examine how they interact with task and individual characteristics.
Montazemi and Wang (1988–1989)	Provides a meta-analysis of information presentation modes on information dimensions. The major finding is the confirmation of situations in which different graphical representations are preferred

	including analysis of the task environment's effect on timesaving and accuracy. Additionally, the authors confirm that field dependency (one dimension of cognitive ability) is a significant moderator between color and relevancy.
Preston et al. (1996)	Explore theoretical reasons why visual images in annual reports could influence readers decisions by changing how they perceive (see) the information that is presented.
Reneau and Grabski (1987)	Review computer–human interaction research as it relates to AIS. Stress the need for theory-based research that examines how the decision process is influenced by interactions between decision-maker variables (ability and knowledge) and decision task variables (task environment and decision information).
Sabherwal and Grover (1989)	Stress the need to differentiate between strategic and operational decisions when testing the impact of information systems. Identify the variables that impact strategic decisions and different dimensions of decision information.
Schick et al. (1990)	Review the literature on information load. Suggest that information overload is a function of user attention and time pressure rather than an artifact of the amount of information provided.
Silver (1991)	Discusses how decisional guidance provided by an information system (e.g. menu structure, help messages, etc.) can influence the decision process by changing decision strategy.
Stone (1990)	AIS research has concentrated on user satisfaction and largely ignored the association between system characteristics and decision making. Advocates more descriptive research into decision-making processes.
Sutton and Arnold (1995)	Discuss opportunities for future behavioral research in AIS.
Tan and Benbasat (1990)	The authors develop a framework to match task characteristics, in particular data extraction requirements, with the preferred graphical characteristics to communicate information to users. They also review empirical studies that have examined such tasks and graphical representations to validate the taxonomy.
Ting-Peng-Liang and Jones (1987)	Provide an approach to developing DSS that will evolve to individual user preferences. Recognizes the need for such systems to include user profiles, a knowledge base for rules to translate user preferences into system characteristics, and a means to control the evolution.
Vessey (1991)	Reviews the literature that examines how cognitive fit (ability) interacts with information presentation (tables versus graphs). Stresses the importance of matching information presentation with task environment and advocates extending this line of research into complex, strategic decision tasks.

References

Amer T. An experimental investigation of multi-cue financial information display and decision making. J Inf Syst 1991;5(2):18–34 (Fall).

Amer T, Bailey AD, De P. A review of the computer information systems research related to accounting and auditing. J Inf Syst 1987;2(1):3–28 (Fall).

Anderson JC, Kaplan SE. An investigation of the effect of presentation format on auditors' noninvestigation region judgments. Adv Account Inf Syst 1992;1:71–88.

Anderson J, Reckers P. An empirical investigation of the effects of presentation format and personality on auditor's judgment in applying analytical procedures. Adv Account 1992;10:19–43.

Ang S, Cummings LL, Straub DW, Early PC. The effects of information technology and the perceived mood of the feedback giver on feedback seeking. Inf Syst Res 1993;4(3):240–561 (September).

Applegate LM, Chen TT, Nunamaker JF. Knowledge management in organizational planning. J Manage Inf Syst 1987;3(4):20–38.

Arnold V. Accounting information systems research: attitudes and perceptions of publication outlets. Adv Account Inf Syst 1993;2:150–60.

Arunachalam V, Daly BA. The effects of judgment feedback in an earnings prediction task using accounting information. Adv Account Inf Syst 1995;3:63–99.

Arunachalam V, Daly BA. An empirical investigation of judgment feedback and computerized decision support in a prediction task. Account Manage Inf Technol 1996;6(3):139–56.

Asahi T, Turo D, Schneiderman B. Using treemaps to visualize the analytic hierarchy process. Inf Syst Res 1995;6(4):257–375.

Benbasat I, Dexter AS. Value and events approaches to accounting: an experimental evaluation. Account Rev 1979;54(4):735– 49 (October).

Benbasat I, Nault BR. An evaluation of empirical research in managerial support systems. Decis Support Syst 1990;6(3):203– 26 (August).

Benbasat I, Todd P. The effects of decision support and task contingencies on model formulation: a cognitive perspective. Decis Support Syst 1996;17(4):241–60 (August).

Berger M. Can you supply on time? Sales Mark Manage 1997;149(10):317–9 (September).

Blocker E, Moffie R, Zmud R. Report format and task complexity: interactions in risk judgments. Account Organ Soc 1986;11(6):457–70.

Borthick AF. Helping users get the information they want, when they want it, in the form they want it: integrating the choice and use of information (Editorial). J Inf Syst 1992;6(2):v–ix (Fall).

Bricker R, Nehmer R. Information presentation format, degree of information processing, and decision quality. Adv Account Inf Syst 1995;3:3–29.

Chewning EG, Harrell AM. The effect of information load on decision makers' cue utilization levels and decision quality in a financial distress decision task. Account Organ Soc 1990;15(6):527–42.

Chu P. A study of the influence of a decision support aid on decision processes: exploring the black box. J Inf Syst 1991;5(2):1–17 (Fall).

Clements CE, Wolfe C. An experimental analysis of multimedia annual reports on nonexpert report users. Adv Account Inf Syst 1997;5:107–36.

Cushing BE. On the feasibility and the consequences of a database approach to corporate financial reporting. J Inf Syst 1989;3(2):29–52 (Spring).

Cushing BE. Frameworks, paradigms, and scientific research in management information systems. J Inf Syst 1990;4(2):38– 59 (Spring).

Davenport TH. Managing with R/3: effective use of SAP information, Working paper. Boston University, 1998a.

Davenport TH. Putting the enterprise into enterprise systems. Harv Bus Rev 1998b;73(4):109–19 (July–August).

David JS, Dunn CL, McCarthy WE, Poston RS. The research pyramid: a framework for accounting information systems research. J Inf Syst 1999;13(1):7–30 (Spring).

David JS, Steinbart PJ. Data warehousing and data mining: opportunities for internal auditors. Florida: Institute of Internal Auditors, 2000.

Davis LR. Report format and the decision maker's task: an experimental investigation. Account Organ Soc 1989;14(5/6):495–508.

Dennis AR, Carte TA. Using geographical information systems for decision making: extending cognitive fit theory to map-based presentations. Inf Syst Res 1998;9(2):194–203 (June).

DeSanctis G, Jarvenpaa SL. Graphical presentation of accounting data for financial forecasting: an experimental investigation. Account Organ Soc 1989;14(5/6):509–25.

Diamond L, Lerch FJ. Fading frames: data presentation and framing effects. Decis Sci 1992;23(5):1050–71 (September).

Dunk AS, Roohani SJ. A framework analysis of the relation between information technology and performance: the influence of operational change factors and organizational culture. Adv Account Inf Syst 1997; 5:81–97.

Eining MM, Dorr PB. The impact of expert system usage on experimental learning in an auditing setting. J Inf Syst 1991;5(1):1–16 (Spring).

Evans PB, Wurster TS. Strategy and the new economics of information. Harv Bus Rev 1997;75(5):71–82 (October).

Frownfelter-Lohrke C. The effects of differing information presentations of general purpose financial statements on users' decisions. J Inf Syst 1998;12(2):99–108 (Fall).

Galletta DF, Hartzel KS, Johnson SE, Joseph JL, Rustagi S. Spreadsheet presentation and error detection: an experimental study. J Manage Inf Syst 1996;13(3):45–63.

Gerlach JH, Kuo F. Understanding human–computer interaction for information systems design. MIS Q 1991;15(4):527–50 (December).

Gibson DL. The effects of screen layout and feedback type on productivity and satisfaction of occasional users. J Inf Syst 1994;8(2):105–14 (Fall).

Gilbert A, Sweat J. Chain of e-vents. Inf Week 1999;(745):18–9 (July 26).

Gillett P. Automated dynamic audit programme tailoring: an expert system approach. Auditing: J Pract Theory 1993;12:173–93 (Audit Judgment Symposium Supplement).

Goodhue DL, Thompson RL. Task-technology fit and individual performance. MIS Q 1995;19(2):213–37 (June).

Goodhue DL, Wybo MD, Kirsch LJ. The impact of data integration on the costs and benefits of information systems. MIS Q 1992;16(3):293–312 (September).

Hard NJ, Vanecek MT. The implications of tasks and format on the use of financial information. J Inf Syst 1991;5(2):33–49 (Fall).

Iselin ER. The effects of information load and information diversity on decision quality in a structured decision task. Account Organ Soc 1988;13(2):147–64.

Johnson VE, Kaplan SE. Auditors' decision-aided probability assessments: an analysis of the effects of list length and response format. J Inf Syst 1996;10(2):87–101 (Fall).

Kaplan S. An examination of the effect of presentation format on auditors' expected value judgments. Account Horiz 1988;2(3):90–5 (September).

Kasper GM. A theory of decision support system design for user calibration. Inf Syst Res 1996;7(2):215–32.

Kasper GM, Morris AH. The effect of presentation media on recipient performance in text-based information systems. J Manage Inf Syst 1988;4(4):25–43.

Kida T, Smith JF. The encoding and retrieval of numerical data for decision making in accounting contexts: model development. Account Organ Soc 1995;20(7/8):585–610.

Kim CN, Chung HM, Paradice DB. Inductive modeling of expert decision making in loan evaluation: a decision strategy perspective. Decis Support Syst 1997;21(2):83–98 (October).

Kottermann JE, Remus WE. A study of the relationship between decision model naturalness and performance. MIS Q 1989;13(2):171–81 (June).

Lederer A, Smith GL. Individual differences and decision-making using various levels of aggregation of information. J Manage Inf Syst 1988;5(3):53–69 (Winter).

Leidner DE, Elam JJ. Executive information systems: their impact on executive decision making. J Manage Inf Syst 1993;10(3):139–55 (Winter).

Lenard MJ, Madey GR, Alam P. The design and validation of a hybrid information system for the auditor's going concern decision. J Manage Inf Syst 1998;14(4):219–37.

Liberatore MJ, Titus GJ, Dixon PW. The effects of display formats on information system design. J Manage Inf Syst 1989;5(3):85–99 (Winter).
MacKay DB, Villarreal A. Performance differences in the use of graphic and tabular displays of multivariate data. Decis Sci 1987;18(4):535–46 (Fall).
Mackay JM, Elam JJ. A comparative study of how experts and novices use a decision aid to solve problems in complex knowledge domains. Inf Syst Res 1992;3(2):150–72.
Mackay JM, Barr SH, Kletke MG. An empirical investigation of the effects of decision aids on problem-solving processes. Decis Sci 1992;23(3):648–72 (May).
Magretta J. Fast, global, and entrepreneurial: supply chain management, Hong Kong style. Harv Bus Rev 1998;76(5):103–14 (September–October).
March ST, Smith GF. Design and natural science research on information technology. Decis Support Syst 1995;15:251–66.
Mauldin EG, Ruchala LV. Towards a meta-theory of accounting information systems. Account Organ Soc 1999;24(4):317–31.
McCarthy WE. Accounting information systems: research directions and perspective. J Inf Syst 1987;2(1):29–32 (Fall).
McGrath JE. Groups: interaction and performance. Englewood Cliffs, NJ: Prentice-Hall, 1994.
Mia L, Chenhall RH. The usefulness of management accounting systems, functional differentiation and managerial effectiveness. Account Organ Soc 1994;19(1):1–13.
Minch RP. Application and research areas for hypertext in decision support systems. J Manage Inf Syst 1990;6(3):119–38 (Winter).
Montazemi AR, Wang F. The effects of modes of information presentation on decision-making: a review and meta-analysis. J Manage Inf Syst 1988;5(3):101–27 (Winter).
Montazemi AR, Wang F, Khalid Nainar SM, Bart CK. On the effectiveness of decisional guidance. Decis Support Syst 1996;18(2):181–98 (October).
Nee E. Paper-clip software. Forbes 1997;160(6):240 (September 22).
Newell A, Simon H. Human problem solving. Englewood Cliffs, NJ: Prentice-Hall, 1972.
Payne J, Bettman J, Johnson E. The adaptive decision maker. New York: Cambridge Univ. Press, 1993.
Piturro M. How midsize companies are buying ERP. J Accountancy 1999;188(3):41–8 (September).
Poston R, Grabski S. Accounting information systems research: is it another *QUERTY*? Int J Account Inf Syst 2000;1(1):9–53 (March).
Preston AM, Wright C, Young JJ. Imag(in)ing annual reports. Account Organ Soc 1996;21(1):113–37.
Ramarapu NK, Frolick MN, Wilkes RB, Wetherbe JC. The emergence of hypertext and problem solving: an experimental investigation of accessing and using information from linear versus nonlinear systems. Decis Sci 1997;28(4):825–50 (Fall).
Reneau JH, Grabski SV. A review of research in computer–human interaction and individual differences within a model for research in accounting information systems. J Inf Syst 1987;2(1):33–53 (Fall).
Roy MC, Lerch FJ. Overcoming ineffective mental representations in base-rate problems. Inf Syst Res 1996;7(2):223–47 (June).
Sabherwal R, Grover V. Computer support for strategic decision-making processes: review and analysis. Decis Sci 1989;20(1):54–76 (Winter).
Sachdeva SP. Meta data architecture for data warehousing. DM Rev. Available at http://www.dmreview.com/ (April).
Santhanam R, Sein M. Improving end-user proficiency: effects of conceptual training and nature of interaction. Inf Syst Res 1994;5(4):378–99.
Schick AG, Gordon LA, Haka S. Information overload: a temporal approach. Account Organ Soc 1990;15(3):199–220.
Schulz A, Booth P. The effects of presentation format on the effectiveness and efficiency of auditors' analytical review judgments. Account Finance 1995;35:107–31 (May).
Silver MS. Decisional guidance for computer-based support. MIS Q 1991;15(1):105–33 (March).
Simon HA. Invariants of human behavior. Annu Rev Psychol 1990;41:1–19.
Sonnen D. Spatial information: out of the basement. Intell Enterp 2000;3(2):39–43 (January 20).

Stocks MH, Harrell A. The impact of an increase in accounting information level on the judgment quality of individuals and groups. Account Organ Soc 1995;20(7/8):685–700.

Stocks MH, Tuttle B. An examination of information presentation effects on financial distress predictions. Adv Account Inf Syst 1998;6:107–28.

Stone DN. Assumptions and values in the practice of information systems evaluation. J Inf Syst 1990;4(3):1–17 (Fall).

Stone DN. The joint effects of DSS feedback and users' expectations on decision processes and performance. J Inf Syst 1995;9(1):23–41 (Spring).

Suh KS, Jenkins AM. A comparison of linear keyword and restricted natural language data base interfaces for novice users. Inf Syst Res 1992;3(3):252–72.

Sutton SG. Can we research a field we cannot define? Toward an understanding of the AIS discipline. Adv Account Inf Syst 1992;1:1–13.

Sutton SG. Have we lost the accounting in AIS research? Adv Account Inf Syst 1996;4:1–7.

Sutton SG, Arnold V. Opportunities neglected: foundations for behavioral research in accounting information systems. Adv Account Inf Syst 1995;3:201–23.

Swink M. The influences of user characteristics on performance in a logistics DSS application. Decis Sci 1995;26(4):503–29 (July/August).

Tan JKH, Benbasat I. Processing graphical information: a decomposition taxonomy to match data extraction tasks and graphical representations. J Inf Syst Res 1990;1(4):416–39 (December).

Ting-Peng-Liang, Jones CV. Design of a self-evolving decision support system. J Manage Inf Syst 1987; 4(1):59–82.

Todd P, Benbasat I. An experimental investigation of the impact of computer based decision aids on decision making strategy. Inf Syst Res 1991;2(2):87–115.

Todd P, Benbasat I. The use of information in decision making: an experimental investigation of the impact of computer-based decision aids. MIS Q 1992;16(3):373–94 (September).

Tuttle B, Kershaw R. Information presentation and judgment strategy from a cognitive fit perspective. J Inf Syst 1998;12(1):1–18 (Spring).

Umanath NS, Vessey I. Multiattribute data presentation and human judgment: a cognitive fit perspective. Decis Sci 1994;25(5–6):795–824 (September/December).

Vandnebosch B, Higgins C. Executive support systems and learning: a model and empirical test. J Manage Inf Syst 1995;12(2):99–130 (Fall).

Vandnebosch B, Higgins C. Information acquisition and mental models: an investigation into the relationship between behavior and learning. Inf Syst Res 1996;7(2):198–214 (June).

Vasarhelyi M. Discussion of automated dynamic audit programme tailoring: an expert system approach. Auditing: J Pract Theory 1993;12:173–93 (Audit Judgment Symposium Supplement).

Vessey I. Cognitive fit: a theory-based analysis of the graphs versus tables literature. Decis Sci 1991;22(2):219–40 (Spring).

Wilson EV, Zigurs I. Decisional guidance and end-user display choices. Account Manage Inf Technol 1999;9: 49–75.

Wright WF. Superior loan collectibility judgments given graphical displays. Auditing: J Pract Theory 1995; 14(2):144–54 (Fall).

Yates JF. Judgment and decision making. Englewood Cliffs, NJ: Prentice-Hall, 1990.