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ABSTRACT

Exception management is a critical design function of organizational information systems (IS) whose effectiveness relies, in large part, on end-user decision-making about how to proceed. Because IS increasingly support the underlying business processes of the company, careless mismanagement of IS exceptions pose substantial risks to corporate information and operations. As a step toward better understanding this area of end-user computing, our study develops a theoretical model of end-user decision-making when faced with IS exceptions. Specifically, we apply heuristic-systematic processing theory to identify salient individual-, task-, and exception- related factors that predict when end-users will engage in effortful, more-thorough information processing when encountering an IS exception. The results can aid both managers and system designers in the development of interventions aimed at improving end-user management of IS exceptions.

Keywords (Required)

Software exceptions; Heuristic-systematic processing theory; End-user computing; Information sufficiency

INTRODUCTION

With a primary aim of enhancing workers' productivity, many of today's organizational information systems (IS) are tightly meshed with the company's underlying business processes (Venkatesh 2006). Unfortunately, IS can encounter extraordinary information processing situations that cannot be handled routinely by the system (Perry, Romanovsky, and Tripathi 2000). These exception conditions often require some form of end-user intervention (Wirfs-Brock 2006) creating a context in which end-user decision-making can substantially influence organizational information quality and business process execution. Given the increasingly tight relationship between organizational IS and underlying business processes, exception conditions can pose substantial risk to the effectiveness of the system and operations overall. Careless end-user decisions and insufficient information processing when managing IS exceptions can result in lost or corrupted information, lost time and money. Hence, end-user management of IS exceptions increasingly becomes an important managerial issue.

Despite its importance, surprisingly little IS research examines why end-users respond differently to similar IS exceptions. Instead, much of the existing literature addresses the technical attributes of exception management and managing communications with the end-user (e.g., Wirfs-Brock 2006; Amer and Marris 2007). Although producing an informative exception message may be necessary, anecdotal evidence suggest that end-users tend to view exception messages as irritating--something to get rid of as quickly as possible (McMillan 2008). These users tend to respond mechanically to IS exceptions, even in high risk situations --"they click 'OK' and hope it will disappear" (Sharek, Swofford and Wogalter 2008).

In response, we attempt to further the literature on human-computer interaction, particularly with respect to IS exceptions, by developing and testing a theoretical model of end-users' information processing when managing IS exceptions. Rooted in the heuristic-systematic model of information processing (HSM) (Chaiken, 1987), our model positions information sufficiency as the central underlying mechanism driving end-user information processing in this context. In addition, we identify and empirically confirm the roles of salient individual-, task-, and exception-related factors that motivate the end-user to carefully and systematically process exception-related information when managing these situations. The results hold important implications for a number of organizational initiatives including computer training and exception message design. Overall, this study seeks to answer the following specific research questions:

RQ1: What are the underlying mechanisms involved in the decision about how to respond to an IS exception condition?

RQ2: How do individual-, task-, and exception-related factors influence the end-user's decision about how to respond to an IS exception conditions?

THEORETICAL BACKGROUND

On each page, HSM belongs to a collection of dual-process, persuasion-based models that examine information processing as an antecedent to judgment formation (Trumbo 1999). HSM asserts that individuals engage in two distinct information-processing modes when forming a judgment: systematic processing and heuristic processing (Chaiken et al. 1989; Chen et al. 2000). Systematic processing is an information intensive and analytically-oriented approach whereby the individual accesses and scrutinizes various information sources for relevance and importance to the judgment task, and integrating relevant information into the subsequent judgment (Chen and Chaiken 1999). Heuristic processing on the other hand can be viewed as a limited processing mode demanding much less cognitive effort, whereby the decision-maker focuses on a subset of available information referred to as heuristic cues (Chaiken et al. 1989). Because heuristic processing involves the use of simple decision rules to formulate judgments, it does not carry the cognitive burden of systematic processing; however, it carries higher potential for an inaccurate judgment.

Generally speaking, efficient information processors seek to strike a balance between minimizing processing efforts and maximizing judgmental confidence (Maheswaran and Chaiken 1991). Because systematic processing is the more effortful alternative, it will only occur when the decision-maker possesses adequate levels of motivation for doing so (Chaiken 1987; Zuckerman and Chaiken 1998). Motivation here is tied to whether or not the enough information has been processed to form a likely-accurate judgment. Specifically, the sufficiency principle posits that with any given judgment, a continuum of confidence exists along which two critical points lie. The first point reflects the decision maker's level of confidence that is presently experienced in his/her ability to make a correct judgment (Maheswaran and Chaiken 1991). The second point reflects the decision maker's desired level of confidence in his/her judgment, based on the information currently held, referred to as the sufficiency threshold (Chen, Shechter, and Chaiken 1996). Information sufficiency then, is the difference between the amount of information an individual thinks he/she needs to make a decision (sufficiency threshold) and the amount of information currently held (Trumbo 1999).

Motivation to obtain additional information increases when information sufficiency is not achieved (Trumbo 2006). Under these circumstances, individuals will exert additional cognitive effort in order to close the gap between actual and desired confidence levels (Chen et al. 1996). Information processing stops once the individual's actual confidence meets or exceeds the sufficiency threshold (Maheswaran and Chaiken 1991).

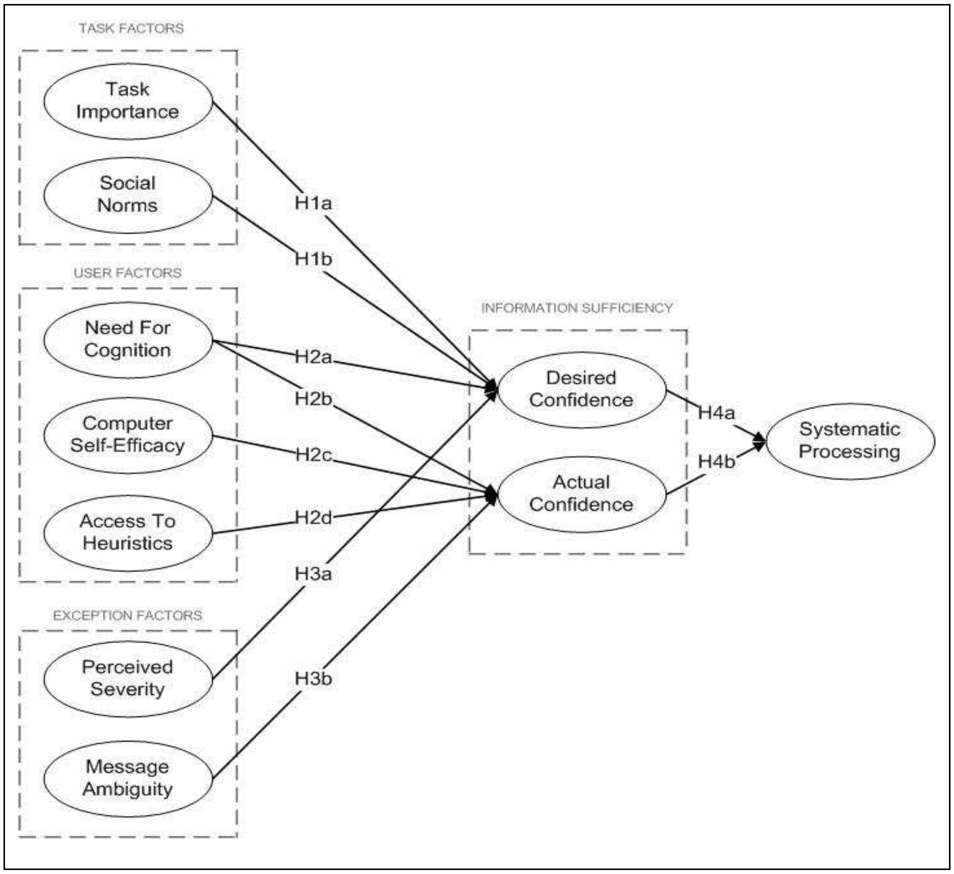

Figure 1: Research Model

HST and IS Exception Messages

Consistent with HSM, when actual confidence falls short of the sufficiency threshold, the end-user will engage in systematic processing, carefully and thoroughly processing additional relevant exception-related information. Systematic processing in this context includes accessing the computer's help function, using search engines such as Google to process new information about the exception condition, and/or re-reading the error message to ensure more complete understanding of the situation. Additionally, any factor which decreases actual confidence or increases the sufficiency threshold will indirectly motivate systematic information processing by reducing information sufficiency.

Task Factors

One factor that should play a role is task importance. If responding incorrectly to an IS exception endangers the ability of the system to complete an important computing task, the end-user should require relatively more information before achieving adequate confidence about how to proceed (Maheswaran and Chaiken 1991; Chen and Chaiken 1999). To the extent that a specific computing task undertaken by the end-user is important to system functionality, it should directly increase the end-user's sufficiency threshold.

H1a: Perceived task importance increases the end-user's sufficiency threshold.

Perceptions about social norms can also motivate decision-makers to express attitudes which satisfy interpersonal goals, such as the desire to get along with others (Zuckerman and Chaiken 1998). Generally speaking, to the extent that one perceives consequential social implications associated with an incorrect judgment, motivation is heightened (Zuckerman and Chaiken 1998). Such norms become part of managing IS exceptions because they influence the standard for successful end-user management of situations where success is uncertain. When people who are important to the end-user believe that he/she should know exactly what to do about an error message before proceeding, one expects the end-user to maintain a higher sufficiency threshold.

H1b: Social norms are positively related to the end-user's sufficiency threshold.

Individual End-user Factors

Need for cognition is generally tied to an individual's desire to think deeply and understand an issue (Wood and Swait 2002). We propose that this additional processing will heighten the individual's perception of possible negative consequences, thus increasing the sufficiency threshold. At the same time, the end-user should think more deeply about the difficulties they may encounter trying to correct the problem. This will negatively impact actual confidence in one's ability to solve the problem without more information.

H2a: Need for cognition is positively associated with the end-user's sufficiency threshold.

H2b: Need for cognition is negatively associated with actual confidence.

Another end-user factor that should drive end-user management of IS exceptions is computer self-efficacy (Compeau and Higgins 1995). Higher levels of computer self-efficacy are associated with higher levels of confidence in working with an IS, lower computer anxiety and more positive attitudes about IS in general (Durndell and Haagb 2002). Moreover, past work identifies self-efficacy as a primary driver of systematic information; specifically, "systematic processing is a more demanding activity, and thus will more likely be used in situations wherein the individual feels most efficacious" (Trumbo 1999).

H2c: Computer self-efficacy is positively associated with actual confidence.

Somewhat related to computer self-efficacy is access to heuristics. The more access to exception-related heuristics that is possessed by the end-user, the more likely he/she will feel confident about how to proceed (Chen et al. 2000). For instance, one heuristic that some end-users develop through experience that is applicable to end-user computing is to reboot the computer. In this case, past experience and knowledge using this approach to solve computer problems should influence whether the end-user believes he/she can solve the problem with what is already known.

H2d: Past experience and knowledge of heuristics is positively associated with the end-user's actual confidence.

Exception Factors

Exception messages often convey important exception-related information and hence, should influence information sufficiency. Existing literature identifies two broad categories of message characteristics that should affect the end-user's response in this context. The first is related to message clarity and understandability. Message ambiguity, when considered within the context of HSM reduces the end-user's actual confidence in their ability to correctly solve the problem, decreasing information sufficiency.

H3a: Message ambiguity is negatively associated with the end-user's actual confidence.

The second exception factor is what the message communicates about the severity of the exception itself. Severity here relates to the end-user's perceptions regarding the possible negative consequences and risks associated with responding incorrectly to an exception message. Specifically, HSM argues that perceptions of exception severity should increase the end-user's desired level of confidence, thus increasing the sufficiency threshold. Therefore, we expect an end-user to be more concerned about solving a severe problem than a trivial problem.

H3b: Message severity is positively associated with the end-user's sufficiency threshold.

In the context of end-users management of IS exceptions, the sufficiency principle posits that information sufficiency—actual confidence in knowing how to proceed versus the sufficiency threshold—will determine end-user behavior. Specifically, if actual confidence is less than the sufficiency threshold, the end-user will engage in seeking additional information before determining how to respond to the exception condition. Stated alternatively, actual confidence should be negatively related to systematic processing and the sufficiency threshold should be positively related to systematic processing.

H4a: The end-user's sufficiency threshold is positively associated with systematic information processing.

H4b: The end-user's actual confidence is negatively associated with systematic information processing.

METHOD AND RESULTS

Study Context and Sample

The research was tested using a survey instrument focused on the context of Microsoft Excel exceptions. Given Microsoft Excel's significant presence on desktop computers and its dominance in the market, we deemed exceptions generated by this software to be representative of those a typical computer end-user might find while using spreadsheet software. The respondents were undergraduate business administration students enrolled at a major university in the Eastern United States. Each of the students had successfully completed hands-on training with Microsoft Excel in an introductory MIS course for business students and regularly used Excel in their coursework. The course provided each student the same level of training on using Excel to solve business problems. While the participants in this study do represent a convenience sample, the sample comprises future business professionals with substantial training in Microsoft Excel 2007. Overall, 71 students were invited to participate in the study by going to an on-line survey site (http://qualtrics.com) outside of class, in exchange for 3 points extra credit on a homework assignment. 61 usable responses were received for a response rate of 85.9 percent.

Survey Design

The survey instrument was designed by first selecting specific instances of exception-related information from among the comprehensive set of exceptions produced by Microsoft Excel 2007, as cataloged in the Microsoft Excel 2007 Solution Center available at the Microsoft support site. We determined that this online resource provides the most comprehensive list of exceptions incurred while using Microsoft Excel 2007. In addition, the Solution Center's documentation of each exception includes the exception message as well as the computing operation leading to the exception.

After establishing the master list of exceptions, the list was filtered to remove exceptions related to installation of the software, opening a spreadsheet document, and/or saving changes to a document. We then reduced the number to 10 by selecting every 20th exception after beginning at a random point. For the pretesting phase, we enlisted the help of 18 regular end-users of Microsoft Excel to rate the perceived risk of each exception using a seven-point Likert style scale anchored by Very Low Risk and Very High Risk along five dimensions—unrecoverable data changes; inability to execute important actions; possibility of software corruption; possibility of hardware corruption; and inability to correct the exception. The results indicated that each exception was perceived as moderately severe, as indicated by average ratings along each dimension of greater than 3.0. From this list, we then chose four exceptions which occur while accomplishing specific spreadsheet tasks that, in our judgment, end-users in a typical office environment would be likely to perform—starting the application; working with ranges of data; and saving changes. All of these steps were conducted to ensure practically significant results.

Each participant in the final sample evaluated all four exception conditions. Because four exceptions were included in the survey, exception-specific variables were measured four times per participant, once for each distinct exception. To arrive at a single measure for each of the exception-specific constructs, individual measurement items were averaged across the four exception scenarios to develop a single, mean-score value for each item. Figure 2 below presents each of the four exceptions evaluated by the participants.

Message 1: Assume that you start Microsoft Excel and receive the following error message:

Your system is low on virtual memory. To ensure that Windows runs properly, increase the size of you virtual memory paging file.

Message 2: Assume that you attempt to save a Microsoft Excel workbook and receive the following error message:

Excel cannot complete this task with the available resources. Choose less data or close other applications.

Message 3: Assume that you try to sort a range in a Microsoft Excel worksheet but Excel does not sort the range. Instead, you receive the following error message:

This operation requires the merged cells to be identically sized.

Message 4: Assume that you try to hide columns of data in Microsoft Excel and receive the following error message:

Cannot shift objects off sheet.

Note: For each exception message above, scales for Message Ambiguity, Task Importance, Exception Severity, Actual Confidence, Sufficiency Threshold, and Systematic Information Processing were captured.

Figure 2: Exception Scenarios Presented to Each Participant

Data Analysis and Results

Consistent with the theory-building nature of the study, the data were analyzed using partial least squares (PLS) estimation as applied in the software package SmartPLS version 2.0.M3 (Ringle et al. 2005). PLS uses regression-based techniques to analyze structural models with multi-item latent constructs (Chin 1998; Gefen et al. 2000). The PLS algorithm used to analyze the data in the present study requires at least 5 times as many data points as the number of paths leading to the construct with the most incoming paths (Falk and Miller 1992). The data used to empirically test the conceptual model of the present study meet this requirement.

The measurement model was first assessed by examining factor loadings for each item on its intended construct (table 1). Although many of the scales were well-known and previously validated, the confirmatory factor analysis results indicated that the measurement quality of some variables would increase by eliminating a number of individual items. Subsequently we deleted items with factor loadings less than 0.4 (Nunnally 1978).

CONSTRUCT	LOADING	ITEM
Access To Heuristics	0.6948	When working with computers, there are simple workarounds for most problems.
	0.2458	***Most computer errors can be solved without knowing too much about the technical issues.***
	0.1464	***Even if I don't know what a computer error message means, I still can usually get around the problem.***
	0.4652	I ignore most error messages on the computer and just get around the problem myself.
	0.0969	***If I don't completely understand an error message, I try to find out what it means before proceeding.***
Computer Self-Efficacy *(Compeau and Higgins 1995)*		***I could use the software package...***
	0.1885	***…if there were someone giving me step by step instructions.***
	0.4370	…if there were no one around to tell me what to do as I go.
	0.2266	***…if I had only the manuals for reference.***
	0.0604	***…if I had seen someone else doing the task before trying it myself.***

	0.8060	…if I could call someone for help if I got stuck.
	0.7493	…if someone else had helped me get started.
	0.4526	…if I had a lot of time to complete the task.
	-0.1128	***....if I had only the built-in help facility for assistance.***
	0.5718	…if someone showed me how to do it first.
	0.5959	…if I had used a similar system before to do the same task.
Actual Confidence	0.8300	I am very confident that I know what to do about this error message.
	0.819	I am sure what I am to do about this error message.
	0.9305	After getting this error message, I am confident that I know enough to proceed.
Message Ambiguity	0.9295	The information in this error message can be interpreted in several ways.
	0.8464	The information in this error message may mean different things to different people.
	-0.2041	***This error message is clear and unambiguous.***
Sufficiency Threshold	0.6371	I need to be very confident that I know what to do about this error message.
	0.7921	This error message makes me want to be sure what I should do.
	0.7598	Unless I feel that I know what I am doing about this error message, I should not proceed.
Perceived Message Severity	0.9427	I believe this error poses a substantial risk.
	0.8367	I believe negative consequences are possible from this error.
	0.8635	I believe that this error presents a threat.
Systematic Information Processing		***Upon receipt of the error message, I would…***
	0.6018	…consult the Excel spreadsheet help function.
	0.5513	…go to the Microsoft online documentation and look up this error.
	0.4942	…Google the error message for more information.
	0.5392	…ask a coworker for advice.
	0.4175	…read and re-read if necessary the complete error message.
	0.4564	…call technical support at the company where I work.
Task Importance	0.9661	The task being performed which led to the error message is important to having a workable spreadsheet.
Need for Cognition (Wood and Swait 2002)	0.5026	I would rather do something that requires little thought than something that is sure to challenge my thinking abilities.
	0.4919	I try to anticipate and avoid situations where there is likely chance I will have to think in depth about something.
	0.5383	I only think as hard as I have to.
	0.4554	The idea of relying on thought to make my way to the top appeals to me.
	0.4003	The notion of thinking abstractly is appealing to me.
Social Norm (Feishbein and Ajzen 1980)	0.5837	People in my organization who are important to me believe that I should know what to do about an error message before proceeding.
	0.4923	People in my organization who are important to me believe that the way someone responds to an error message is important.
	0.1312	***People in my organization who are important to me do not care what I do about an error message.***
	0.6604	The norm in my organization is to know what to do about an error message before proceeding.

Table 1: Measurement Items and Factor Loadings

Using the retained items, reliability of each construct was assessed by examining the composite reliability scores. Discriminant validity was then assessed by determining whether the square root of the average variance extracted (AVE) for each latent construct is larger than the inter-construct correlations (Chin 1998). The results (table 2) indicated good reliability and discriminant validity of the measurement items.

Construct	Composite Reliability	ATH	ACTUAL	CSE	THRESH	EQUIV	NFC	SEVERITY	SUBJ_ NORM	SYSTEM-ATIC	TASK_ IMP
ATH	0.674	***0.716***									
ACTUAL	0.973	0.278	***0.960***								
CSE	0.763	-0.187	-0.301	***0.687***							
THRESH	0.905	-0.086	-0.112	-0.004	***0.873***						
AMBIG	0.898	0.120	-0.479	0.171	0.007	***0.903***					
NFC	0.808	-0.144	-0.075	-0.045	-0.227	0.063	***0.685***				
SEVERITY	0.956	0.059	-0.303	0.114	0.378	0.411	0.115	***0.938***			
SUBJ_NORM	0.846	0.081	0.088	-0.048	0.356	0.061	-0.284	0.072	***0.767***		
SYSTEMATIC	0.877	0.023	-0.397	0.213	0.465	0.400	-0.106	0.519	0.350	***0.741***	
TASK_IMP	1.000	-0.205	-0.084	0.069	0.411	-0.060	-0.307	0.006	-0.054	0.034	***1.000***

Notes: Highlighted values along the diagonal represent square root of AVE for the construct.
ATH=Access To Heuristics; ACTUAL=Actual Confidence; CSE=Computer Self Efficacy; THRESH=Sufficiency Theshold; AMBIG=Message Ambiguity; NFC=Need for Cognition; SEVERITY=Message Severity; SUBJ_NORM=Subjective Norm; SYSTEMATIC=Systematic Information Processing; TASK_IMP=Task Importance

Table 2: Reliability and Discriminant Validity Testing Results

Evaluation of the structural model was assessed based on the significance of path coefficients between the constructs and R^2 values obtained for the dependent variables (Gefen et al. 2000). Overall, task factors and exception factors account for 43.6 percent of the variance in end-users' sufficiency thresholds. Likewise, end-user factors and exception factors account for 36.7 percent of actual confidence levels. Finally actual confidence and the sufficiency threshold together explain 34.5 percent of variance in end-users' systematic-processing reactions.

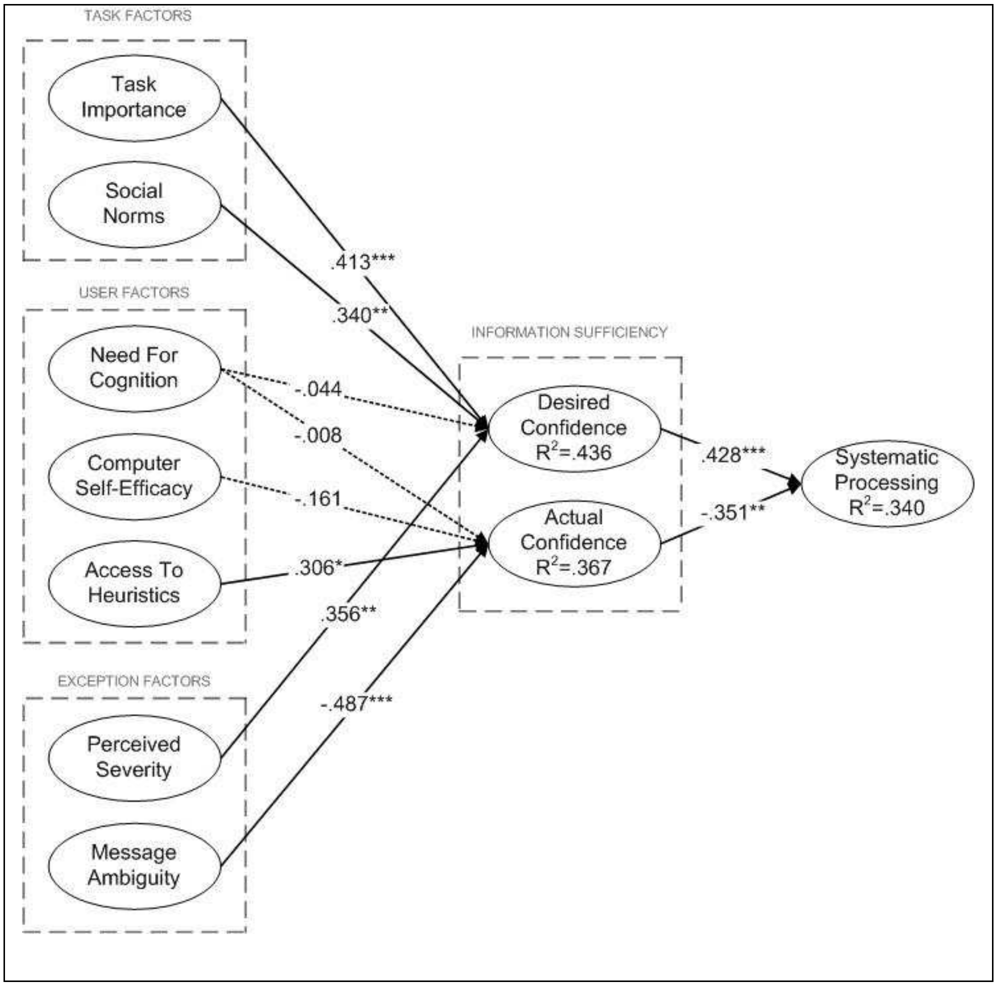

Figure 3: Structural Model Results

Task factors strongly influence information sufficiency by increasing the sufficiency threshold. The coefficient on Task Importance is 0.413 ($p < .001$) and the coefficient on Social Norms is 0.340 ($p < 0.01$) indicating that, as task importance (H1a) and social expectations (H1b) increase, participants required more information to achieve adequate confidence about how to manage the exceptions. Need for Cognition is not associated with either desired or actual confidence such that H2a is not supported by the model. Likewise, Computer Self-Efficacy is not associated with actual confidence (H2b). However, H2c, which predicts that Access to Heuristics will increase actual confidence, is supported (β=0.306, $p < 0.05$). Both the exception related factors bear significant influence information sufficiency as predicted by H3. Specifically, Perceived Severity of the exception (H3a) increases the sufficiency threshold (β=0.356, $p < 0.01$) and Message Ambiguity (H3b) reduces the actual confidence experienced by the participants (β =-0.487, $p < 0.001$). Finally, the data confirm that the components of information sufficiency—actual confidence (β=-0.333, $p < 0.01$) and the end-user's sufficiency threshold (β=0.401, $p < 0.001$)—can drive systematic information processing when faced with an IS exception as predicted by H4.

DISCUSSION

The effect of social norms on the sufficiency threshold (and ultimately systematic information processing) holds important implications for managers seeking to improve end-user management of IS exceptions. Specifically, the relationship highlights the role of organizational climate and the attitudes of other organizational members, in the end-user's decision to put effort into managing IS exceptions. By simply communicating the risk of IS exceptions to the underlying business processes and stating the importance of carefully responding to these situations, managers can work to develop a climate that emphasizes cautious end-user behavior. With a multitude of resources available today for more-deeply investigating the nature of a software exception message, end-users should be encouraged to take the time to leverage the best channels for successfully managing this area of IS risk.

The significant effects of message ambiguity, task importance, and perceived risk highlight three important areas that system designers can focus on to develop more effective hazard communications with the end-user base. While conventional wisdom might suggest that "dumbing down" exception messages will motivate end-users to carefully respond, HSM and the results of this study suggest that the opposite may actually be true. Specifically, the significant effect of message ambiguity on information sufficiency indicates that the ambiguous "techno-speak" may actually drive desired systematic information processing. Future research is warranted to investigate this possibility. Moreover, the results of this study identify two under-addressed aspects of exception conditions that drive end-users' effortful information processing and careful management of IS exceptions—task importance and the perceived severity of the exception. The results of this study suggest that by communicating the impact of the task on the functionality of the IS and the overall severity of the exception in general, system designers can promote more desired end-user behavior when managing the unexpected situation.

For researchers, this study is an initial attempt to apply HSM to the IS exception context in order to understand how and why end-users respond in the way they do. Future studies are encouraged to apply HSM to other IS areas in order to explain the mechanisms that underlie decision making. Furthermore, this is one of only a few studies in IS that focuses on the critical area of IS exceptions. Despite the criticality of this component in almost every system in the organization, researchers are just beginning to examine the dynamics of human computer interaction within this context. This study should serve as a step in the direction of deeper investigation of end-user decision making in the IS exception context.

LIMITATIONS

Certain limitations should be considered while interpreting the results of the present study. First, this study used a small subset of the all possible exception conditions. While several steps were taken to ensure that the subset is representative, both in terms of the system (Microsoft Excel) and the task giving rise to the exception condition, the results should be generalized with caution. Furthermore, while the students that participated in this study were frequent computer users with experience using Microsoft Excel to accomplish business problems, generalizing these results to working professionals in other organizational contexts should also be done with some caution.

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