NORTHERN ARIZONA UNIVERSITY
The W. A. Franke College of Business

Toward Iconic-Based Information Technology and Application Control Exception Messages

Working Paper Series—07-09 | September 2007

Corresponding Author, T.S. Amer
Professor
(928) 523-7370
FAX (928) 523-7331
tsamer@nau.edu

and

Jo-Mae B. Maris
Associate Professor
(928) 523-7403
(928) 523-7331 Fax
jomae.maris@nau.edu

Professors at
Northern Arizona University
The W. A. Franke College of Business
Flagstaff, AZ 86011-5066

August 2007

Toward Iconic-Based Information Technology and Application Control Exception Messages

I. Introduction

Users of information technology (IT) commonly encounter exception messages during their interactions with application programs. Exception messages, sometimes referred to as "dialogs," appear over the main window of the parent application program and engage the user by offering information and requesting some input (Cooper and Reimann 2003). When the user has finished viewing or changing the information presented, he has the option of accepting or rejecting his changes. The exception message then disappears and returns the user to the main application program.

Exception messages are an important element in accounting application controls. Accounting application controls deal with exposures within specific computer application programs such as payroll, sales processing, and cash disbursements (Hall 2006; Weber 1999). For instance, validation input controls are intended to detect errors in transaction data before the data are processed by the system. An example of this type of control is a missing data check whereby the computer application examines the contents of data input for blank spaces or empty fields. When the program detects a blank during data entry where it expects data, an exception message is displayed warning the data input clerk that data is missing. Program execution is halted until the user corrects the error.

Exception messages are similar in purpose to the warning messages that appear on consumer products and equipment (e.g., cigarettes, power tools, etc.), in various work environments (e.g., around machinery), and on chemicals. Warnings, like exception messages, are designed to inform people of problems or actions required to be taken. For example, warnings appear on household cleaners and ladders to inform the user of a problem if the item is used inappropriately. Likewise, warnings appear in various environments to notify and advise people in the correct use of equipment and of potential hazards. A significant amount of research examining the content of warnings has been carried out by human factors psychologists to determine the effect on human perceptions, judgment and decision making (see Wogalter 2006a). In addition, the American National Standards Institute (ANSI) and the International Standards Organization (ISO) have focused attention on the content of warning messages (see Miller and Parent 2006 for a bibliography of standards). A result of both research and the standard setting process is a set of normative guidelines specifying the elements and information that should be included in warning messages. Including these elements improves the informativeness of these messages.

In contrast, very little guidance is offered in the academic and professional IT literature as to the form and content of exception messages (Amer and Maris, forthcoming and Amer and Maris 2007). Accordingly, there are two objectives of the current research. First, to review the normative elements and information that are included in product, chemical, and environment warnings and to propose that these elements and information should also be included in IT exception messages. Including these elements will increase the effectiveness, informativeness, and consistency of exception messages. A second objective of this manuscript is to report the results of an experiment carried out to determine if IT and application control exception messages designed to conform to the normative elements improves user interactions. Specifically, we focus on the inclusion of descriptive icons in the body of exception messages. These descriptive icons are a key element in warning messages and provide information as to the nature of the hazard facing the user. The results of the experiment confirm that when users interact with exception messages incorporating descriptive icons, their behavioral compliance with the exception message significantly increases.

Taken together, the proposal set forth in this manuscript and the results of the experiment can aid systems designers by providing guidance as to how to overcome limitations in the user interface with respect to exception messages. This study contributes to both the academic literature and practice. On the academic side, it extends the IT and accounting literature on the effectiveness of exception messages. In addition, the study reported herein established experimental controls to address the mixed results of similar research in the human factors literature. As for practice, the proposal establishes workable prescriptions for the design of exception messages in all user interfaces. Indeed, the prescriptions articulated are applicable to exception messages in all environments, regardless of computing platform.

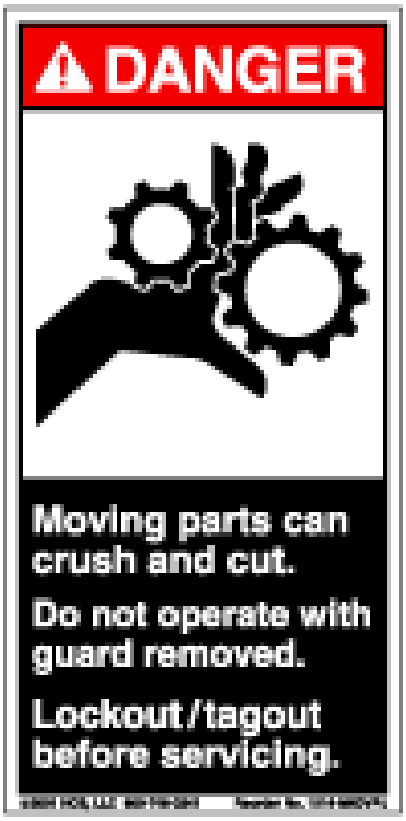
The next section of this manuscript outlines the normative guidelines set forth by human factors psychologists for the elements to be included in the warnings for consumer products and equipment, and proposes that these elements also be included in IT and application control exception messages. The sections that follow discuss the theoretical predictions and the experiment carried out to evaluate the effectiveness of including a key

element, descriptive icons, in exception messages. The final section highlights the results and discusses the implications for research and practice.

II. Well Designed Warnings – An Application To It And Application Control Exception Messages

Two examples of product and environmental warnings are shown in Figure 1. The warnings literature and standards suggests that a well-designed warning should contain two key sections or "panels:" a signal word panel and a message panel (Wogalter 2006b, Wogalter et al. 2002). The two warnings of Figure 1 each possess these two panels and each panel has a specific purpose or function.

Figure 1. Examples of Warnings used in Work Environments



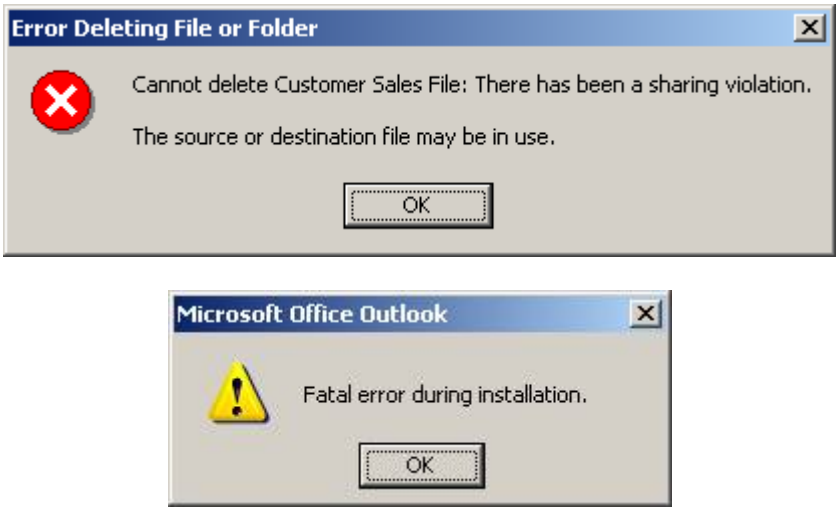
The purpose of the signal word in the upper panel is to draw attention of the user and to express a level of hazard or probability of injury associated with the environment or situation. The signal word panel itself is to contain three elements: (1) a signal word, (2) color coding, and (3), a signal icon. Note that the signal word in the first warning of Figure 1 is "DANGER" and in the second, "WARNING." The color coding in the frame around the signal word is red in the first message, and orange in the second. Finally, both warnings in Figure 1 contain the signal icon in the form of an exclamation point contained in a triangle. Research findings in the warnings literature and the American National Standards Institute (ANSI 2002) have identified suitable sets of signal words and signal icons to be included in this panel of a warning.

The purpose of the message panel is to convey specific information about the hazard or situation. This information can be expressed using written language, using icons or by using both language and icons. Both the warnings in Figure 1 contain an icon and written language. The icons and/or language of the message panel should communicate three informational elements: (1) identification of the hazard, (2) explanation of the consequences of the hazard, and (3) directions as to how to avoid the hazard.

The three informational items in the message panel should be as explicit and as complete as possible. Consider the first warning of Figure 1. The hazard is specifically noted as "Moving parts…" The consequence of the hazard is illustrated by the mangling of the hand in the symbol as well as by the language in the panel: "…can crush and cut." Finally, the language also provides directions on how to avoid the hazard: "Do not operate with guard removed" and "Lockout/tagout before servicing."

Taken together, the elements of a well-designed warning would seem to be very appropriate for IT exception messages. An examination of the two actual IT exception messages of Figure 2 shows deficiencies relative to the prescriptions described above for warnings. Indeed, the second exception message of Figure 2 is especially lacking in information content. Of course not all IT exception messages are deficient but as will be noted below, Amer and Maris (2007) provided preliminary evidence that a large percentage of exception messages are deficient in their ability to inform the user. This is, perhaps, not surprising given the lack of prescriptive guidance in both the academic and professional IT guidelines as to the content of exception messages.

Figure 2. Examples of IT Exception Messages



Guidance in the IT Literature

On the academic side, Amer and Maris (forthcoming) examined and measured the "arousal strength" (i.e., the perceived severity of hazard a warning communicates) of the common signal words and signal icons used in IT exception messages. The data captured allows exception messages to be designed to communicate different levels of hazard in order to achieve so called "hazard matching." Hazard matching occurs when the severity of the hazard that is implied by the signal word and icon within the exception message matches the level of hazard faced by the user. One objective of their research was to provide system designers with data that will allow them to improve the informativeness of exception messages by achieving hazard matching.

The professional literature and researchers in human computer interaction (HCI) offer limited guidance as to the content of exception messages. Apple Corporation (1989) notes that some icons that appear in exception

messages have “standard accepted uses” (p.115). These icons are “right and left arrows, return arrow, About box balloon, check box, radio button, and the house icon” (p.115). However, only ambiguous advice is given as to how these elements should be used: “Any button in one of these shapes must conform to the expected use, or users will be confused” (p.115). Little is offered with respect to the informational content of exception messages.

Microsoft, in ***The Official Guidelines for User Interface Developers and Designers*** (***UI Guidelines:*** Windows XP Design Team 2001) contains more specific guidance for the components of what they term “message boxes.” The UI Guidelines provide recommendations for the following components of message boxes: (1) title bar text, (2) use of icons, and (3) message box text. The general view of the Microsoft UI Guidelines is that the title bar identifies the source of the message, the icon identifies the type of message, and the text presents the message.

Cooper and Reimann (2003) believe that error-type exception messages are abused by systems programmers and should be eliminated if possible. If they are to be used, Cooper and Reimann offer some guidance on key design features such as including a title bar, minimizing the size of the message window, and offering terminating commands. With respect to error messages, Cooper and Reimann advise that a well-formed message should be polite, illuminating, and helpful. In addition, they indicate that an error message should give the user the information he needs to solve the problem, make clear the scope of the problem, the alternatives available, and offer to take care of the problem. This advice corresponds to that noted above by warnings researchers who specify that the message panel of a warning should communicate: (1) the identification of the hazard, (2) an explanation of the consequences of the hazard, and (3) directions as to how to avoid the hazard.

Shneidermann and Plaisant (2005) note that exception messages should provide informative feedback. In addition, error messages should offer specific information about the nature of the problem, and indicate what the user needs to do. Error messages should also provide simple, constructive, and specific instructions for error recovery. As with Cooper and Reimann (2003), the recommendations of Shneiderman and Plaisant align with that of the researchers in warnings.

Proposed Elements of Effective Exception Messages

Combining the guidelines established in the warnings literature with the recommendations provided by the IT authors Cooper and Reimann and Shneiderman and Plaisant leads to a set of normative elements that, arguably, should be possessed by IT exception messages. The following five elements are proposed:

1. **Signal word and/or Icon:** An exception message should include an appropriate signal word and/or icon to catch the attention of the user. The signal word/icon combination should arouse the user to a level that matches the nature of the underlying hazard.
2. **Hazard Information** (illuminate the problem): An exception message should inform the user what the problem is.
3. **Instructions**: An exception message should instruct the user about what to do or not do.
4. **Consequences** (alternatives): An exception message should inform the user as to what will result from all actions taken or from inaction.
5. **Offer a Solution**: An exception message should offer to implement at least one solution itself, without requiring the user to take unreasonable action.

It seems reasonable that IT and application control exception messages should contain all the above elements to improve their informativeness, consistency, and effectiveness. Establishing such standards for the form and content of exception messages is consistent with the views expressed in the academic and professional literature in IT. Blackwell and Green (2003) note that presenting similar information in different ways compromises usability. Shneiderman and Plaisant (2005) state the need for consistency, conventions, and guidelines in the design of interfaces in general, and for effective exception messages in particular. The first of their eight “golden rules” of interface design is “strive for consistency.” Likewise, consistency and standards in interface design are noted by Cooper and Reimann (2003).

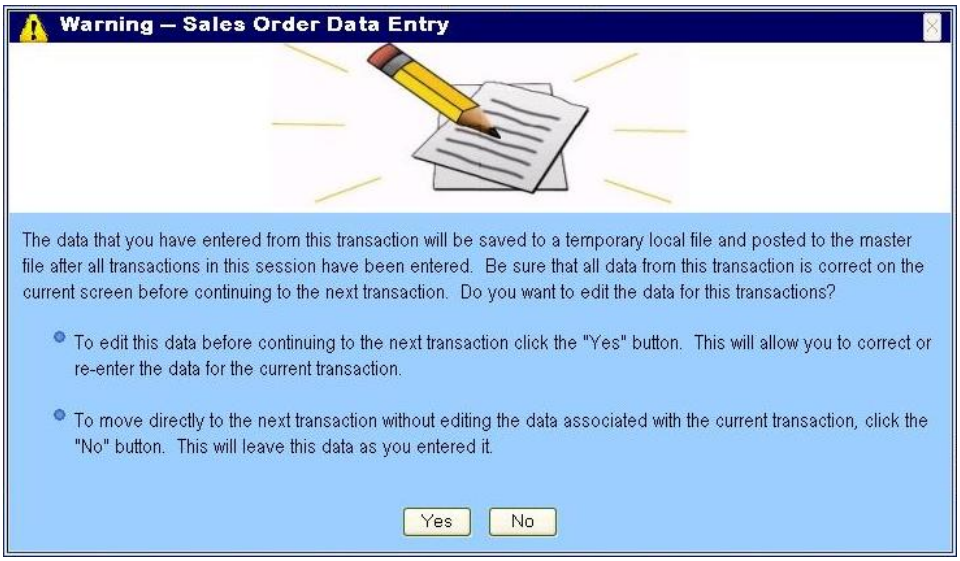
Amer and Maris (2007) discovered that very few messages contain the informational elements proposed above. Their data also reveals considerable variations in content. They collected a sample of exception messages over a two month period during normal computing interactions. Approximately 83% of the exception messages contained a signal word and/or signal icon, and 81% contained information regarding hazard information. However, only 23% of the messages listed the consequences of what will happen or not happen as a result of actions taken by the user, and just 24% offered any sort of a solution. Less than 6% contained all five elements.[1]

Compliant IT and Application Control Exception Messages

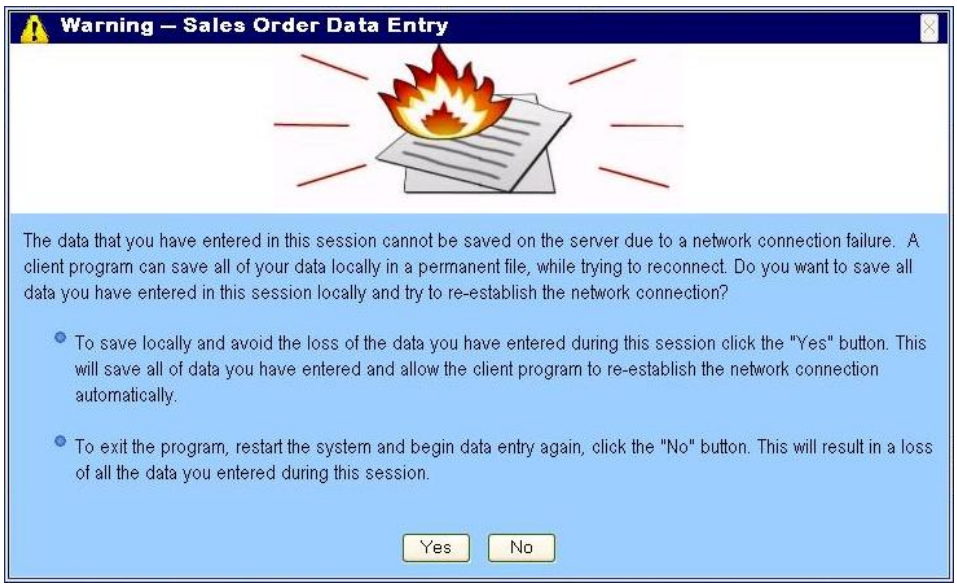
Incorporating the above proposed elements to exception messages could be accomplished relatively easily in IT environments when compared to other situations (e.g., consumer product warning labels) given the ability to easily alter the display of information on a computer screen. Consider mock ups of two exception messages illustrated in Figure 3. The first, an "edit-request" exception message, could be displayed when prompting a user to review the data just entered in a data input screen prior to submitting the data for processing. The second, a "network connection failure" exception message, could be used to communicate to a user that data may be lost due to a network connection failure. The format and contents of both exception messages comply with the proposal above and contain a signal word panel and message panel. In addition, both messages contain the five informational elements set forth earlier in this manuscript: (1) Signal word and Icon, (2) Hazard Information, (3) Instructions, (4) Consequences, and (5) Offer a Solution.[2]

Figure 3. Examples of Iconic-Based Exception Messages Compliant with the Proposed Informational Elements

a. Edit-Request Exception Message:



b. Network Connection Failure Exception Message:



Of special note are the iconic representations in each exception message. Both icons provide a visual representation of the situation faced by the user. In the edit-request message of Figure 3a. the iconic representation of the pencil and paper indicates that the user has the opportunity to rewrite the data before submitting it for processing. In the network connection failure message of Figure 3b. the flames provide a vivid indication as to the hazard faced by the user (loss of data) as a result of the failure of the network connection. These icons were created to reasonably comply with the paper paradigm within the Xerox PARC (Palo Alto Research Center) desktop metaphor. The desktop metaphor is the primary operating system concept used by most computing applications in the fields of business and accounting and is comprised of text on a white background (paper), files within folders, and a "desktop."[3]

Note that the iconic representations included in these example exception messages are qualitatively different than the signal icons that appear in the signal word panel of the messages. Recall that signal icons, the exclamation point in these messages, are intended to arouse the user to a level that matches the nature of the underlying hazard or problem. In contrast, the icons in the message panel of the exception message are purposed to provide information about the hazard or situation faced by the user. While many exception messages include signal icons (approximately 79% in the sample collected by Amer and Maris 2007), only a few include iconic representations that provide information as to the nature of the hazard or situation faced by the user (approximately 13% in the sample collected by Amer and Maris 2007).

At this point it is reasonable to ask: "Will exception messages that comply with the proposal set forth above improve user interactions with IT systems?" If so, then systems designers and programmers can target their efforts to begin improving exception message design by incorporating the proposed elements. To this end, the following section of this manuscript describes an experimental evaluation of this question, with a focus on the inclusion of iconic representations in IT and application control exception messages. The inclusion of icons in exception messages would be the most significant change to the current state of practice, and as such is a key element to consider.

III. Empirical Test Of Effectiveness – Theoretical Predictions And Prior Literature

As noted earlier, a significant amount of research has been carried out by human factors psychologists to determine the effect of various features (e.g., signal words, colors, instructions, etc.) of consumer product and environment warnings on human perceptions, judgment and decision making. A primary objective of this work has been to determine the optimal informational elements and features to include in warnings to enhance their informativeness, resulting in the standards and guidelines referenced in Section II above. One feature of warnings that has received some attention in the literature is the use of iconic representations of hazard information. Such icons are commonly used in warnings and are seen in the examples illustrated in Figure 1.

Iconic Representations – Theoretical Models and Hypotheses

The use of icons in lieu of written words in warnings is prompted by the notion of their "alerting value' whereby they call attention to themselves better than textual material (Wogalter et al. 2006). Because of visual differentiations of shape, size, and color, symbols may be more salient than text. Symbols typically have unique details and possess more differences in appearance than do the letters of the alphabet. Letters also tend to be highly familiar and are more similar to one another than most graphical symbols. Accordingly, using icons should result in better "attention maintenance" (Wogalter and Vigilante 2006) whereby attention to the exception message is maintained long enough for the user to extract meaning from the information contained in the message and act on that information (Amer and Maris forthcoming).

The notion of symbol superiority is also noted by Cooper and Reimann (2003). They list as a design axiom to "[***v***]***isually*** communicate function and behavior (emphasis added)." When possible, the user interface should incorporate visual elements to show the user what the results of their actions will be.

Based upon the increased alerting value of symbols, iconic-based exception messages should result in a higher degree of behavioral compliance than text-based exception messages:

> **H1:** Behavioral compliance to IT exception messages will be higher with iconic-based exception messages than with text-based exception messages.

Warnings literature – Mixed Findings

Some research in the warnings literature has examined the use of symbols and icons in the context of product and environmental hazards to determine the effect on behavioral compliance. The results have been mixed. Schneider (1977), Friedmann (1988), and Wogalter et al. (1993) all found no increase in behavioral compliance associated with warnings that incorporate symbols. In contrast, Otsubo (1988), Jaynes and Boles (1990), and

Thorley et al. (2001) found an increase in behavioral compliance using warnings that incorporated symbols. The reason for the difference in the findings is difficult to determine given the different contextual factors involved with each study and the potential for confounding variables.

For example, Schneider (1977) examined the behavioral compliance of children and their use of household chemicals. Friedmann (1988) examined warning factors in the context of warning labels on household consumer products with college students. Wogalter et al. (1993) found no effect of symbols in a mocked laboratory chemistry experiment using college students. Curiously, Jaynes and Boles (1990) used a similar task as in Wogalter et al. (1993) but found results (perhaps there was a confound with the inclusion of a triangular border in their treatment condition). The participants in Otsubo's (1988) study were required to use power saws. Finally, Thorley et al. (2001) observed student participants' use of classroom doors posted with a warning sign reading **"DEFECTIVE DOORS, PLEASE USE OTHER DOORS."** Thorley et al. note confounds in their experiment in that the familiarity of the surrounding environment and social influence may have affected the results.

IT and Application Control Exception Messages

The case of IT and application control exception messages perhaps provides a better context in which to examine the inclusion of icons. First, relative to consumer product and environmental warnings the IT environment is arguably more controllable in that participants can be guided precisely through the experimental task through sequential and dependent exchanges prompted by a computing program. Most of the interactions can also be measured relatively precisely and timed using keystroke mapping and by reference to an internal clock.

Additionally, in computing environments participants are typically involved in a well defined, tightly focused and constrained task: interaction with a system on a computer screen. Such interactions are relatively tightly focused given that computer screens are small. More importantly, the interaction in computing environments is also constrained due the nature of "blocking" exception messages. In this case the exception message is launched by the program and all processing in the main application is suspended (blocked) until the user responds (Cooper and Reimann 2003). As such, user responses to exception messages requires direct interaction with the system in response to the exception message as opposed to passive response to posted warnings on consumer products. That is, a consumer may simply pick up a chemical bottle and open it without even seeing the warning label. In contrast, an IT user cannot continue with the task at hand until he actively interacts with the exception message.[4]

IV. METHOD

An experiment was carried out to examine the effect of iconic-based exception messages as set forth in hypothesis **H1**. In this experiment, participants were randomly assigned across treatment conditions to determine if exception messages containing icons resulted in a higher degree of behavioral compliance than exception messages containing text. Following Amer and Maris (forthcoming), the participants completed a simple yet relevant accounting data entry task that required the entry of sales order information using an on-line sales order data entry screen. The data entry task was intentionally designed to habituate the participants and thereby desensitize them to repeated exposure to similar exception messages. As noted by Amer and Maris (forthcoming) habituation leads to a lack of attention maintenance (Wogalter and Vigilante 2006) whereby attention to the exception message is ***not*** maintained long enough for the user to extract meaning from the information contained in the message. The result is a significant decrease in compliance to the exception message.

It is within this context that we examine if iconic-based exception messages increase compliance. As noted in the discussion leading to **H1**, the alerting nature and picture superiority effect of icons should increase attention maintenance and result in a higher level of compliance after users become habituated from repeated exposure to exception messages.

Participants

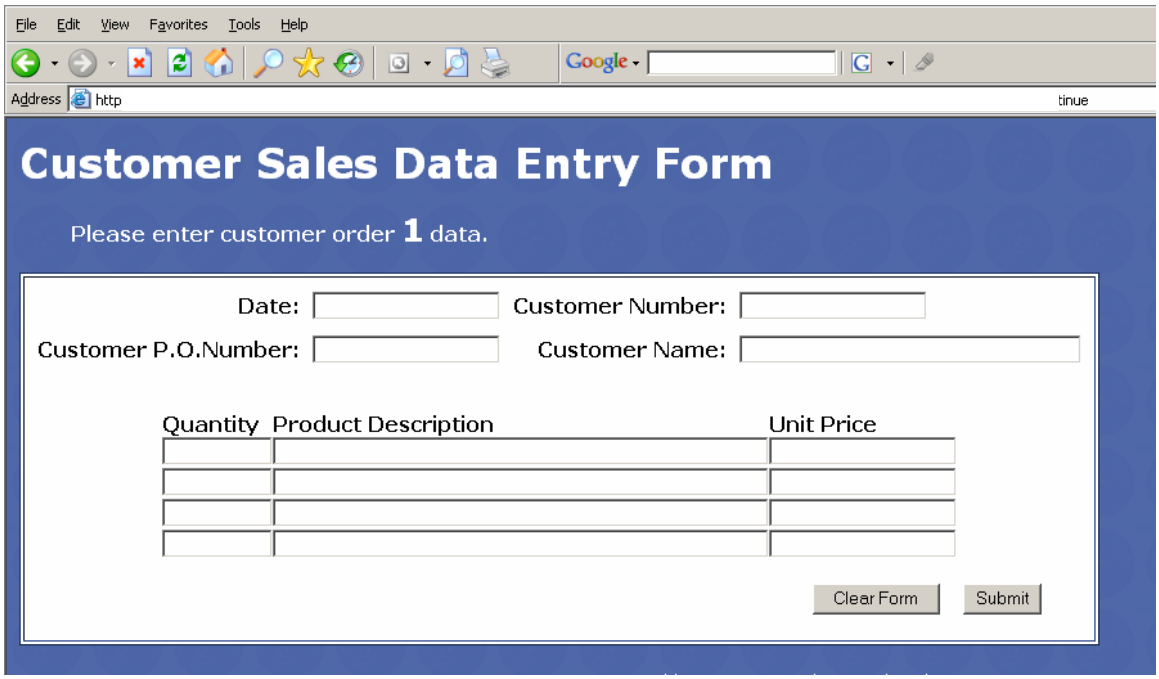
The authors recruited 90 upper-division accounting students at a large university to complete the task. All participants had completed multiple accounting courses and other business coursework. Accordingly, a group of participants with this background would reasonably be expected to complete the data entry task utilized in the experiment (described below) in an actual working environment. Each participant was awarded extra credit course points if they successfully and accurately completed the task.

Procedure and Task

The habituation task used by Amer and Maris (forthcoming) was administered using a Web-based computerized data collection program. The program was accessed individually by each participant through the internet at their convenience. The participants completed the task in its entirety during one sitting. Each participant was randomly assigned to one of two treatment conditions (see below) in a between subject design.

At the start of the exercise, the participants were instructed that the purpose of the study was to carry out a short system test by entering data from several sales transactions for a hypothetical wholesale distributor of sporting goods. The data for each transaction was provided to the participants in document form.[5] Each participant then logged onto the system and entered the data for each transaction in a separate data input screen. The data entry task was modeled after the on-demand software model whereby computer applications are hosted and maintained by a software vendor – not an internal IT staff – and then delivered over the Web like a service (Lacy 2006). These systems are growing in popularity and are structured as a client-server topology (see www.everestsoftwareinc.com, www.act.com, www.netsuite.com, and www.redwingsoftware.com for examples). A sample of the data entry screen used in the experiment is shown in Figure 4.

Figure 4. Example of Data Entry Screen used for Transaction Entry by the Participants



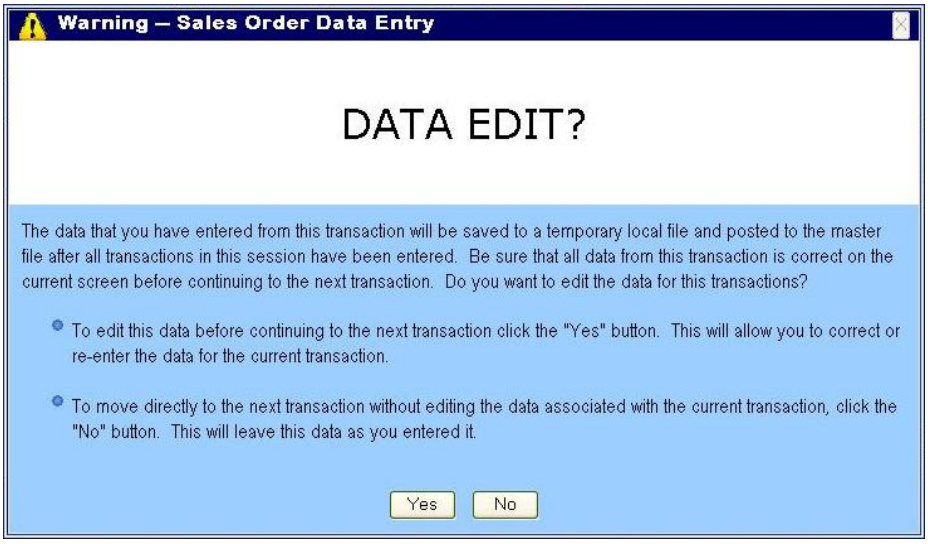
Habituation was induced by having the participants enter several similar sales transactions in the system, one after the other. After entering the data for each of the sales transactions an edit-request exception message, appeared on the screen asking if the user would like to edit the data before submitting the transaction. The most common response to the edit-request message would be "No" as the participants would have to select the "No" button before continuing to enter the data for the next transaction. Amer and Maris (forthcoming) found that habituation occurs rapidly in this task, after the entry of just three transactions.

Treatment Conditions and Dependent Variable

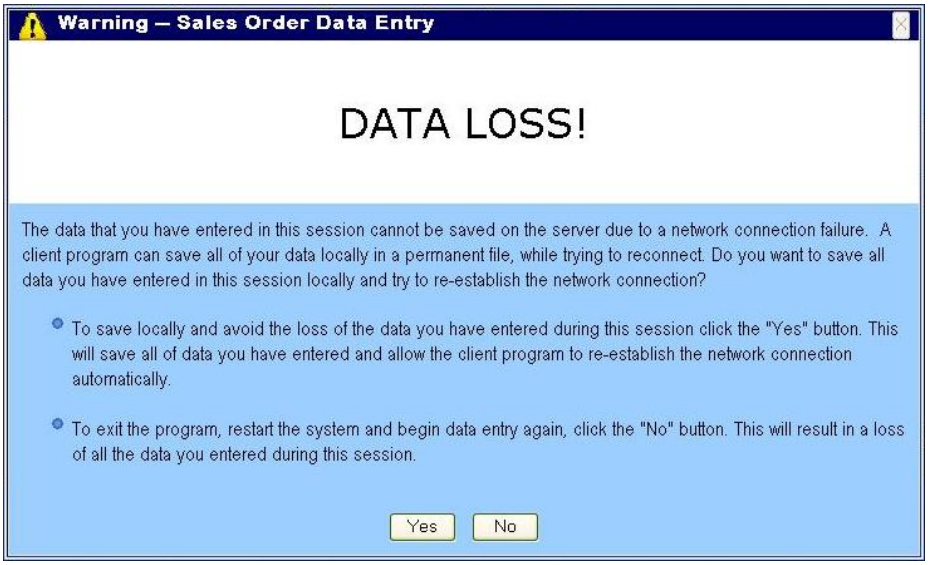
Two treatment conditions were established to examine **H1**. The first treatment condition, "iconic-based," used the exception messages displayed in Figure 3. The second treatment condition, "text-based," used the exception messages displayed in Figure 5. Note that all elements, (e.g., size, color, written content, etc.) of the messages in both Figures are identical ***but*** for the icons used in those of Figure 3. After entering data from each transaction each participant received an edit-request exception message as shown in Figure 3a. or Figure 5a., depending upon the treatment condition to which they were randomly assigned. This was repeated through the first eight transactions. Accordingly, they were all habituated by the repeated exposure to the edit-request exception message, with the common response of selecting the "No" button on this message.

Figure 5. Examples of Non-Iconic (Text-based) Exception Messages

a. Edit-Request Exception Message:



b. Network Connection Failure Exception Message:



To examine the behavioral compliance prediction of **H1**, a different hazardous situation with a different exception message was developed. The exception message was similar in appearance to the first but the context required a different action to be taken. After each participant entered the data for a ninth transaction, a simulated network connection failure occurred. The participants were informed of the connection failure by a network connection failure exception message that notified them that all data would be lost if they did not save it to a local file. The exception messages utilized appear in Figure 3b. for the iconic-based treatment condition and Figure 5b. for the text-based treatment condition.

Note that the network connection failure exception messages are similar in format to the edit-request messages that each participant would have seen eight times prior, but that the action required is “Yes” not “No”. That is, each participant would have been habituated to respond “No” to the edit-request exception message before encountering the network connection failure exception message. If a “No” response was selected in the later case, each participant would suffer the loss of all the data they had entered to that point in the exercise, a clearly undesirable occurrence.

The predictions of **H1** regarding the enhancement of behavioral compliance can be examined by measuring the "hit rate" of the participants on the network connection failure exception message. That is, the percentage of participants who take the desirable action (selecting "Yes") in response to the network connection failure exception message. This is the case because the action required to avoid the loss of data in the network connection failure message is opposite to the habituated action required in response to the edit-request exception message. Amer and Maris (forthcoming) found relatively low levels of post habituation compliance in this task environment. Accordingly, such a task provides a good context to examine how alternative exception message design changes behavioral compliance.

V. Results

Table 1 presents the hit rate percentages associated with the iconic-based and text-based exception messages of Figure 3 and Figure 5 ***after*** habituation. That is, the participant's responses to the network connection failure exception message after habituation to the edit-request exception message. In support of **H1** the percentages indicate that iconic-based exception message have a higher hit rate than the text-based message 48% to 30%. A binomial test reveals a statistically significant difference ($z = 1.79$, $p = .038$). These results support the notion that behavioral compliance increases with iconic-based exception messages.[6]

Table 1. Hit Rate Percentages – Iconic-Based Versus Text-Based Exception Messages

Treatment Condition	Hit Rate
Iconic-Based (n = 46)	48%
Text-Based (n = 44)	30%

Control Treatment

To place these hit rates in context it is helpful to compare them to a hit rate associated with exception messages similar to those currently employed in IT programs. Consider the exception messages in Figure 6. The general form and content of these edit-request and network connection failure messages of Figure 6 were modeled after two actual Microsoft exception messages – an Excel exception message for potential data loss, and a Word exception message for format conversion.

Figure 6. Exception Messages Similar to Those Currently Employed in IT Environments

a. Edit-Request Exception Message:

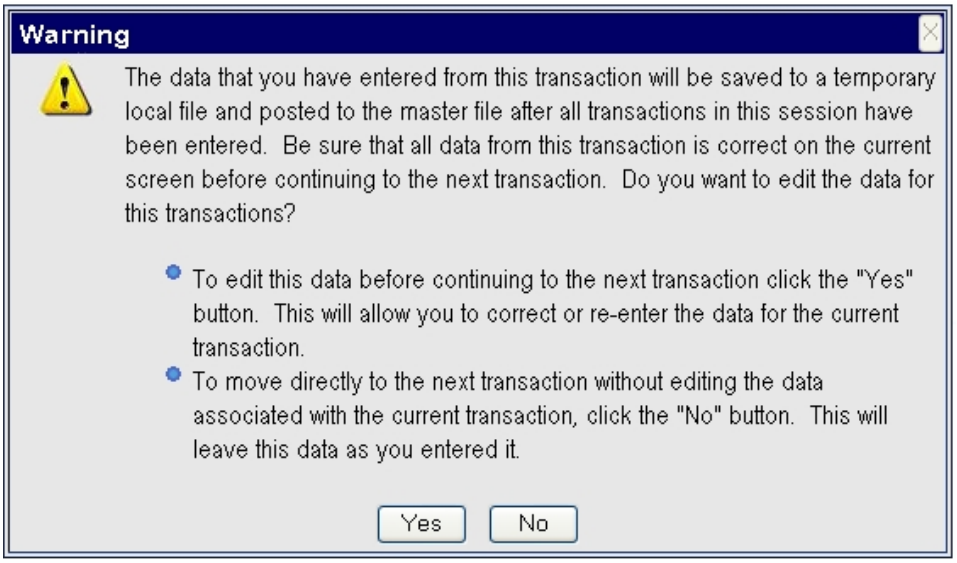
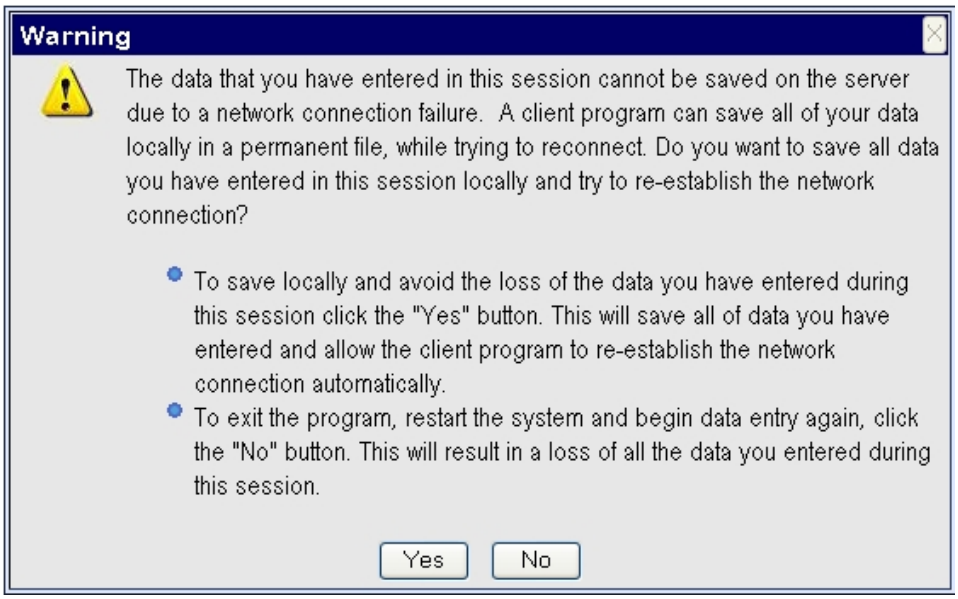


Figure 6. Exception Messages Similar to Those Currently Employed in IT Environments (continued)

b. Network Connection Failure Exception Message:



Thirty-three (33) participants completed the same habituation data entry task as the participants above who were exposed to either iconic-based or text-based exception messages. These later participants, however, were exposed to the exception messages of Figure 6. The hit rate for these participants was 11% - lower than the hit rates associated with the iconic-based (48%) or text-based exception messages (30%). A binomial test indicates that this 11% hit rate is statistically lower ($p < .05$) than both hit rates of the iconic-based and text-based messages. Such a result supports the notion that while the iconic-based exception message lead to the highest level of compliance, even the text-based exception messages that are structured according to the design elements outlined in the first part of this paper result in superior compliance when compared to exception messages similar to those currently employed in IT programs.

VI. Discussion And Conclusions

This paper accomplishes two primary objectives. First, it proposes and sets forth standards for the form and content of IT and application control exception messages. Building upon the work in consumer product and environmental warnings and linking to the literature in IT, five elements of well-prepared exception messages are established. This call for standards and consistency in exception messages is consistent with the views of IT academics and professionals in that such standards should improve user interactions and the overall informativeness of IT and application control exception messages. Of special note is the proposal to incorporate icons in exception messages. The proposed icons are different from signal icons that are currently utilized in exception messages and provide a visual representation of the situation or hazard faced by the user.

The second objective is to report the results of an experiment in which the effects of iconic-based exception messages on behavioral compliance are examined. The IT context and the structure of the experiment allowed for control over possible confounds and other factors that arguably have complicated the experiments reported by researchers in the consumer products and environmental hazard warnings literature. These results indicate that behavioral compliance is increased by incorporating icons in exception messages.

This research contributes to both the professional and academic literature. First, if systems designers adopt the proposed standardized format and elements set forth in the first part of this paper, the informativeness and effectiveness of exception messages should be enhanced. Exception design itself can also become more efficient because a set of standards can be referenced during system programming thus eliminating ad-hoc exception message coding. The academic literature is also enhanced as this research provides a well-controlled test of the effects of habituation and how iconic-based exception messages improve behavioral compliance in this situation.

References

Amer, T.S. and J-M. B. Maris. Forthcoming. Signal words and signal icons in application control and information technology exception messages – Hazard matching and habituation effects. ***The Journal of Information Systems.***

Amer, T.S. and J-M. B. Maris. 2007. Information technology exception messages – A preliminary investigation of compliance with the normative standards of warnings. ***Proceedings of the Western Decision Sciences Instituted Thirty-Sixth Annual Meeting***, April 3 – 7, 2007, Denver, Colorado. ISBN: 1098-2248.

American National Standards Institute (ANSI). (2002). *American National Standard for Product Safety Signs and Labels*. New York: ANSI.

Apple Computer, Inc. 1989. HyperCard Stack Design Guidelines. Menlo Park, CA: Addison-Wesley Publishing Company, Inc. ISBN 0-201-51784-1.

Blackwell, A. and T. Green. 2003. Notational systems – The cognitive dimensions of notations frameworks. In ***HCI Models, Theories, and Frameworks: Toward a multidisciplinary science***, Edited by J. M. Carroll, Morgan Kaufmann Publishers, Amsterdam, ISBN 1-55860-808-7. 103 – 121.

Cooper, A. and R. Reimann. 2003. ***About Face: The Essentials of Interaction Design.*** Indianapolis, IN: Wiley Publishing, Inc. ISBN 0-7645-2641-3.

Friedmann, K. (1988). The effect of adding symbols to written warning labels on user behavior and recall. ***Human Factors***, 30, 507 – 515.

Hall, J.A. 2006. *Accounting Information Systems 5e*. Thomson/Southwestern Publishing Company, Mason, Ohio. ISBN 0-324-31295-4.

Jaynes, L.S. and Boles, D.B. 1990. The effect of symbols on warning compliance. In ***Proceedings of the Human Factors Society 34th Annual Meeting*** (pp. 984 – 987). Santa Monica, CA: Human Factors Society.

Lacy, S. 2006. The On-Demand Software Scrum. BusinessWeek Online. www.businessweek.com. April 17, 2006.

Miller, J.M. and D. Parent. 2006. Bibliography of standards. Appendix in: Wogalter, M.S. (Ed.), ***Handbook of Warnings.*** Lawrence Erlbaum Associates, New Jersey/London, 795 – 804.

Otsubo, S.M. 1988. A behavioral study of warning labels for consumer products: Perceived danger and use of pictographs. ***Proceedings of the Human Factors Society***, 32, 536 – 540.

Schneider, K.C. 1977. Prevention of accidental poisoning through package and label design. ***Journal of Consumer Research***, 4, 67 – 74

Shneiderman, B. and C. Plaisant. 2005. Designing the user interface. Pearson/Addison Wesley Publishing, New York, ISBN 0-321-19786-0.

Thorley, P., E. Hellier, and J. Edworthy. 2001. Habituation Effects in Visual Warnings. In: Hanson, M.A. (Ed.), ***Contemporary Ergonomics.***, 223–228.

Weber, R. 1999. *Information Systems Control and Audit.* Upper Saddle River, NJ: Prentice Hall.

Windows XP Design Team. 2001. Windows XP Visual Guidelines. Microsoft Corporation. Retrieved June 16, 2004 from http://www.microsoft.com/whdc/hwdev/windowsxp/downloads/default.mspx

Wogalter, M.S., Kalsher, M.J., and Racicot, B.M. 1993. Behavioral compliance with warnings: Effects of voice, context, and location. ***Safety Science***, 16, 637 – 654. Address ceiling effects with habituation.

Wogalter, M.S., V. Conzola and T. Smith-Jackson. 2002. Research-based guidelines for warning design and evaluation. *Applied Ergonomics* (33) Number 3, 219–230.

Wogalter, M.S., N.C. Silver, S.D. Leonard, and H. Zaikina. 2006. Warning symbols. In: Wogalter, M.S. (Ed.), ***Handbook of Warnings.*** Lawrence Erlbaum Associates, New Jersey/London, 159–176.

Wogalter, M.S. and W.J. Vigilante. 2006. Attention Switch and Maintenance. In: Wogalter, M.S. (Ed.), *Handbook of Warnings.* Lawrence Erlbaum Associates, New Jersey/London, 245–265.

Wogalter, M.S. 2006a. *Handbook of Warnings.* Wogalter, M.S. (Ed.), Lawrence Erlbaum Associates, New Jersey/London, ISBN: 0-8058-4724-3.

Wogalter, M.S. 2006b. Communication-human information processing (C-HIP) Model. In: Wogalter, M.S. (Ed.), ***Handbook of Warnings***. Lawrence Erlbaum Associates, New Jersey/London, 51–61.

Endnotes

[1] The types of interactions and application programs utilized during the collection of the sample included e-mail, word processing, spreadsheet implementations, Internet interactions, etc. In addition, nearly all the exception messages captured were displayed by Microsoft products or Windows based applications.

[2] Note that the application name "Sales Data Entry" appears in the signal word panel of the proposed exception messages of Figure 3. Including the application name in exception messages is common practice in IT because multiple applications may be open at the same time on a users computing screen. Without such application identification, a user may not know which application triggered the exception message. Indeed, even applications running in the background, out of site of the user can call exception messages.

[3] The paper paradigm within the desktop metaphor was created by many individuals and organizations, including Douglas Engelbart, Xerox PARC, and Apple Computer.

[4] As will be noted below, just because the IT user is "blocked" by the exception message does not mean that attention to the exception message is maintained long enough for the user to extract meaning from the information contained in the message.

[5] The order of the transactions was randomized across participants to avoid order effects on the measures collected.

[6] Amer and Maris (forthcoming) manipulated the arousal strength intensity of the signal words and signal icons in exception messages in an effort to increase behavioral compliance in a habituation task. The highest level of compliance they achieved was a hit rate of 39%.