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## EMOTIONAL RESPONSE TO COMPUTER ERROR MESSAGES

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Motto:

*Three things are certain: death, taxes and lost data.  
Guess which has occurred.  
(Japanese Error Message)*

### Abstract

*This research is investigating the computer error messages as a source for the user's state anxiety. Forty-six Psychology students were distributed in three experimental conditions: "neutral message", "neutral error message" and "blaming error message". The dependent variable was state anxiety, measured with a self-report questionnaire. Variables such as state anxiety and "fake good" tendency were statistically controlled. Results showed that 18 to 21% of state anxiety variance is generated by the error messages. Implications of the results and further developments of the current study are discussed.*

**Key-words:** state anxiety, error message

### THEORETICAL BACKGROUND

Within the last decade, the personal computer has become an indispensable tool in the great majority of the human activities. With the implementation of such a complex tool, problems related to human-computer interaction became a focus for industrial psychologists as they tried to optimize this particular human-machine interaction.

Human-Computer Interaction (HCI) is a particular research domain focused on improving the way humans interact with computers. Within this domain, researchers "are focused on the design of the computer interface, on the evaluation and implementation of interactive computational systems and on the complex phenomenon that occurs within this process" (Jurcău, 2003). All of these aspects are concentrated in a characteristic of the computer software named *usability*.

According to Maurer (2004), usability is an umbrella term that encompasses two main concepts: on one hand usability refers to an *attribute of the quality of a system* (a usable system is an intuitive, easy to use system), and on the other hand usability refers to a *process or set of techniques* used during the design and development of a software application. From this perspective, usability

refers to the design elements of a user interface that make this interface easy to use. Van der Veer and van Vliet (2003) observed that the user interface is usually designed after the main functions are defined by program developers, and so the usability issue is related only to the way the interface is designed.

Recent research (Karat, Karat & Ukeslon 2000; Kujala, Kauppinen and Rekola 2001; Van der Veer & van Vliet, 2003) showed that the software developer's focus on the ergonomics of an interface solves only a part of the usability issues. For example, Karat *et al.* (2000) suggests that designers should take into account the *user's cognitive characteristics*, the *nature of the task* that is carried through the software program and the *context* in which the user achieves tasks and goals. This new approach involves a far more detailed analysis of the user and his/hers needs and leads to customized interfaces, depending on the nature of the task and the context the user is working in.

Starting from the ideas promoted by Karat *et al.* (2000), Kujala, Kauppinen and Rekola (2001) usability refers now to:

- how the software responds to *user needs* - this set of demands refers to user problems and options, user tasks and user environment;
- how the software answers to *requirements* - there are two main types of requirements:

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a) *user's requirements* - are written from the user's point of view and are referring to any function, constraint or other property that can satisfy the user's needs;

b) *technical requirements* - describe how the product will be implemented.

This new point of view is a shift in the usability concept, from the strict cognitive ergonomics framework to a wider needs based perspective. Moreover, current research interests are focused on developing and implementing adaptive interfaces (Alpert, Karat, Karat, Brodie & Vergo, 2003) that can offer only the information a particular user is interested in. Although this technology is used mainly in Web design, one can expect adaptive desktop applications in the near future.

An interesting perspective on the HCI is proposed by Van der Veer and van Vliet (2003), who tried to re-define this interaction by introducing three key concepts: user virtual machine, user mental model and design model. The *conceptual model* is the explicit model of the system, as it was conceived by the programmers and interface designers. The *user virtual machine* is a construct that includes everything the user should know about the system in order to use it (physical appearance of the computer, style of interaction, form and content of the information exchange). The user virtual machine is a normative model that includes all the information the user *should* know about the computer in order to have a high level of performance when using the machine. The user virtual machine is different, depending on the job: a system administrator must know how to install different software applications, while the statistician who uses the computer should know how to use his statistical program. According to Van der Veer and van Vliet (2003), when using a computer, the user has a *mental model* of the system being used, and the human plans actions and interprets system responses according to this mental model. The main idea of this theory is that "one has to attune his mental model to the conceptual model" (Van der Veer & van Vliet 2003).

Computer error is an often incident in human-computer interactions. According to Brodbeck, Zapf, Prumper & Frese (1993), there are two main types of errors: *functionality errors* (generated by a mismatch between the work task and the computer) and *usability errors* (generated by a mismatch between the user and the computer). Vinter *et al.* (1996,

*apud.* van der Veer & van Vliet, 2003) found out that 60% of software errors are caused by usability errors, while only 15% are caused by functionality issues.

User reactions to computer error were analyzed by focusing on the way people adapt themselves to the new technology (Birdi, Pennington & Zapf 1997; Birdi & Zapf, 1997). Although Birdi, Pennington & Zapf (1997) reported no significant differences between young and older users regarding the number of errors made, results reported by Birdi & Zapf (1997) showed that older users have stronger, more negative emotional responses to error messages than young users. Older users are also less likely to seek support by asking a co-worker and rely mainly on written documentation to solve the problem (Birdi & Zapf, 1997).

The frequent occurrence of computer errors led to the development of various strategies for minimizing their effects. One of the strategy consisted in developing computer software that can identify an error and then write an error report to the software developer. The other strategy was focused on the user and consisted in developing specialized trainings on error management.

Error reports represent a very useful way to improve software applications: developers usually use these feedbacks when they try to improve the stability of an application. Seebach (2004) suggested that a good error report should contain the answers for the following three questions: what the user was doing, what the user thought it happened and what actually happened. The answers to these questions allow the developers to reproduce the error (if they know what the user was doing), to identify the problem and to solve it.

Error management trainings are using errors as learning tools, through a trial-and-error method: errors are a source of negative feedback and have a positive and informative function in training (Heimbeck, Frese, Sonnentag & Keith, 2003). Moreover, Frese *et al.* (1991) showed that using errors when learning a computer program leads to better performance in nonspeed performance tests, compared to the situation where the computer program was learned without committing errors.

Previous research on this topic, Birdi & Zapf (1997) conducted a field study using self-report questionnaires and observational methods to investigate the relationship between the error and emotional response. In

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this research, we approach the phenomenon through an experimental study conducted in the Centre for Psychological Research and Studies from Timișoara.

In this study, we have taken into account two main types of error that occur while using the computer:

- "blaming errors" - are computer error messages that report a problem and indicate as a source of the error one of the user's actions;
- "neutral errors" - are error messages that report a problem, without revealing the potential source of the error.

We are particularly interested in the "neutral" error (system error) because it represents a particular type of error: it can't be attributed to the user, the user has nothing to learn from it and it usually implies a general failure of the system being used.

A problem that is under-researched is how users who don't speak English react to computer errors. In their case, low proficiency in English can be a moderator factor between the user and the computer.

### **Objective and hypothesis**

This study focuses on the emotional reactions of users to computer error messages. Our main hypothesis are:

H1: *Neutral error messages will generate a significantly higher level of anxiety, compared to a neutral message.*

H2: *Blaming error messages generate a significantly higher level of state anxiety, compared to a neutral message.*

H3: *High English proficiency will associate with a low level of state anxiety.*

H4: *The time spent by the subjects for reading the message will lead to an increase in state anxiety.*

## **METHOD**

### **Participants**

Forty six 2nd year students in Psychology participated as subjects in this study. The subjects were mainly female (80%) and were rewarded for the participation with 7 credits out of 100 in the Advanced Data Analysis discipline. All subjects reported

weekly or daily use of computer for Web browsing or text editing.

### **Measures**

Participants were told that the objective of the study is to evaluate the possibility of administrating the Raven Progressive Matrixes general intelligence test using the computer. This information was transmitted in order to deceive the subjects on the main objective of the study.

The dependent variable of this research is the subjects' score at the STAI X2 questionnaire (state anxiety). According to the hypothesis we formulated, we expect to find a significantly higher level of state anxiety at the subjects who received a "neutral error" message and a "blaming error" message, compared with the subjects that received a neutral message.

The experiment consisted in three main steps: in the first step, subjects answered a series of self-report measures that included:

- A *general survey* that recorded the frequency of the participant's interaction with the computer (measured on a 5 point anchor scale ranging from *1-daily* to *5-less than a few times a year*) and the *participant's self-reported linguistic proficiency in English*, measured on a scale ranging from 1 to 10 (10 meaning excellent). The participants were asked to evaluate their reading, writing and speaking skills on this 1 to 10 scale and the scores from these three ratings were cumulated in a more general indicator of the self-reported linguistic proficiency in English;
- *STAI X2* is a self-report questionnaire developed by Spielberger, Gorsuch & Lushene in 1970 (*apud. Pitariu 2003*) that measures the anxiety as a trait;
- *Eysenck Personality Inventory* (E.P.I.) - was used to assess the participant's tendency to "fake good" using the L scale from this inventory.

The second step consisted in answering a computer version of the Raven Progressive Matrixes specially developed for this experiment, that had only the A and B series of the test. Although the Raven Progressive Matrixes is administrated with a time limit of 30 minutes, subjects were instructed that in this testing session the time limit does not exist because the researcher is interested to see the time needed to complete the entire test. Subjects were not informed that

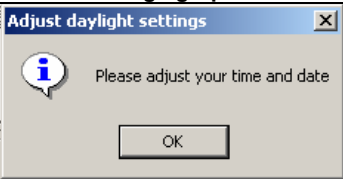
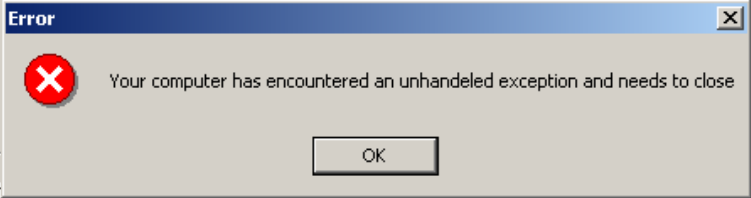

they will complete only the A and B series of the test. In this step, subjects completed the electronic version alone, in a room specially reserved for this purpose. The computer version had the following functions:

- to record the answers given by the subjects;
- to generate a computer message, depending on the experimental condition. There were three types of messages: a *neutral message* ("Please adjust your time and date"), a computer error message revealing a *neutral error* ("Your computer has encountered an unhandled exception and needs to close") and computer error message revealing a *blaming*

*error* ("One of your actions caused an unhandled exception and as a result your computer will have to close"). The messages generated by the application are presented in Table 1. The message always appeared between the A12 and B1 items of the Raven Progressive Matrixes. Once the "OK" button was pushed, the message did not re-appeared and the B1 item appeared on the screen;

- to record the time spent by the subjects between the moment the message appeared and the moment they pushed the "Ok" button.

**Table 1**  
Types of computer messages

| Type of message       | Message graphics   |
|-----------------------|--|
| Neutral message       |    |
| Neutral error message |   |
| Blaming error message |  |

The third step consisted in completing the *State-Trait Anxiety Expression Inventory STAI X1* developed by Spielberger, Gorsuch & Lushene in 1970 (*apud*. Pitariu 2003), which is a self-report questionnaire that measures the level of the anxiety as a state.

The causal relationship between the computer message and the state of anxiety was studied while statistically controlling other variables that may interfere between these two elements:

- *trait anxiety* - measured with STAI X2, trait anxiety refers to subject's general inclination towards experiencing the state of anxiety;

- *subject's tendency to "fake good"* - previous research on Romanian subjects (Radulovici & Duma, 2001) showed that this variable is usually positively associated with our dependent variable (state anxiety).

## RESULTS

Hypothesis testing was conducted using ANCOVA technique, with *State Anxiety* as dependent variable and experimental conditions as fixed factors. All other variables discussed in the previous section were included as covariates. The results of the ANCOVA analysis are presented in Table 2.

**Table 2**

Results of ANCOVA analysis (dependent variable: State anxiety)

|                       | Source                             | Type III Sum of Squares | df | Mean Square | F      | Sig.  |
|-----------------------|------------------------------------|-------------------------|----|-------------|--------|-------|
|                       | Corrected Model                    | 2667.485                | 6  | 444.581     | 18.577 | <.001 |
|                       | Intercept                          | 142.246                 | 1  | 142.246     | 5.944  | .019  |
| Independent variables | Experimental condition             | 291.359                 | 2  | 145.680     | 6.087  | .005  |
| Covariates            | English proficiency                | 10.605                  | 1  | 10.605      | .443   | .510  |
|                       | Time spent for reading the message | 168.081                 | 1  | 168.081     | 7.023  | .012  |
| Controlled variables  | Trait anxiety                      | 2012.911                | 1  | 2012.911    | 84.112 | <.001 |
|                       | "Fake good" tendency               | 103.065                 | 1  | 103.065     | 4.307  | .045  |
|                       | Error                              | 933.320                 | 39 | 23.931      |        |       |
|                       | Total                              | 44821.000               | 46 |             |        |       |
|                       | Corrected Total                    | 3600.804                | 45 |             |        |       |

R Squared = .758 (Adjusted R Squared = .714)

Our first two hypothesizes stated that the state anxiety reported by our subjects will be higher if they have encountered an error message, compared with the state anxiety reported by the subjects that encountered a non-error message. After obtaining significant results in Table 1 for the experimental condition variable ( $F(2,39) = 6.087$ ,  $p = .005$ ), we conducted a

contrast analysis using the standardized simple contrast technique for comparing each of the error message condition with the non-error message condition (Table 3). We preferred the contrast analysis to the post-hoc analysis because it allowed us to test specific hypothesis (Sava, 2004).

**Table 3**

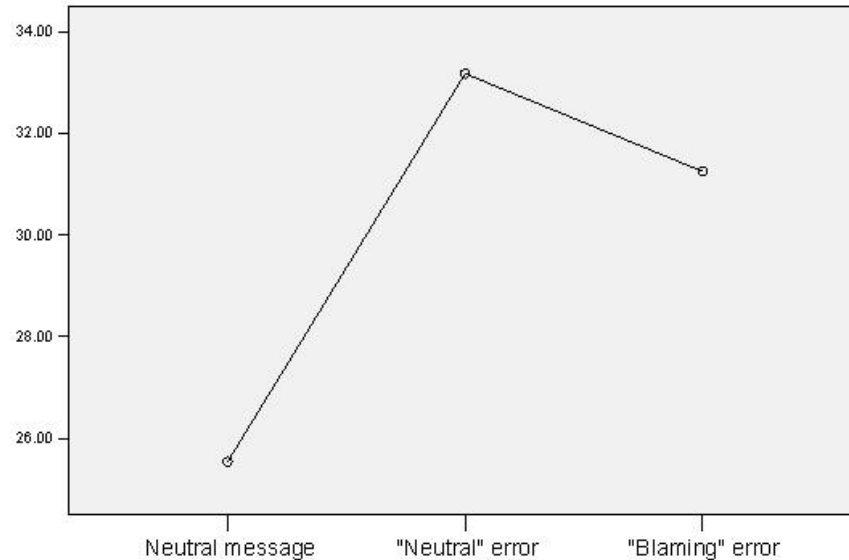
Contrast analysis results

|                                       |  |        |       |
|---------------------------------------|--|--------|-------|
| "Neutral error" vs. "Neutral message" | Contrast Estimate                      |        | 8.426 |
|                                       | Hypothesized Value                     |        | 0     |
|                                       | Difference (Estimate - Hypothesized)   |        | 8.426 |
|                                       | Std. Error                             |        | 2.563 |
|                                       | Sig.                                   |        | .002  |
|                                       | 95% Confidence Interval for Difference |        |       |
|                                       | Lower Bound                            | 3.242  |       |
|                                       | Upper Bound                            | 13.609 |       |
| "Blaming error" vs. "neutral message" | Contrast Estimate                      |        | 6.343 |
|                                       | Hypothesized Value                     |        | 0     |
|                                       | Difference (Estimate - Hypothesized)   |        | 6.343 |
|                                       | Std. Error                             |        | 2.088 |
|                                       | Sig.                                   |        | .004  |
|                                       | 95% Confidence Interval for Difference |        |       |
|                                       | Lower Bound                            | 2.119  |       |
|                                       | Upper Bound                            | 10.567 |       |

 $F(2,38) = 4.996$ ,  $p = 0.1$ 

Results of the contrast analysis confirmed both our hypothesis, indicating that computer error messages generate a higher level of state anxiety compared to a neutral message, even when variables such as *Trait Anxiety* are

statistically controlled. The estimates of effect size showed an  $r^2 = .21$  for the "neutral error" message and an  $r^2 = .18$  for the "blaming error" message.



**Figure 1.** Graphic representation of the state anxiety level, on our three experimental conditions

Our third hypothesis stated that a high proficiency in English will associate with a low level of anxiety. We believed that a better understanding of the message the computer is showing will be associated with lower levels of anxiety. This relationship was not confirmed by the results presented in Table 2.

Our fourth hypothesis stated that "The time spent by the subjects for reading the message will lead to an increase in state anxiety". Although the main effect is statistically significant ( $F(1,39) = 7.023, p = .012$ ), the direction of the relationship is not positive (as hypothesized) but negative. This means that the less time our subjects spent reading the computer message, the higher the state anxiety reported by them was.

## DISCUSSION

Contrast analysis showed a significant effect of the error messages on state anxiety. This result sustains the thesis postulated by Keith (2005), stating that the effectiveness of error management training sessions are mediated by the individual's emotion control capabilities. If the error is responsible for 18-21% of the state anxiety variance while trait anxiety is statistically controlled, then emotion control capabilities are crucial in finding the right approach in dealing with computer errors.

These results also indicate that an error message is perceived by users as a potential threat to the possibility of continuing their tasks. An important finding is that errors

that indicate a usability issue ("blaming errors") have almost the same impact as system errors. This result suggests that the theoretical difference we imposed between these two types of errors does not exist from a user's point of view. An alternative explanation refers to the fact that both error messages indicated the same result: the immediate shutdown of the system. It is possible that this unpleasant result influenced our subjects' anxiety in both conditions and the subtle difference between system error and user error was not significant in this case.

In our presentation of the theoretical background of this study, we observed the lack of research on the relationship between linguistic competencies and usability. Our results showed that English proficiency is not associated with the emotional response to error messages. We believe that this result can admit three complementary explanations, which should be tested in future studies:

- the first possible explanation for this result might be the fact that the state of anxiety is not related with the verbal contents of the message, but with the graphic elements that are associated with it: error messages have different graphics than information messages (see Table 3);
- the second alternative explanation is the presence of the word "error" in the blue bar of the window. This word is very similar with the Romanian "eroare" and therefore it should have

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been correctly interpreted by all our subjects, regardless their English proficiency level;

- the third explanation starts from the usability model developed by Van der Veer and van Vliet (2003) and refers to the user's mental model: if the user's mental model does not contain any information related to error diagnosis, then the user can't understand the meaning of the error message, although he/she can understand English.

A surprising result was the negative, significant correlation between the time spent for reading the message and state anxiety. A possible explanation for this unexpected result is that subjects that tried to remove the message as soon as possible (by clicking the "OK" button) are more worried about a possible negative outcome, simply because they did not read the whole message. This finding is important, as understanding the nature of the error is one of the first conditions for learning how to solve errors or how to recover from them (Seebach, 2004).

Further research should focus on the cognitive effects of the error messages, as the results reported by Bailey, Konstan & Carlis (2000), McFarlane (1999, 2002), McFarlane & Latorella (2002) show that computer interruptions have disruptive effects on cognitive focusing. We believe that error messages can be considered as a combination between interruption and threat, so the effects on the cognitive focusing should be major. Also, emotions such as anger should be further investigated in relationship with the computer errors.

Another issue that needs to be further investigated is how these messages affect expert users. For example, it would be interesting to see the results on a sample of programmers. A significant effect on this type of users can have important implications for the software development process, as accurate programming leads to the elimination of error messages.

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