Romanian Journal of Applied Psychology
2011, Vol. 13, No. 2, 56-63

Measurement of Implicit Associations between Emotional States and Computer Errors Using the Implicit Association Test

Laurențiu P. Maricuțoiu

Universitatea de Vest din Timișoara, România

Previous research identified two main emotional outcomes of computer error: anxiety and frustration. These emotions have been associated with low levels of performance in using a computer. The present research used innovative methodology for studying the relations between computer error messages, user anxiety and user frustration. We used the Implicit Association Test (IAT) to measure automated associations between error messages and these two emotional outcomes. A sample of 80 participants completed two questionnaires and two IAT designs. Results indicated that user error messages are more strongly associated with anxiety, than with frustration. Personal characteristics such as emotional stability and English proficiency were significantly associated with the implicit anxiety measure, but not with the frustration measure. No significant relations were found between two measures of computer experience and the emotional measures. These results indicated that error related anxiety is associated with personal characteristics.

Keywords: error messages, anxiety, frustration, implicit association test

Address of correspondence: lmaricutoiu@socio.uvt.ro

The software anyone uses today contains millions of programming code lines. For example, Microsoft Vista® is based on 50 millions of programming code lines (Blakely, 2006), and this number does not include the programming code lines of the software running within that operating system. If we take into account the programming code lines of all applications installed on any given computer, the number mentioned by Blakely (2006) is likely to double. Such a large number of code lines increases probability of encountering a software malfunction or a software problem. When it occurs, the operating system signals any such problem using error messages.

Previous research on psychological reactions to error messages indicated that users could feel frustrated (Ceaparu, Lazar, Bessiere, Robinson & Shneiderman, 2004) or anxious (Maricuțoiu, 2006). These research directions showed strong evidence for the apparition of emotional states following error messages, but focused only on one of the two emotions.

Therefore, the first objective of this paper was to investigate the two emotional reactions, by studying how users associate them with computer error messages. Using the Implicit Association Test (IAT – Greenwald, McGhee & Schwartz, 1998), we focused on the implicit associations between error messages and the two emotional reactions (frustration and anxiety). The second objective of this paper was to investigate relations between the implicit associations and various personal variables such as computer experience, personality variables and English comprehension.

Emotional reactions to error messages

The literature that addresses user's emotional reactions to computer error has two directions: the study of effectiveness in error management trainings and the Ipsos MORI (2009) survey. In error management training, trainees are encouraged to deal with errors and not to avoid them (Frese, Brodbeck, Heinbokel, Mooser, Schleiffenbaum & Thiemann, 1991). Starting from the idea that errors cannot be avoided, this research field focused on improving the way people react to errors. Results showed that participants' ability to control their emotion is a crucial factor for the success of such training programs (Frese et al., 1991; Heimbeck, Frese, Sonnentag & Keith, 2003; Keith, 2005). More specific, usage of anxiety management techniques in computer trainings is enhancing post-training performance, but does not influence computer anxiety (Bloom & Hautaluoma, 1990).

The second research direction was generated by a survey conducted in 1999 by Ipsos MORI, for the European division of Compaq. The results indicated that anger and frustration are two of the main emotional reactions to errors (Ipsos MORI, 2009): colleagues are reported to be swearing their personal computer, and the IT department personnel are subject to bullying actions.

Frustration as a psychological reaction to error messages.

Frustration is defined by Spector (1978, p.815) as "interference with goal oriented activity or interference with goal maintenance". In human-computer interaction, frustration is the most frequent negative result of computing experience and is considered a pre-emotional

state. From this perspective, the main function of frustration is to redirect attention resources from the current task to elements of the environment that may become obstacles (Bessiere, Newhage, Robinson & Schneiderman, 2006).

Research on computer frustration indicated that it is generated by user's characteristics (mainly lack of knowledge) and system malfunction (Ceaparu et al., 2004). The most frequent system malfunctions that frustrate users are Internet connection malfunctions, application errors and hardware malfunction (Ceaparu et al., 2004; Lazar, Jones & Schneiderman, 2006). For dealing with such events, users spend approximately 40% of their work time, thus leading to major financial losses for their employers (Lazar et al., 2006, Ceaparu et al. 2004).

When attempting to explain and predict the intensity of frustration, researchers took into account various dispositional variables. Previous research indicated that one's frustration level is positively associated with low computer self-efficacy (Bessiere et al. 2006), high neuroticism (Rose, Bennet-Murphy, Byard & Nikzad, 2002) and computer anxiety (Bessiere, Ceaparu, Lazar, Robinson & Shneiderman, 2004). All these variables influence the intensity of the frustration, regardless of the specific incident that triggered this emotion (Bessiere et al., 2004). For example, users with high neuroticism will feel more frustrated than emotionally stable users, when they encounter the same computer error.

Anxiety as a psychological reaction to error messages.

State anxiety is defined as "subjective, consciously perceived feelings of apprehension and tension, together with activation of the autonomic nervous system" (Gaundry, Vagg & Spielberger, 1975, p. 331). In human-computer interaction, computer anxiety refers to fears about the implications of computer use (Thatcher & Perrewe, 2002). Research on computer anxiety found significant relations between this variable and dispositional variables such as neuroticism (or low emotional stability), locus of control and general self-efficacy (Pitariu, 2000; Thatcher & Perrewe, 2002).

Although computer anxiety is related to user performance (Smith & Caputi, 2001), few research studies attempted to evaluate the relation between error messages and state anxiety. Previous research showed only circumstantial proofs indicating that state anxiety is an effect of computer errors.

The literature on interruption in human-computer interaction showed that users that are interrupted from their current activity reported higher levels of state anxiety, as compared to users that are not interrupted (Zijlstra, Roe, Leonora, & Kredict, 1999). The intensity of state anxiety was positively related to the complexity of the secondary task (the task that interrupted the main activity of the user). Yet, the research conducted by Zijlstra et al. (1999) had several limitations. First, the design did not include a control group (a group of subjects that should not be interrupted). Because of this limitation, the study did not offered any estimation of the anxiety difference from a "non-interrupted" task. The second limitation of this research is the authors' argumentation for studying state anxiety as a result of interruptions. According to Zijlstra et al. (1999, p.164), interruptions are "often regarded as annoying and frustrating because they keep people from their work". In our opinion, this argument is offering more support to the frustration hypothesis, rather than to the anxiety hypothesis.

In a similar research reported by Bailey, Konstan and Carlis (2001), users were asked to perform various secondary tasks (tasks that interrupted their activity). Unlike the research conducted by Zijlstra et al. (1999), Bailey, Konstan and Carlis (2001) included a control group. Their results showed a higher level of state anxiety at users that were interrupted, as compared with users that were not interrupted.

Other approaches suggested that error messages are threatening the finalisation of the task, because are indicating a possible unsolvable problem (Maricuțoiu, 2006). Such research contrasted the state anxiety level reported by participants that were interrupted by a neutral computer message (control group), by a system-error message (a message that did not attributed the error to user action) or by a user-error message (a message that attributed the error to user action). Results showed that encountering an error message explains 18-21% of the state anxiety variance, when trait anxiety is statistically controlled. Furthermore, Maricuțoiu (2006) found no differences in the anxiety level reported by users that encountered system-error messages and users that encountered user-error messages.

Comparison of the two emotional reactions to error messages

As presented earlier in the paper, previous research focused exclusively on one emotional state (anxiety or frustration). Although both emotional states were found to be related to apparition of computer error messages, knowing which one is more strongly associated with error messages could have some practical implications. First, in the case of participants at error management trainings (Frese et al., 1991), the control of anxiety requires a different approach that the control of frustration. Therefore, these participants should benefit from emotional control technique which addresses the primary emotional reaction of error messages. Second, the dominance of a specific emotional reaction should lead to specific user behaviours after the occurrence of an error message.

The research mentioned in the previous sections used self-report measures for assessing frustration or anxiety. Although the results presented are consistent, this approach has more deficiencies that should be taken into account. First, self-reported measures of anxiety can easily be faked by subjects. For example, Bailey et al. (2001) used the STAI-Y1 questionnaire in a pretest-posttest manner and compared the results without using a measure of social desirability for controlling participants' tendency to create a good impression. In previous research conducted by Maricuțoiu (2006), social desirability had a small (yet significant) effect on the self-reported measure of state anxiety. Second, no research aimed at comparing the two emotions. All studies focused either on quantifying the frustration level, either on quantifying the anxiety level of participants. By using the Implicit Association Test (IAT), we aim to overpass several methodological deficiencies of previous research.

The Implicit Association Test (IAT) was developed by Greenwald et al. (1998) for the measurement of the intensity of implicit association between a stimulus and

certain characteristics. James and Rentsch (2004) indicated that implicit tests measure semantic associations that are not available to introspection such as basic biological drives, learning experiences that have been lost to memory, cognitive processing that has become automatic or cognitive processes that serve to enhance or to protect self-esteem and subjective well-being.

The typical IAT requires participants to categorize various target-stimuli and adjectives as fast as they can. The assumption behind IAT is that users who associate error messages with anxiety will sort faster when these two categories share the same key, than when different buttons are assigned for the two categories. The IAT score is computed as the standardized difference between the average response-time of the block where the two categories share common buttons, and the average response-time of the block where the two categories share different buttons.

Using the IAT has the advantage of having a common measurement scale for assessing implicit associations between error messages and anxiety, and association between error messages and frustration. This common measurement scale will allow us to compare the strength of association of each emotion with the error messages, using a within-group design.

The second advantage of using the IAT is the fact that its measure is not influenced by motivational factors and is more resistant to faking than self-report measures (Hofman, Gawronski, Gschwendner, Lee, & Schmitt, 2005; Tulbure, 2006).

The third advantage of the IAT is that it measures the intensity of automated responses (Greenwald et al. 1998). As we have stated before, Bessiere et al. (2006) define frustration as a pre-emotional state and this characteristic alone makes it difficult to measure it using self-report instruments. Research on anxiety and personality using the IAT showed that behavioural indicators were best predicted by the IAT measures, while self-report measures had a lower predictive power (Steffens & Shultze-Konig, 2006; Gschwendner, Hofmann, & Schmitt, 2008). Therefore, we can conclude that measuring implicit associations between error messages and emotional responses should lead to a better predictive power and higher ecological validity than self-report questionnaires.

Correlates of frustration and anxiety

Computer experience

When studying emotions in human-computer interaction, user's computer experience is an important variable that should be taken into account. Relations between computer experience and user emotions are interpreted through the self-efficacy theory (Bandura, 1997). According to this theory, people's positive experiences are reinforcing their belief in their ability to obtain better results. These performance beliefs make people less anxious when approaching new tasks and more motivated when dealing with obstacles (Bandura, 1997). Previous research has demonstrated that high computer experience associates with low computer anxiety (Heinssen, Glass, & Knight, 1987), low computer frustration (Bessiere et al., 2006) and high computer self-efficacy (Rozell & Gardner, 1999).

English proficiency

Understanding the messages provided by the computer is a key issue in human-computer interaction. This statement is supported by the Model for Notification Systems Evaluation (McCrickard, Catrambone, & Stasko, 2001; McCrickard, Chewar, Somervell, & Ndiwalana 2003), which suggests that any mean of notification should be evaluated on three criteria: how the notification system is interrupting the user, how the user reacts to the information provided by the notification system (in terms of rapidity and accuracy of the response) and to what degree the information provided is comprehensible.

The main problem of understanding error messages is not related to the message itself, but to understanding the consequences of this message (van der Linden, Sonnentag, Frese, & van Dick, 2001). Because understanding the error message implies understanding the words that compose it, user linguistic capabilities are most important.

English comprehension is not a researched theme in human-computer interaction. We believe that this lack of interest has two main explanations. First, most of human-computer interaction research is conducted on native English speakers. Second, even if the research is involving participants that do not speak English as their native language, the interface of the software is written in their native language. Although the major software producers are developing multi-language interfaces, little has been done for translating the error messages. For example, Microsoft® has developed Romanian versions of its most popular software, but these versions do not include translated error messages.

The relation between error comprehension and performance when learning a computer program is well documented by previous research (Frese et al., 1991; van der Linden et al., 2001). Such research showed that better understanding of error messages is associated with better error-solving strategies in post-training evaluations (Frese et al., 1991, Heimbeck et al. 2003; Keith, 2005). This situation raises several questions about the relations between English proficiency, user's ability to understand the error messages and user's emotional reactions to such events. Not being able to understand what is happening should lead to high computer anxiety and low performance in solving the issues signalled by the error messages.

Overview of the present research

Starting from these observations, we intended to analyse the implicit associations between each of these two emotions (frustration and anxiety) and the error messages. In order to achieve this objective, we used the IAT. In the present research, the stimuli were various computer messages and the atributes were various synonims of the emotional states (anxiety and frustration). This approach allowed us measure the strength of implicit association between each of these emotional states and error messages, using a common measurement scale (the D index). Thus it is predicted that:

Hypothesis 1. There are statistically significant differences between the implicit association of error messages and anxiety and the implicit association of error messages and frustration.

Previous research indicated that computer experience is negatively correlated with computer anxiety (Heinssen et al., 1987) and computer frustration (Bessiere et al. 2006). Therefore, we expect that:

Hypothesis 2a. Computer experience is negatively associated with the implicit association between error messages and anxiety.

Hypothesis 2b. Computer experience is negatively associated with the implicit association between error messages and frustration.

Hypothesis 2c. Longer computer ownership correlates with low implicit associations between error messages and anxiety.

Hypothesis 2d. Longer computer ownership correlates with low implicit associations between error messages and frustration.

Previous research showed that high neuroticism (or low emotional stability) correlates with high computer anxiety (Pitariu, 2000) and high frustration levels (Rose et al., 2002). Therefore, we expect that:

Hypothesis 3a. High emotional stability correlates with low implicit associations between error messages and anxiety.

Hypothesis 3b. High emotional stability correlates with low implicit associations between error messages and frustration.

We expected English proficiency to associate with users' emotional reactions when using a personal computer. Understanding the content of error messages should lead to lower levels of anxiety and higher levels of frustration. Therefore, we expect that:

Hypothesis 4a. A high level of English comprehension correlates with low implicit associations between error messages and anxiety.

Hypothesis 4b. A high level of English comprehension correlates with high implicit associations between error messages and frustration.

Method

Participants

When planning this research, we conducted an a-priori sample estimation using PowerStaTim 1.0 (Maricuțoiu & Sava, 2009). We expected a medium effect size (d=.50, according to Cohen, 1988) and a targeted statistical power of .80. The estimated sample size required to achieve this level of statistical power is N = 64.

Eighty undergraduate students in Psychology participated in this study (23.8% males, average age 20.91 years), in return for partial course credit. All participants declared they own a personal computer, that was purchased 2-11 years ago ($m = 6.95$, $\sigma = 2.86$). The average computer experience of our subjects is 8.34 years ($\sigma = 2.24$).

Measures

The Implicit Association Test (IAT). In any IAT design, each participant has to classify the stimuli that appear on the computer screen, on two categories. Participants' task consisted in seven classification blocks, five of which were used as practice trials and two were used as critical (or test) trials. The categories were: synonyms of anxiety (or frustration), synonyms of relaxation, pictures of computer error messages, and pictures of computer neutral messages. All stimuli that used in the IAT designs are presented in Table 1.

Each participant completed the IAT twice. The structure of each IAT design is presented in Table 2 and Table 3. Half of the participants first completed the IAT that measured implicit associations between anxiety and error messages, while the other half first completed the IAT that measured implicit associations between frustration and error messages. This strategy was used for counterbalancing a possible order effect.

The IAT was administered using DirectRT®, using the settings recommended by Greenwald, Nosek and Banaji (2003): the time lag between a response and the aparition of the next stimulus was set to 150 miliseconds, and we used 40 trials for the critical blocks.

We scored the IAT by following the indications provided by Greenwald et al. (2003): we checked the database for response times smaller than 300 miliseconds and larger than 10000 miliseconds. We eliminated seven participants that made wrong clasifications in more than 20% of the critical trials. For the remaining participants, we computed a D value using the formula specified by Greenwald et al. (2003): $D = (Mean_{B7} - Mean_{B4})/(SD_{B7\&B4})$. As all participants completed two IATs, we computed two D values for each subject

Table1. Stimuli used in the IAT designs.

Anxiety	Frustration	Relaxation	Error message	Neutral message
Fraught	Anger	Calm	Your application has encountered an error	Please adjust your date and time
Fright	Hostility	Relaxation	Error #32894 encountered in log file	Your data has been saved
Agitation	Irritation	At ease	Could not read segment 257.896 on your local disk	You received a new e-mail
Uncertainty	Indignation	Peaceful	Unable to load component	Your files have been saved
Fear	Vehemence	Sedate	The connection to 192.186.1.13 was reset by the host machine	Your report is ready. Please press OK to open it

Note: the verbal stimuli were translated from Romanian. Computer messages were displayed in English and contained icons of real error messages (a red circle with a white cross) or icons of real informative messages (a white callout with the letter "*i*").

Table 2. The structure of IAT design (anxiety vs. relaxation).

Block	No. of trials	Stimuli	Categories assigned to left-key response	Categories assigned to right-key response
B1 - Trial	20	5 error messages + 5 neutral messages	Error message	Neutral message
B2 – Trial	20	5 anxiety synonyms + 5 relaxation synonyms	Anxiety	Relaxation
B3 – Trial	20	5 error messages + 5 neutral messages + 5 anxiety synonyms +5 relaxation synonyms	Error message + Anxiety	Neutral message + Relaxation
B4 – Critical	40	5 error messages + 5 neutral messages + 5 anxiety synonyms +5 relaxation synonyms	Error message + Anxiety	Neutral message + Relaxation
B5 – Trial	20	5 anxiety synonyms + 5 relaxation synonyms	Relaxation	Anxiety
B6 – Trial	20	5 error messages + 5 neutral messages + 5 anxiety synonyms +5 relaxation synonyms	Error message + Relaxation	Neutral message + Anxiety
B7 – Critical	40	5 error messages + 5 neutral messages + 5 anxiety synonyms +5 relaxation synonyms	Error message + Relaxation	Neutral message + Anxiety

Table 3. The structure of IAT design (frustration vs. relaxation).

Block	No. of trials	Stimuli	Categories assigned to left-key response	Categories assigned to right-key response
B1 - Trial	20	5 error messages + 5 neutral messages	Error message	Neutral message
B2 – Trial	20	5 frustration synonyms + 5 relaxation synonyms	Frustration	Relaxation
B3 – Trial	20	5 error messages + 5 neutral messages + 5 frustration synonyms +5 relaxation synonyms	Error message + Frustration	Neutral message + Relaxation
B4 – Critical	40	5 error messages + 5 neutral messages + 5 frustration synonyms +5 relaxation synonyms	Error message + Frustration	Neutral message + Relaxation
B5 – Trial	20	5 frustration synonyms + 5 relaxation synonyms	Relaxation	Frustration
B6 – Trial	20	5 error messages + 5 neutral messages + 5 frustration synonyms +5 relaxation synonyms	Error message + Relaxation	Neutral message + Frustration
B7 – Critical	40	5 error messages + 5 neutral messages + 5 frustration synonyms +5 relaxation synonyms	Error message + Relaxation	Neutral message + Frustration

DECAS personality inventory. All participants in the study were tested with the DECAS Personality Inventory (Sava, 2008). DECAS is a 95 item test which solicits a dichotomic answer („true" / „false") distributed in five content scales: openness; extraversion, consciousness, agreeability and emotional stability (as opposed to neuroticism). The internal consistency of the scales, for the entire representative sample at national level, varies between .70 for consciousness and .75 for emotional stability, whilst their six weeks test-retest stability coefficients range from .79 to .91. The test contains, also, three other empirical scales, with the aim to validate the answers: social desirability, random answers and acquiescence scale. Concurrent validity data showed very good relationship with the Romanian version of NEO PI-R (Costa & McRae, 1992), uncorrected correlation coefficients ranging from .57 for Agreeableness scale to .81 for Extraversion. Convergent findings supporting the five factor structure of the DECAS Personality Inventory (e.g. RMSEA of .08) were gathered in a validation study that included concurrent instruments such as the Romanian adapted version of BFQ (Caprara, Barbanelli, Borgogni, & Perugini, 1993) and Goldberg's IPIP items (Goldberg, 1992). Supplementary data about the psychometrical features of the test can be found in Sava (2008).

Computer experience questionnaire. All participants completed a brief questionnaire that investigated their experience with personal computers. We solicited information regarding the moment they first interacted with a personal computer, the moment they first owned a personal computer, and information regarding the software applications used. At the end, this questionnaire requested participants to provide self-evaluations of English proficiency (reading, writing, comprehension and speaking) using a 10 grades scale. Higher grades indicate a higher level of English proficiency.

Procedure

Participants were tested in the Center for Studies and Psychological Research in Timișoara. In the first stage of the study, participants completed the DECAS personality inventory and the Computer experience questionnaire. In the second stage, participants were invited individually in a separate room, were they completed both IAT tasks. Both IAT designs were programmed into DirectRT® and scheduled using MediaLab®. The use of MediaLab® allowed the participants to complete both IAT tasks without interruption from the experimenter.

Results

Differences between the two implicit measures

This study investigated the difference between implicit associations of error messages with anxiety and implicit associations of error messages with frustration. The IAT measures the strength of cognitive associations between stimuli (error and neutral computer messages) and attributes (synonyms of anxiety and frustration). As participants completed two IATs, we obtained two measures of the strength of implicit associations that use a common measuring scale (IAT's D value). Descriptive statistics of these two measures are presented in Table 4.

Table 4. Descriptive statistics of the IAT results.

	min	max	mean	SD
IAT anxiety	-0.129	1.459	0.656	0.350
IAT frustration	-0.329	1.239	0.494	0.331

Table 5 shows that anxiety and frustration are both implicitly associated with error messages, but the intensity of this association is significantly different from one emotion to the other: $t(71) = 4.171$, $p < .001$. The effect size of the difference between the two means was d (Cohen) = .487 and can be considered a medium effect (Cohen, 1988). The statistical power of the t test was .98 (for $\alpha = .05$, two tailed test).

Table 5. Statistical results of the within-group comparison.

t (Student) test for paired samples	Linear Correlation (*r*) between the two measures	*d* (Cohen)
$t(71) = 4.171$, $p<.001$	$r(71) = .513$	0.487

These results support Hypothesis 1, showing significant differences between the implicit associations of error messages with anxiety and frustration. According to our results, error messages are more strongly associated with anxiety (m = 0.656, SD = 0.350), than with frustration (m = 0.494, SD = 0.331).

Computer experience

We measured two facets of computer experience: the number of years our participants are using a computer and the number of years our participants owned a computer. Results presented in Table 6 show very low correlations (absolute r values between .053 and .099) between these two facets of computer experience and the implicit associations of anxiety and frustration with computer error.

English proficiency

English proficiency was measured by asking participants to rate their reading, writing, comprehension and speaking abilities in English, using a 10 grades scale. Higher grades indicate a higher level of English proficiency. The results presented in Table 6 supported Hypothesis 4a, predicting that English proficiency will correlate negatively with the implicit association between anxiety and error messages: $r(73) = -.307$, $p < .05$, with a statistical power of .84 (for $\alpha = .05$, one-tail test). The correlation that tested Hypothesis 4b was statistically insignificant: $r(73) = -.192$, $p > .05$, with a statistical power of .50 (for $\alpha = .05$, one-tail test).

Table 6. Corelation matrix of the variables included in Hypotesis 2, 3 and 4.

	1	2	3	4	5	6
1. IAT anxiety	1					
2. IAT frustration	.513*	1				
3. Emotional stability	-.306*	-.161	1			
4. English comprehension	-.307*	-.192	.119	1		
5. Years of computer experience	-.099	.053	.088	.253*	1	
6. Years of owning a personal computer	.063	.098	.153	.183	.653*	1

Note: N = 73. Correlations marked with * are statistically significant at $p < .05$ (one tail).

Emotional stability

Emotional stability (or low neuroticism) was measured using the DECAS Personality Inventory (Sava, 2008). Results presented in Table 6 indicate a negative correlation between Emotional Stability and IAT-anxiety, thus supporting Hypothesis 3a: $r(73) = -.306$, $p < .05$. The statistical power for this correlation coefficient is .84 (for $\alpha = .05$, one-tail test). No support was found for Hypothesis 3b: $r(73) = -.161$, $p > .05$, with a statistical power of .40 (for $\alpha = .05$, one-tail test).

Discussions

As computer software is becoming more complex, the focus placed by developers on the cognitive ergonomics of their products does not solve all the usability issues (Karat, Karat, & Ukeslon, 2000). Therefore, current research of the Human-Computer Interaction is shifting its interest on user's emotional reactions to computers. In this context, the present research investigated two of the main emotional outcomes of error messages: user anxiety and user frustration.

This study investigated the implicit associations of anxiety and frustration with computer error messages. Using this approach, we found a significant correlation between the two implicit measures, which could indicate that error messages are associated with undifferentiated, negative affectivity. This particular result indicates that, when error messages occur, high levels of anxiety are associated with high levels of frustration. Nevertheless, it seems that anxiety has a more powerful implicit association with error messages than frustration. From the information processing perspective, it seems that error messages have stronger automatic associations with users' anxious behaviours, than with frustration releasing behaviours. If the IAT measures learning experiences that have been lost to memory (James & Rentsch, 2004), it seems that in the early moments of computer experience, users were more frequently scared than frustrated. Although both anxiety and frustration are associated with biological increased non-specific arousal, these emotions have different mechanisms for using this arousal. State anxiety uses the non-specific arousal for securing the user from any anticipated threat, and frustration uses the non-specific arousal for dealing and overcoming obstacles. Our

results suggest that users are more likely to involve in security enhancing behaviours when facing error messages, rather than in problem solving behaviours. These results also indicate that anxiety-reducing techniques should be used in error management trainings, as a measure for improving their efficacy when learning a new computer program.

A surprising result is the lack of association between computer experience and our two implicit measures. Although the literature reports the existence of such associations with explicit measures of computer anxiety and computer frustration, our correlation coefficients were very small. We believe there are two possible explanations for this finding. First of all, it is possible that our participants were too experienced. If we consider that the IAT measure is the product of a forgotten learning experience (James & Rentsch, 2004), it is possible that our subjects' learning experience has ended. Therefore, more years of experience should not lead to stronger or weaker implicit associations. The second explanation is related to the different nature of explicit and implicit measures. As implicit associations are not available to introspection (Greenwald et al., 1998), their evolution should not associate with the increase of experience. On the other hand, more experience should lead to better coping mechanisms and lower emotional reactivity to threatening or frustrating events. Therefore, it is reasonable to conclude that increased experience is negatively associated with negative emotional reactions (due to better coping mechanisms and better solving strategies), but not with implicit reactions (which are related to an earlier experience with computers).

The present research also tested the relations between the implicit associations and emotional stability. Results suggest that a high level of emotional stability is associated with a low level of implicit association between error messages and anxiety. Emotional stability is not significantly associated with the implicit association between error messages and frustration. This result indicates that frustration might be related to contextual variables, not dispositional variables.

English comprehension is an important variable that should be taken into consideration by research conducted on computer users that do not speak English as their native language. Our results indicate that difficulties in understanding the contents of error messages are associated with high levels of implicit associations between error messages and anxiety. English comprehension was not associated with the implicit measure of error message frustration. This result indicates that people are more likely to feel anxious than frustrated when they cannot understand an error message.

The results of the present research indicated that learning how to deal with computer error messages involves coping with anxiety and, to a smaller extent, coping with frustration. Therefore, trainers should pay attention to creating a secured environment, in order to facilitate the learning of new computer programs. The correlation between English comprehension and IAT anxiety indicated that the linguistic barrier should be one of the first that should be addressed when creating a proper environment for development of computer skills.

Future research should incorporate implicit measures, in order to investigate the relations between implicit and explicit reactions to various computer experiences. This approach should provide a better understanding of user computer experiences and ultimately should lead to better interface design.

References

Bailey B. P., Konstan J. A., & Carlis J. V. (2001). The effects of interruptions on task performance, annoyance, and anxiety in the user interface. In: M. Hirose (Ed.), *Human-Computer Interaction – INTERACT 2001 Conference Proceedings* (pp.593-601). Amsterdam: IOS Press.

Bandura, A. (1997). Self-efficacy. *Harvard Mental Health Letter*, *13*, 4-7.

Bessiere, K., Ceaparu, I., Lazar, J., Robinson, J.P., & Shneiderman, B. (2004). Social and Psychological Influences on Computer User Frustration. In Bucy, E. and Newhagen, J. (eds.) *Media Access: Social and Psychological Dimensions of New Technology Use* (pp.169-192). Mahwah, NJ: Lawrence Erlbaum Associates.

Bessiere, K., Newhagen, J.E., Robinson, J.P., & Shneiderman, B. (2006). A Model for Computer Frustration: The Role of Instrumental and Dispositional Factors on Incident, Session, Post-session Frustration and Mood. *Computers in Human Behavior*, *22*, 941-961.

Blakely, R. (2006). As Microsoft looks ahead, will Vista be the end of an era?. *The Times*, 9 December, 66.

Bloom, A.J., & Hautoluoma, J.E. (1990). Anxiety management training as a strategy for enhancing computer user performance. *Computers in Human Behavior*, *6*, 337-349.

Caprara, G.V., Barbaranelli, C., Borgogni, L., & Perugini, M. (1993). The Big Five Questionnaire: A new questionnaire for the measurement of the five-factor model. *Personality and Individual Differences*, *15*, 281-288.

Ceaparu, I., Lazar, J., Bessiere, K., Robinson, J.P., & Shneiderman, B. (2004). Determining Causes and Severity of End-User Frustration. *International Journal of Human-Computer Interaction*, *17*, 333-356.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences (2nd ed.)*. Hillsdale: Erlbaum.

Costa, P.T. Jr., & McCrae, R.R. (1992). *Revised NEO Personality Inventory (NEO PI-R) and NEO Five-Factor Inventory (NEO PI-FFI).* Odessa, FL: Psychological Assessment Resources.

Frese, M., Brodbeck, F., Heinbokel, T., Mooser, C., Schleiffenbaum, E., & Thiemann, P. (1991). Errors in Training Computer Skills: On the Positive Function of Errors. *Human-Computer Interaction*, *6*, 77-93.

Gaudry, E., Vagg, P., & Spielberger, C.D. (1975). Validation of The State-Trait Distinction in Anxiety Research. *Multivariate Behavioral Research*, *10*, 331-341.

Goldberg, L.R. (1992). The development of markers of the Big-Five factor structure. *Psychological Assessment*, *4*, 26-42.

Greenwald, A.G., McGhee, D.E., & Schwartz, J.L. (1998). Measuring Individual Differences in Implicit Cognition: The Implicit Association Test. *Journal of Personality and Social Psychology*, *74*, 1464-1480.

Greenwald, A.G., Nosek, B.A., & Banaji, M.R. (2003). Understanding and Using the Implicit Association Test: I. An Improved Scoring Algorithm. *Journal of Personality and Social Psychology*, *85*, 197-216.

Gschwendner, T., Hoffmann, W., & Schmitt, M. (2008). Convergent and Predictive Validity of Implicit and Explicit Anxiety Measures as a Function of Specificity

Similarity and Content Similarity. *European Journal of Psychological Assessment, 24*, 254-262.

Heimbeck, D., Frese, M., Sonnentag, S., & Keith, N. (2003). Integrating errors into the training process: the function of error management instructions and the role of goal orientation. *Personnel Psychology*, *56*, 333-361.

Heinssen, R.K., Glass, C.R., & Knight, L.A. (1987). Assessing computer anxiety: Development and validation of the Computer Anxiety Rating Scale. *Computers in Human Behavior*, *3*, 49-59.

Hofmann, W., Gawronski, B., Gschwendner, T., Lee, H., & Schmitt, M. (2005). A Meta-Analysis on the Correlation Between the Implicit Association Test and Explicit Self-Report Measures. *Personality and Social Psychology Bulletin*, *31*, 1369-1385.

Ipsos MORI (2009). *Employees Get 'It' Out Of Their Systems*. Available online at: http://www.ipsos-mori.com/content/employees-get-it-out-of-their-systems.ashx (accessed 15 February 2009).

James, L.R., & Rentsch, J.R. (2004). J-U-S-T-I-F-Y to Explain the Reasons Why: A Conditional Reasoning Approach to Understand Motivated Behavior. In Schneider, B. and Smith, D.B (eds.). *Personality and Organizations* (pp. 223-250). New Jersey: Lawrence Erlbaum Associates, Inc.

Karat, J., Karat, C.M., & Ukelson, J. (2000). Affordances, Motivation, and the Design of User Interfaces. *Communications of the ACM, 43*, 49-51.

Keith, N. (2005), *Self-Regulatory Processes In Error Management Training*, Inaugural-Dissertation zur Erlangung des Doktorgrades der Philosophie des Fachbereiches 06 psychologie und Sportwissenschaft der Justus-Liebig-Universität Gießen, Frankfurt.

Lazar, J., Jones, A., & Schneiderman, B. (2006). Workplace user frustration with computers: an exploratory investigation of the causes and severity. *Behaviour and Information Technology, 25*, 239-251.

Maricuțoiu, L.P., & Sava, F.A. (2009). *PowerStaTim 1.0. The analysis of statistical power and effect size* [computer software]. Available online at www.psihologietm.ro/download/membrii/powerstatim.rar (accessed 20 March 2009).

Maricuțoiu, L.P. (2006). Emotional response to computer error messages. *Psihologia Resurselor Umane/Human Resources Psychology*, *4*, 46-53.

McCrickard, D. S., Catrambone, R., & Stasko, J. T. (2001). Evaluating animation in the periphery as a mechanism for maintaining awareness. In M. Hirose (Ed.), *Human-Computer Interaction – INTERACT 2001 Conference Proceedings* (pp.148-156). Amsterdam: IOS Press.

McCrickard, D. S., Chewar, C. M., Somervell, J. P., & Ndiwalana, A. (2003). A model for notification systems evaluation – Assessing user goals for multitasking activity. *ACM Transactions on Computer-Human Interaction*, *10*, 312-338.

Pitariu, H. (1994). Psychophysiological responses during human-computer interaction of naive users: Preliminary data. *Creier, Cogniție, Comportament / Cognition, Brain, Behavior*, *4*, 11-27.

Rose, C.L., Bennett-Murphy, L., Byard, L., & Nikzad, L. (2002). The Role of the Big Five Personality Factors in Vigilance Performance and Workload. *European Journal of Personality*, *16*, 185-200.

Rozell, E.J., & Gardner, W.L. III (1999). Computer-Related Success and Failure: A longitudinal Field Study of the Factors Influencing Computer-Related Performance. *Computers in Human Behavior*, *15*, 1-10.

Sava, F.A. (2008). *Inventarul de personalitate DECAS/DECAS Personality Inventory*. Timișoara: Artpress.

Smith, B., & Caputi, P. (2001). Cognitive interference in computer anxiety. *Behaviour and Information Technology*, *20*, 265-273.

Spector, P.E. (1978). Organizational Frustration: A Model and Review of the Literature. *Personnel Psychology*, *31*, 815-829.

Steffens, M.C., & Schulze-Konig, S. (2006). Predicting Spontaneous Big Five Behavior with Implicit Association Tests. *European Journal of Psychological Assessment*, *22*, 13-20.

Thatcher, J.B., & Perrewe, P.L.(2002). An Empirical Examination of Individual Traits as Antecedents to Computer Anxiety and Computer Self-Efficacy. *MIS Quarterly*, *26*, 381-396.

Tulbure, B.T. (2006). *Dissimulating Anxiety in Front of The Implicit Association Test (IAT). Cogniție, Creier, Comportament / Cognition, Brain, Behavior*, *10*, 559-579.

van der Linden, D., Sonnentag, S., Frese, M. & van Dick, C. (2001). Exploration strategies, performance, and error consequences when learning a complex computer task. *Behavior and Information Technology*, *20*, 189-198.

Zijlstra, F. R. H., Roe, R. A., Leonova, A. B., & Krediet, I. (1999). Temporal factors in mental work: Effects of interrupted activities. *Journal of Occupational and Organizational Psychology*, *72*, 163-190.