Touch OK to Continue: Error Messages and Affective Response on Interactive Public Displays

Hannu Kukka[1], Jorge Goncalves[1], Tommi Heikkinen[1], Olli-Pekka Suua[2], Yifei Zuo[2], Hannu Raappana[2], Mohamed Abdellatif[2], Olli Okkonen[2], Raúl Jiménez[2], Timo Ojala[1]

Department of Computer Science and Engineering, University of Oulu, Finland
[1][firstname].[lastname]@ee.oulu.fi [2][firstname].[lastname]@student.oulu.fi

ABSTRACT

This paper contributes to the important, if somewhat overlooked, topic of error message handling on interactive public displays. As the complexity of public display services increase, error situations are likely to increase correspondingly. This study is a first step in attempting to discover and understand the effect different types of error messages have on the user's affective response while using a public display application. A total of 12 error messages that varied in *tone*, *severity*, and *mode* (3x2x2 factorial design) were designed, and data was gathered in a field trial with 84 participants. Results show that using friendly or neutral tones, and providing users with an active role, has a positive impact on their affective state, and the active role also helps persuade users to continue the interaction after an error situation. Further, errors that force users to return to the main menu instead of allowing them to continue their current session have a strong negative impact on their affective state, and will more likely cause a person to quit the interaction and leave the display.

Author Keywords

Error messages; affective response; tone; severity; mode; field trial; factorial design;

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

As public display installations become more common, the spectrum of services provided on this platform naturally also grows. While the service offering will vary in purpose and technological implementation, qualitative attributes such as usability and user experience will require increasingly careful attention. This is because, quite often, public displays do not contain *critical* information - information that a person will need in order to carry out his/her primary task in the setting where the display is installed. Conversely, the prevalent use case for interactive public screens is to provide *convenience* services that provide added value to their users.

PerDis '15, June 10 - 12, 2015, Saarbruecken, Germany
ACM 978-1-4503-3608-6/15/06…$15.00
DOI: http://dx.doi.org/10.1145/2757710.2757723

Public displays are, quintessentially, *public artifacts* and, as such, people have no personal investment (monetary or otherwise) in them. People will therefore likely give up and move along rather than spend copious amounts of time attempting to master an interface they deem difficult. In other words, public display interfaces need to be *intuitive*, *self-explanatory*, and *engaging*, all at the same time. Meeting these requirements, however, may lead to superficial services that do not offer much beyond ephemeral interactions [9].

When we look at the way public display applications and services have developed over the years, from simple presence and noticeboard apps (*e.g.* [3,4]) to fully fledged platforms with their own app stores [5] and multiple services in various categories [12], we can see that public displays as a platform are growing more complex. One potential consequence of the increased complexity and functionality of a public display service is that error situations may occur more frequently. Due to the very limited I/O capabilities and lack of any administrative privileges provided to the user, and the fact that these devices are always owned by "somebody else", diagnosing and responding to error situations is something that users will not likely do [25]. As error situations are virtually unavoidable on any computer system, instead of simply accepting them as a fact of life, designers of public display services should be aware of how these messages could potentially be used to convey important information and, more importantly, keep the user from leaving the moment something goes wrong.

In this paper we will look at the impact particular aspects of error messages (*tone*, *severity*, and *mode*) have on affective response while using a simple puzzle game on a public display. Data was gathered in a field trial on a university campus with 84 participants. Based on this study, we will explore how the aforementioned attributes contribute to the users' willingness to continue the interaction after an error occurs, and how they influence the user's affective responses using the Panas X affect scale [28].

Specifically, this study focuses on the following related research questions:

Question 1: Do different *tones* (friendly, neutral, hostile) of error messages cause specific affective responses, and/or affect the users' willingness to continue the interaction after an error has occurred?

Question 2: Is the affective impact of error messages moderated by the *mode* (active/passive) they are delivered, and/or does the mode affect the users' willingness to continue the interaction after an error has occurred?

Question 3: Are there differences between affective responses or the willingness to continue with interaction after an error situation when the *severity* (soft/hard) of the error is modified?

This paper thus contributes to the important, if somewhat overlooked, topic of error message handling on interactive public displays. Although far from definite, our results serve as a solid starting point for designing error dialogues, and as an overall conversation starter on the effect of different types of error messages on the affective response of the users.

RELATED WORK

To the best of our best knowledge, the effect of error messages on affective response has not been studied in the context of public displays. There has been some preliminary work regarding using personal media on public displays to increase users' attachment and to reduce display blindness [14], and using public displays as a platform to assess community members' diurnal collective emotion [7]. Outside public displays, affective user interfaces have seen an extensive research effort with personal computers. Here, we will focus mainly on reviewing this literature as related work.

In the context of information retrieval systems on personal computers, Park et al. [17] studied affect and perceptions of users between three types of on-screen messages: neutral, apologetic, and non-apologetic. Similar to our study, the authors focused on user frustration in the presence of on-screen messages based on the tone of the message. In addition, they considered how these tones affect the trust users have for the system and how aesthetically appealing and useful they experience them. A study with 30 participants revealed that apologetic messages caused users to perceive the system as more aesthetically appealing and usable, and apologetic messages were also shown to lower user frustration.

Tzeng [26] explored the effect of in-game feedback messages on the perception of performance and frustration with a word guessing game on personal computers that was deliberately made imperfect. Feedback messages used apologetic (taking the responsibility of the poor performance of user), and non-apologetic tone, and the messages either did or did not use emoticons. Apologetic messages appeared to yield more desirable psychological experience for the users, but the computer's actual performance dominated the perception of performance. The emoticon helped to improve perceived aesthetic quality.

Pfister et al. [18] conducted a study using three types of messages, which were presented either as text or speech, and either alone or in combination with icons or sounds while users worked on typical computer tasks. Their results showed that different message categories elicit different patterns of affective responses, and error messages specifically are associated with unpleasantness, while input requests and status notifications lead to more pleasant feelings.

Akgun et al. [1] studied the perception of performance affected by the presence of apologetic error messages in an educational web interface. Their study design was similar to that presented by Tzeng [26], but in addition considered the initial mood of the users. Results indicated that, in contrast to Tzeng, the perception of performance was affected by the apologetic messages. The human-human interaction apologetic strategies that were applied into human-computer interaction further showed that the mood of the user dictated the best strategy for choosing the content of a message.

Regarding messages that can best persuade participants to continue interacting [13], Fogg and Nass [6] asked participants to play a guessing-game, which gave in-game feedback using tones varying from "sincere praise", "flattery (insincere praise)" to "generic feedback". Both flattering tones significantly increased the users' willingness to continue the interaction compared to the generic feedback, while the specific flattery type did not have a significant effect. Participants also enjoyed the interaction more when flattery was used. Johnson et al. [10] got similar results by purposely mirroring the tones and game setup employed by Fogg and Nass, but they extended the research by looking also how users' experience level affects the results. The study showed that users' experience amplified the results, *i.e.* experienced users trusted the messages from computers more, estimated their performance higher, and experienced more positive affect.

In summary, affective and especially apologetic system messages have been studied in detail in the context of personal computers, and an apologetic tone has been shown to be effective for decreasing user frustration. It has also been shown that the tone can have a positive effect on users' willingness to continue with an interaction. All of the reviewed works focus on private settings and personal computers. In this paper we will contribute to the discussion by extending the focus to user interfaces in public spaces, on interactive public displays.

RESEARCH DESIGN

Task Design

We chose a simple jigsaw puzzle game as the task our participants were asked to perform. The game featured three images the participant could choose from, and the chosen image was divided into segments that were then scrambled on the screen (figure 1). The user had to move segments around by selecting one segment, and then another one with which the chosen segment would switch places.

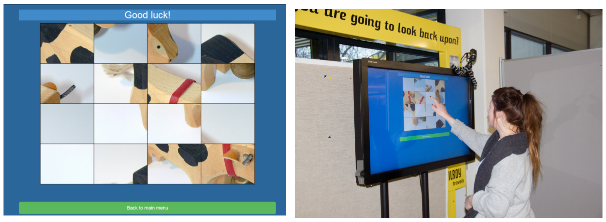

Figure 1. Puzzle game (left); test set-up (right)

The rationale behind selecting a simple game instead of a more complex application was that we wanted to have a very approachable and intuitive walk-up-and-use application with a simple control scheme. This way, errors would appear more random and less tied to user actions than they would with a more complex interface and task designation. Several previous studies on error messages (*e.g.* [6,11,25]) have used a similar design, as it helps focus on the effect of error instead of interface design.

Error Messages

In order to study the effect of error messages on the users' willingness to continue the interaction and their overall use experience, we applied a three-factorial between-subjects design with *tone* (3 levels), *mode* (2 levels), and *severity* (2 levels) as experimental factors. This design results in a total of 12 conditions (error messages). Table 1 lists the error messages that were shown to participants.

Tone	Mode	
	Passive	*Active*
Hostile	"Error! You broke the system. Attempting to restore…"	"Error! You broke the system! Touch OK to resume"
Neutral	"An error has occurred. Attempting to fix the problem…"	"An error has occurred. Touch OK to resume"
Friendly	"We are very sorry but the system just crashed. Trying to fix the problem…"	"We are very sorry but the system just crashed. Touch OK to resume"

Table 1. Error messages

The *tone* of the error message was varied on three levels: messages could either convey a *friendly*, *neutral*, or *hostile* tone. Although using purposefully hostile messages might seem counterintuitive, real-world computer systems do use them frequently. These hostile messages can range from subtle and to-the-point ("Error!"), to more extreme examples such as the "blue screen of death".

The *mode* of the message was varied on two levels, so that the message could either be *active*, requiring user input to dismiss, or *passive*, where the message would disappear after a fixed time period. With passive messages, the user was not informed how long the system would take to resolve the issue, but a counter was counting up from 0 to show that the system had not frozen completely and something was happening. The passive error would resolve itself after 15 seconds. Conversely, active messages required the user to touch an 'OK' button to continue. Examples of active and passive error messages are shown in figure 2.

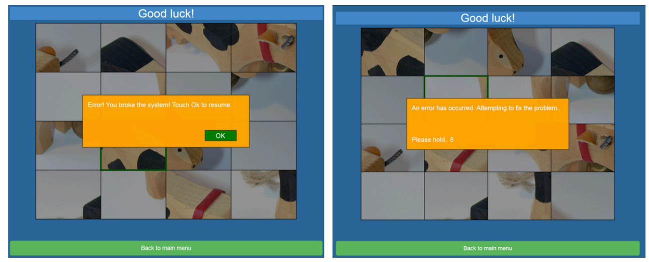

Figure 2. Active (left) and passive (right) error messages

Finally, the *severity* of the error (crash) was also varied on two levels, so that an error situation could result in a *soft crash* (user able to continue his/her current session), or *hard crash* (user taken back to the main menu).

The first error message would appear on the screen after the user had tapped the screen 15 times, and following messages would be shown at random intervals every 3-15 taps. We implemented a short delay between a detected touch and the appearance of a message so that participants would not as easily realize that their actions were causing the errors.

Measuring Affective Response

A well-known fact is that computer crashes may elicit strong emotional responses in users, and previous work has shown that poorly designed error messages can lead to negative effects such as impairment of interaction, decreased productivity, inability to pay attention, and increased levels of anxiety [17]. However, besides anger and frustration, computer interfaces and messages can elicit various other affective responses, which may influence the user's general attitude towards an application. Borrowing from Pfister [18], we adopt the definition of affect as follows: "Affect *is taken as a general category for any valenced feeling state, be it conscious or unconscious, with or without particular cognitive appraisals, and with or without specific physiological or neuronal correlates. Subjectively, affect is usually experienced as a general feeling of pleasure or displeasure [...] An* affective response *is an immediate and for the most part automatic reaction to an eliciting event, such as a fearful reaction upon seeing a snake, or a fit of frustration after experiencing the third computer crash in a row."* According to Russell [22], any affective response involves an evaluation of the eliciting event with respect to it being pleasant or unpleasant, and this basic affective response is assumed to be quick and automatic [29]. In this study we are interested in these kinds of *immediate affective responses* caused by the various types of error messages presented on the public display.

To measure participant's subjective assessment of affect, we employed the Panas X (Positive and Negative Affect Schedule) questionnaire [28]. Panas X is an expanded version of the original PANAS [27], and includes 60 items on a 5-point scale (very slightly or not at all (1) … extremely (5)). The questions measure the respondent's self-assessment of two mood scales: one that measures *positive affect*, and the other which measures *negative affect*. In addition to the two original higher order scales, the expanded Panas X scale measures 11 specific affects: *fear*, *sadness*, *guilt*, *hostility*, *shyness*, *fatigue*, *surprise*, *joviality*, *self-assurance*, *attentiveness*, and *serenity*.

Specifically, we wanted to see if any of the introduced variables (tone, mode, severity) would have a significant effect on the general positive/negative affect and/or the 11 specific affects in the Panas X scale. However, our research design included allowing people to quit at any time they wished, *i.e.* we did not consciously stress the participants by requiring them to complete a fixed number of games (despite the errors). Because of this, we were aware of the fact that especially negative feelings would likely not have time to develop significantly, since participants would likely stop playing and walk away once they started feeling angry/frustrated/*etc*. This is a much more realistic scenario with public displays than requiring people to carry out a specified number of tasks to ensure that a strong emotional response is created. As was explained previously, in a real-life scenario people are much more likely to abandon the interaction sequence in the case of a serious error than attempt to diagnose and/or fix the error, or persevere and continue the interaction despite it. This research design allows us to explore and find the boundaries of the design space around public display error message handling.

Field Trial

The study was carried out as a semi-controlled field trial on a university campus with 84 participants (43 female). A 46" public display was set up at a central location on the main campus (figure 1), and researchers were present during the trial to recruit passers-by to try the system.

Participants were randomly assigned to a condition, and informed that their task was to play a puzzle game on the public display for as long as they wished, and that they could quit at any time. Participants were given space to interact with the system, and were told to come talk to a researcher after they were done. The interaction sequence was videotaped if the participant gave his/her signed consent (n=30). We used a setup with two cameras recording simultaneously: one for capturing the facial expressions of the participant, and the other to capture body language and bodily expressions. During a gameplay session, the system automatically logged information on how many error messages the participant saw, how many retries s/he did, and the total time spent interacting with the display. After the participant decided to quit, s/he was asked to fill in the Panas X questionnaire.

RESULTS

Table 2 shows the results of measurements for each condition. The highest values for each variable are marked with dark green. Values that are better than the average are highlighted with light green and those that are worse are highlighted with light red. Dark red color marks the worst condition for each variable. The variables are marked with letters, so that the first letter signifies the *mode* (**A**ctive or **P**assive), the second *tone* (**H**ostile, **N**eutral, **F**riendly), and the third *severity* (**S**oft crash or **H**ard crash).

Condition	No. retries	Positive affect	Negative affect
1. A-H-S	8.14	28.57	13.71
2. A-H-H	6.14	29.43	16.00
3. A-F-S	7.43	24.43	12.86
4. A-F-H	5.86	29.71	17.57
5. A-N-S	4.57	27.14	12.29
6. A-N-H	3.71	30.86	13.43
7. P-H-S	3.14	30.29	14.29
8. P-H-H	3.43	23.86	14.29
9. P-F-S	3.29	30.14	14.29
10. P-F-H	5.14	26.71	16.29
11. P-N-S	3.43	28.14	14.71
12. P-N-H	3.43	26.57	12.71
Average	**4.81**	**27.99**	**14.37**

Table 2. Number of retries, positive affect and negative affect for each condition

Only condition 1 (active, hostile, soft) got above average values in every measurement. It is noteworthy that negative affect is measured on an inverse scale, *i.e.* lower values are considered better as they signal a lower negative affect. Conditions 2 (active, hostile, hard), 3 (active, friendly, soft), 4 (active, friendly, hard) and 10 (passive, friendly, hard) also got above average number of retries. Other notable conditions with high positive affect, and low negative affect are 6 (active, neutral, hard), 7 (passive, hostile, soft) and 9 (passive, friendly, soft).

A Mann-Whitney U test indicated that the number of retries was significantly greater for those that encountered *active* error message than for those that encountered *passive* error messages ($U=529.5$, $z=-3.18$, $p<.01$). There was no significant difference in number of retries for the *tone* and *severity* independent variables.

Regarding the *positive* and *negative affect* obtained from the Panas X questionnaire, there were no statistically significant differences between participants in different conditions. However, we found several significant results when considering the 11 specific affects measured with the expanded Panas X scale. For instance, there was a statistically significant difference in the *hostility affect* score (U=615, z=-2.42, p=.02) and *surprise affect* score (U=658.5, z=-2.01, p=.04) when considering the *severity* independent variable. Participants that encountered hard crashes reported feeling more *hostile* and *surprised* when compared to those that encountered a soft crash (mean rank score of 48.85 vs. 36.15 for the *hostility* affect and 47.82 vs. 37.18 for the *surprise* affect). There was also a statistically significant difference in the *shyness affect* score when considering the *mode* (U=620, z=-.27, p=.02), with a mean rank *shyness affect* score of 48.74 for *passive* error messages and 36.26 for *active* error messages. Finally, Kruskal-Wallis H-test indicated a significant effect of *tone* on the *serene affect* score ($\chi^2(2)=6.54$, p=.04). The mean rank *serene affect* score for *neutral* error messages was 51.34, 41.07 for *friendly* error messages and 21.35 for *hostile* error messages.

Participant Feedback and Video Analysis

To better understand the effect of errors in general, and the effects of the controlled variables in particular, a video recording was made of participants who gave their consent. This material was then transcribed, and two researchers carried out analysis jointly. It should be noted that participants were not interviewed, and all comments shown here were made spontaneously by the participants. The video recording provided valuable insights on the types of behaviors occurring with different types of error messages, and by using two cameras we were able to capture the full range of non-verbal communication in the form of both bodily gestures and facial expressions. In the scope of this paper, video data can be considered as a supportive source of descriptive qualitative data.

Overall, encountering the first unexpected error caused confusion among the majority of participants:

"I don't understand if I did something wrong here".

"Can I continue? I'm afraid I broke your device".

Another participant, after encountering multiple errors, complained about not being able to complete the task:

"*The game is broken, it won't let me finish!"*

Participants seemed to become increasingly frustrated when encountering errors. However, for the majority of participants encountering aggressively toned messages, or hard crashes, or both error messages, the increase was more rapid, leading to a fewer retries. From the video we can see participants expressing frustration through facial expressions, coarse language, speaking out-loud, and pronounced bodily gestures (figure 3).

Further, video analysis showed that especially with a combination of *active-soft crash* error messages, where participants were able to continue their current game after an error occurred, participants tended to closely read the initial error message before taking action. The subsequent messages, on the other hand, were quickly dismissed with little to no attention given to them, and the observable body language or facial expressions did not convey much anger, frustration, or other negative feelings. This is in agreement with the subjective affective results, which showed lower scores for *hostility* and *surprised* for participants who experienced *soft crash* conditions.

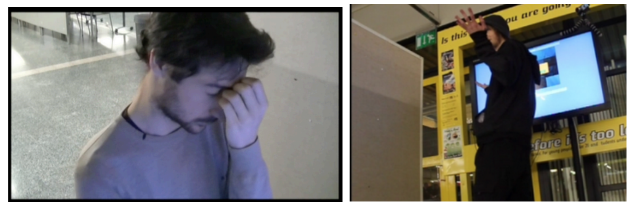

Figure 3. Participants expressing frustration

Interestingly, a few participants did not mention the errors at all. This can partly be explained by the fact that users likely found the errors uncomfortable and did not want to bring attention to the issue, perhaps because they were afraid that they might have inadvertently broken something. These types of reactions further highlight that people are not accustomed to dealing with problem situations while using technology in public spaces.

DISCUSSION

Error situations on public interfaces, such as public displays, have not attracted an extensive research effort. This is perhaps due to the fact that a 3rd party, such as a research group, a company, or the proprietor of a business, always maintains these systems and as such, the end users are not expected to respond to or interact with error dialogues. However, as the complexity of public display applications continues to increase, error situations are likely to also become increasingly common. In this paper we have explored error messages with three attributes (mode, tone and severity) on a public display application. The variables were combined into 12 conditions, and we studied their effect on people's willingness to continue interaction with the application despite recurring error situations, and the way these variables elicited different affective responses from the participants.

Next, we will discuss the results from this study and attempt to answer the three research questions posited in the introduction. First, regarding *research question 1*, the *tone* of the error message did not seem to have an effect on the number of retries or people's willingness to continue the interaction. The tone did, however, significantly impact the *serenity affect* score of participants, indicating that neutral and friendly messages positively influenced the participants' affective state and made them feel calmer than messages using a hostile tone. Hence, similarly to other studies using affective language, people react more positively to friendly tones than hostile ones. However, video analysis did not show strong reactions that could be attributed to messages using a hostile tone. This finding can be at least partially explained by looking at the various roles *affect* can play in human-computer interaction [8,16]. Specifically, of interest here is the so-called *social perspective* [18], also known as Media Equation Theory [23]. The theory posits that a user might perceive the computer as another social actor [21], and a human-computer interaction sequence as a social situation [18]. In this context, an encounter with a public display might take on the characteristics of a civil if somewhat aloof encounter with a stranger in a public space - pleasantries are exchanged, but the conversation is not meaningful enough for the tone to elicit very strong responses. Hence, similarly to accidentally bumping into another person on the train, an error message apologizing for the inconvenience will likely be considered a polite if somewhat meaningless pleasantry. Hence, the tone of the message is of limited importance as long as the main information content is carried across. However, it is noteworthy that we did not design the messages to be overly affective in nature, *e.g.* messages that would be very apologetic, but kept a more neutral wording while varying the tone of our messages. Previous research on desktop computers has shown that apologetic messages can positively influence feelings of usability, aesthetics, trust, *etc.* [17]. Whether the same would hold true for apologetic messages on public displays is a topic for future research.

Regarding *research question 2*, results of the quantitative analysis showed that *active* error messages were by far better at encouraging participants to retry, and that participants did significantly more retries than with *passive* messages. The relative success of active messages follows the early guidelines for compiler error messages presented by Scheiderman already in 1982 [24]: "*place the user in control of the situation and provide him/her with enough information to take action*". Placing the user in control gives him/her agency and a feeling of empowerment, which is important since previous work has shown that interruptions in general [2], and error messages in particular, tend to cause feelings of unpleasantness, and can even cause measurable physiological responses such as increased skin conductivity [18]. Panas X data from our study showed that participants who experienced the *passive* condition reported a significant increase in the *shyness* affect than those who experienced the *active* condition.

Referring back to the results of the video analysis, we saw that participants who experienced the *active* conditions did not display strong bodily reactions or facial cues when encountering error messages, and the body language became even subtler with following messages. Conversely, participants in the *passive* condition seemed helpless and lost, often imploring the researchers to help them. At times, participants in the *passive* condition showed strong bodily reactions such as crossing arms over the chest, shaking their head, or sighing and yawning. Based on this data, we can answer the research question 2: *active* messages are better at helping users keep calm and continue with the interaction, despite recurring error situations, whereas *passive* messages tend to elicit stronger physiological and mental reactions in the participants.

The caveat here is, that even though the error messages in this particular study were always identical for a given user, in a situation where the system needs to communicate variable information through error messages, recurring active messages may be missed as the user quickly learns to dismiss them without shifting his/her attention from the primary task. Conversely, passive messages will likely get more attention from the user, but especially in recurring situations the user's affective state begins to lean towards negative very quickly.

Finally, regarding *research question 3*, we did not find a statistically significant effect of the *severity* attribute on the number of retries. However, the *severity* of the error message does appear to have an influence on the participants' affective state, as participants who encountered hard crashes reported feeling more *hostile* and *surprised* when compared to those that encountered a soft crash, demonstrating a measurable shift in their affective state. Further anecdotal evidence from the video footage reveals that *hard crashes* confused and frustrated users to a much greater extent than soft crashes, and many of the recorded participants experiencing hard crashes attempted to contact the researches after an error occurred. The *hard crash* condition clearly caused visually detectable frustration and anger, and prompted the participants to use profane language and, once, even physical force towards the display.

CONCLUSIONS AND FUTURE WORK

In conclusion, public display systems pose some very unique challenges to interface designers. Conversely from desktop systems, these devices are not owned or administered by the users, and as such presenting meaningful information to the user in error situations is crucial. This study has shown that empowering users to take an active hand in these error situations encourages them to persevere and continue the interaction, even in the case of multiple successive error situations. An obvious future extension of this work is towards affective computing [19,20], so that a public display would recognize and model the affective state and emotions of the user [15] and adapt its interface accordingly.

A limitation of this study is the fact that we only experimented with a simple puzzle game. As the complexity of the interface grows, we assume the number and complexity of error messages also increases, and it will not always be possible to resume operation after an error. Our study followed a between-subjects design, where one participant was exposed to one type of error message. In the future, we plan on experimenting with a within-subject design and doing experience sampling after each error occurs. This way we can hopefully better understand how negative affect and frustration in general accrue over time.

REFERENCES

1. Akgun, M., Cagiltay, K. and Zeyrek, D. The effect of apologetic error messages and mood states on computer users self-appraisal of performance. *Journal of Pragmatics 42,* 9 (2010), 2430-2448.
2. Bailey, B.P. and Konstan, J.A. On the need for attention-aware systems: Measuring effects of interruption on task

performance, error rate, and affective state. *Computers in Human Behavior 22,* 4 (2006), 685-708.

3. Brignull, H. and Rogers, Y. Enticing people to interact with large public displays in public spaces. In *Proceedings of INTERACT.* 2003, 17-24.
4. Churchill, E.F., Nelson, L., Denoue, L. and Girgensohn, A. The Plasma Poster Network: Posting Multimedia Content in Public Places. In *INTERACT.* 2003, 599-606.
5. Clinch, S., Davies, N., Kubitza, T. and Schmidt, A. Designing application stores for public display networks. In *Proceedings of the 2012 International Symposium on Pervasive Displays.* 2012, 10.
6. Fogg, B.J. and Nass, C. Silicon sycophants: the effects of computers that flatter. *International Journal of Human-Computer Studies 46,* 5 (1997), 551-561.
7. Goncalves, J., Pandab, P., Ferreira, D., Ghahramani, M., et al. Projective testing of diurnal collective emotion. In *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing.* 2014, 487-497.
8. Hudlicka, E. To feel or not to feel: The role of affect in human--computer interaction. *International Journal of Human-Computer Studies 59,* 1 (2003), 1-32.
9. Jacucci, G., Morrison, A., Richard, G.T., Kleimola, J., et al. Worlds of information: designing for engagement at a public multi-touch display. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems.* 2010, 2267-2276.
10. Johnson, D., Gardner, J. and Wiles, J. Experience as a moderator of the media equation: the impact of flattery and praise. *International Journal of Human-Computer Studies 61,* 3 (2004), 237-258.
11. Klein, J., Moon, Y. and Picard, R.W. This computer responds to user frustration:: Theory, design, and results. *Interacting with computers 14,* 2 (2002), 119-140.
12. Kostakos, V., Kukka, H., Goncalves, J., Tselios, N. and Ojala, T. Multipurpose public displays: how shortcut menus affect usage. *IEEE Comput Graph Appl 33,* 2 (2013), 56-63.
13. Kukka, H., Oja, H., Kostakos, V., Gonçalves, J. and Ojala, T. What makes you click: exploring visual signals to entice interaction on public displays. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems.* 2013, 1699-1708.
14. Lee, K., Clinch, S., Winstanley, C. and Davies, N. I love my display: combatting display blindness with emotional attachment. In *Proceedings of The International Symposium on Pervasive Displays.* 2014, 154.
15. Marsella, S. and Gratch, J. Computationally modeling human emotion. *Communications of the ACM 57,* 12 (2014), 56-67.
16. Moffat, D. Personality parameters and programs. *Creating personalities for synthetic actors*, 1997, 120-165.
17. Park, S.J., MacDonald, C.M. and Khoo, M. Do you care if a computer says sorry?: user experience design through affective messages. In *Proceedings of the Designing Interactive Systems Conference.* 2012, 731-740.
18. Pfister, H.-R., Wollstädter, S. and Peter, C. Affective responses to system messages in human--computer-interaction: Effects of modality and message type. *Interacting with Computers 23,* 4 (2011), 372-383.
19. Picard, R.W. *Affective computing.* MIT press, 2000.
20. Picard, R.W. Toward computers that recognize and respond to user emotion. *IBM systems journal 39,* 3.4 (2000), 705-719.
21. Reeves, B. and Nass, C.I. *The media equation : how people treat computers, television, and new media like real people and places.* CSLI Publications ; New York : Cambridge University Press, Stanford, Calif., 1996.
22. Russell, J.A. Core affect and the psychological construction of emotion. *Psychol Rev 110,* 1 (2003), 145-72.
23. Schlenker, B.R. and Darby, B.W. The Use of Apologies in Social Predicaments. *Social Psychology Quarterly 44,* 3 (1980), 271-278.
24. Shneiderman, B. Designing computer system messages. *Communications of the ACM 25,* 9 (1982), 610-611.
25. Taivan, C., José, R. and Silva, B. Understanding the use of web technologies for applications in open display networks. In *Pervasive Computing and Communications Workshops (PERCOM Workshops), 2014 IEEE International Conference on.* 2014, 500-505.
26. Tzeng, J.-Y. Toward a more civilized design: studying the effects of computers that apologize. *International Journal of Human-Computer Studies 61,* 3 (2004), 319-345.
27. Watson, D., Clark, L.A. and Tellegen, A. Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of personality and social psychology 54,* 6 (1988), 1063.
28. Watson, D. and Clark, L.A. The PANAS-X: Manual for the positive and negative affect schedule-expanded form. (1999).
29. Zajonc, R.B. On the primacy of affect. *American Psychologist 39,* 2 (1984), 117-123.