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A model for computer frustration: the role of instrumental and dispositional factors on incident, session, and post-session frustration and mood

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Abstract

Frustration is almost universally accepted as the emotional outcome of a negative computing experience. Despite the wide use of the term, however, it has not been rigorously conceptualized as a factor in the study of the human–computer interface. This project sets out to explicate frustration as a pre-emotional state generated by the user's appraisal of the interface as an impediment to goal attainment, and looks at how user characteristics, such as self-efficacy, relate to it. This project employed episode report methodology to capture data from 144 computer users' reports of actual frustrating events as they took place. Diaries taken as users worked at their everyday tasks yield detailed data about the problems they encountered and included information about session length and an estimate of the time lost due to the experiences. Outcomes were measured as either situational or dispositional factors. Situational factors, having to do with specific events, predicted incident frustration. However, disposition variables, especially user self-efficacy, were much stronger, predicting incident and session frustration, and post-session mood. One surprising outcome was the failure of demographic variables as predictors of frustration.

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1. Introduction

Frustration is undeniably the most frequent complaint registered by users who have a negative computing experience. Nearly every computer user has, at one time or another, experienced frustration. Too many users experience the ordeal of a program crash, taking the last hour's of work with it, or finding they cannot open an e-mail attachment. While more and more attention is being paid to human–computer interaction, it seems inevitable that frustration will continue to rank as the number one outcome users experience when their computer will not do what they want it to.

This study sets out to explicate the concept of frustration as a pre-emotional state generated by the user's appraisal of interface performance as an impediment to goal attainment, and looks at how user characteristics such as self-efficacy relate to it. From within that context, the study looks at the consequences of the frustrating experience. How much time is lost on a daily basis as users struggle with their machines? How do these experiences affect users' mood or well-being?

All of these questions bear on the issue of the "digital divide," separating those who can use computers from those who cannot. This divide, defined by inequalities stemming from differential access to the Internet, must be taken especially seriously in a society where information technology plays such a prominent role (Beniger, 1986). The concept of *universal access* has traditionally been used as the line of demarcation between users and non-users for other information and communication technologies. However, physical access alone does not sufficiently describe the problem of using complex computer technology. Shneiderman (2002) prefers the idea of *universal usability*, which stresses the role of the user in the computer interaction. This approach sees the digital divide as a social psychological problem, and focuses on human issues, such as the cognitive skills and social capital a user brings to the computing experience (Newhagen & Bucy, 2004).

In this vein, while frustration is widely acknowledged as a problem, it has not really been taken into account as an important factor in computer use. Frustration is an example of a factor that transcends more obvious causes for the digital divide. The Pew Internet and American Life Project shows 24% of American adults are on the wrong side of the digital divide because they truly do not have physical access to the Internet (Lenhart et al., 2003). However, the report classifies another 20% of their sample as "Net evaders," or people who have someone else send e-mails or perform other Internet functions for them. Further, it lists another 17% as "Net dropouts," or people who had physical access to the Internet but abandoned using it "because of technical problems such as broken computers or problems with their Internet Service Provider." It further reports that this group has increased from 13% since their April 2000 survey. While the report does not explicitly probe the respondents' emotional state, it does not require much of a stretch to imagine that a large percentage of the "evaders" and "dropouts" would list frustration as a cause for their non-use. Those figures ought to give IT research pause, people do not quit watching television, and even if they did, frustration with the technology would not be a leading cause.

The purpose of this study is to look at frustration as an emotional or pre-emotional response to unexpected obstacles impeding goal achievement. It examines the factors that moderate frustration in computer usage, including the individuals' self-efficacy and how it relates to their level of computer experience. In addition, the importance of the task that was interrupted, the frequency of occurrence, and the amount of time or work lost as a result of the problem are considered as factors that may affect the experience of frustration as well.

1.1. Positioning frustration within information processing theories of emotion

Emotion is generally depicted in current information processing theory as an adaptive heuristic device employed to enhance performance. Roseman and Smith (2001) propose that emotions serve as appropriate response guides for coping. Plutchik (1980) describes emotions as adaptive prototype reactions. Frijda, Kuipers, and ter Schure (1989) define emotions as states of action readiness elicited by events appraised as relevant; where different states of action readiness are elicited by different appraisals. They add that autonomic arousal can be considered the logistic support of certain variants of action readiness.

This description works well for a basic emotion such as anger, where a threat will result in a state of heightened arousal, including increased heart rate and the production of adrenalin. This state is an adaptive response to the threat because it causes oxygen rich blood to flow throughout the body, increasing both physical and cognitive capacity.

The problem facing a functional description of frustration in the context of current theories of emotion is to situate it as an *adaptive* response to a changing environment. Historically frustration has nearly always been conceptualized as a *maladaptive* response caused by the absence of change. Frustration, first introduced as a psychological state by Sigmund Freud, was conceptualized as both external and internal in nature and related to the concept of goal attainment. Frustration occurs when there is an inhibiting condition that interferes with or stops the realization of a goal. For Freud, frustration included both external barriers to goal attainment and internal obstacles blocking satisfaction (Freud, 1921). The study of frustration in the 1930s and 40s tended to follow Freud with theories that were somewhat metaphorical, based on the meaning of frustration in natural language (Lawson, 2000). By the 1950s frustration was couched in terms of the dominant behaviorist paradigm. For instance, Amsel (1992) summarizes his 40-year study of frustration as the non-attainment of expected goals, thwarting, or encountering physical or psychological barriers or deterrents in the path of goal attainment.

These perspectives are problematic for two reasons: First, they are keyed to the absence of a goal or object, while a broader theory anticipates the first step in the activation of emotion is the appearance of something novel in the organism's information ecology. Second, frustration is almost invariably linked to aggression and is often described as maladaptive.

1.2. Frustration as pre-emotional appraisal

The key to conceptualizing emotion within information processing theory is to emphasize its role during appraisal. Roseman and Smith (2001) describe appraisal as a pre-emotional process. They point out that perceptual systems are designed to notice change, which in turn triggers appraisal. They qualify this position by pointing out that on some occasions appraisal may take place in an unchanging situation. Frustration can thus be situated in emotion theory, since appraisal can be triggered in the absence of anticipated change.

Amsel (1992) sees frustration as an increase in nonspecific arousal in the reticular activating system that is not associated with afferent sensory nerves. Such a state could be provoked by either internal or external cues indicating that an obstruction has appeared in the path toward goal or task completion. In either case, this process describes a pre-emotional condition that is not necessarily dependent on novel change directly related to the task or goal environment. On the contrary, the state is caused by some distraction or impediment to that goal. This makes sense given that information processing theory increasingly depicts the function of emotion as a control apparatus for attention (Markus, 1990). Thus, the role of frustration would be to redirect limited attentional resources away from the central task or goal at hand to peripheral features of the information environment that may now have become obstacles. Amsel (1992) describes frustration as having "a transient energizing effect on responses with which it coincides, increasing particularly the intensity with which these responses are preformed" (p. 42).

An important feature of this process is that most or all of it goes on well below conscious awareness. Thus, the computer user may be working toward some goal, such as entering data into a spreadsheet, where keyboard and mouse interaction with the interface are automatic and effortless. When the interface fails to respond in the expected fashion, the user experiences frustration. This triggers a low level increase in arousal that enhances cognitive performance and redirects attentional resources to the impediment of other work.

Thus, the key to understanding the function of frustration in problem solving may lie in its relation to arousal. Fig. 1 shows how too little or too much arousal results in performance dysfunction, while an intermediate level of activation is held to be optimal (Hebb, 1955).

In other words, the function of frustration may be to increase arousal – but only to a point. It is further important to consider that where the user ends up in terms of his or her ultimate emotional or mood state, and what their enduring affective state will be, will then be determined by both internal conditions (such as their self-efficacy) and external factors (such as the mutability of the interface).

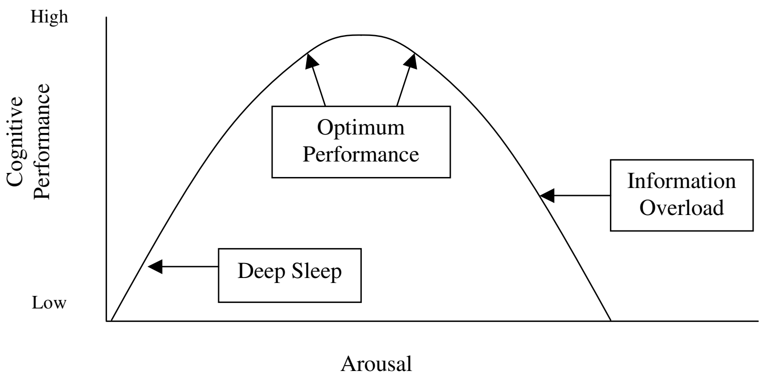

Fig. 1. Optimal level of human performance and learning (from Hebb, 1955).

1.3. User control and the escalation of frustration to complex emotions

A major factor governing whether a user's frustration will mature into more complex emotions has to do with what Lazarus (1991) calls "imputed control" (p. 218). If a problem is not immediately resolved, the user may go beyond simply appraising the event in terms of situational factors and advance to causal attribution, involving user-centered dispositions such as experience and self-efficacy. Roseman and Smith (2001) distinguishes between what he calls "control potentials," which are either instrumental to goal blockage or intrinsic in their negative quality. In this context instrumental factors are related to situational pre-emotional frustration, while intrinsic factors have to do with dispositional factors. In addition, he makes a distinction between the onset of appraisal and later stages of the process. The onset of problem assessment is marked by user *appraisal* of the *situation*. At later stages of the assessment process the user shifts to assess the *achievability* of the *goal.* The process underlying this second stage of a frustrating event warrants closer scrutiny because it is at this point that the user may experience maladaptive outcomes.

1.4. Maladaptive frustration and the coactivation of hedonic valence

The second aspect of frustration theory that makes an adaptive description difficult has to do with the state itself being described as maladaptive – as well as the inhibiting object that caused it. That is, getting more and more frustrated can make the problem solving situation more difficult, rather than less so.

Because an instigated goal response entails only that the goal be anticipated, frustration is due to the expectation and anticipation of a goal, not the actual attainment of the goal (Berkowitz, 1978). If the goal is unfulfilled, frustration is experienced because satisfaction was not achieved and hopes were suddenly thwarted. The thwarting or hindrance – terms often used synonymously with frustration – is not limited to the actual activity in progress, but relates to what the individual is expecting (Mowrer, 1938). Thus it is common for theories of frustration to classify all cases as aversive events (Ferster, 1957) having as their main defining feature the element of a barrier or obstruction. However, this runs contrary to general emotion theory, which sees emotion as adaptive. One clue to this dilemma may be a consideration of the relationship between hedonic valence and frustration.

Dimensional theories of emotion usually propose three orthogonal vectors, intensity, hedonic valence, and potency (Lang, Pinkleton, & Newhagen, 1994). Much of the early work in frustration links it to anger (see Amsel, 1992; Lawson, 2000). Lazarus (1991), however, says behavioristic models of frustration show the lack of differentiation between a cognitive state (such as anger) and a behavioral outcome (such as aggression). He asserts that frustration may be followed by any negative emotion such as anxiety, guilt, shame, envy, or jealousy, and not just anger. However, the outcome of a frustrating event can be exhilarating (positive). If the user inputting data into the spread sheet resolves a momentary problem finding a feature on a complex interface and returns to the main task, the cost may not be too great, and the experience may not be negative. Indeed such a frustrating experience might enhance the user's knowledge of the interface and lead to more expert manipulation of the computer environment in the future. Frustration per se may only be maladaptive if no solution to the problem is found or the path to the solution involves many obstacles. One avenue to understanding this shift from adaptive to maladaptive responses might be found in recent work into the role of valence in emotion.

Cacioppo and Berntson (1994) have taken the position that hedonic valence is not a bipolar vector. Their review of literature leads them to conclude there is evidence of separate positive and negative evaluation centers in the brain. Thus, if activation of the centers is reciprocal, valence may appear to operate as a bipolar dimension. However, under certain circumstances both systems can become active, resulting in coactivation, or ambivalence. This is an interesting conclusion in terms of frustration theory because it is frequently described as an "ambiguous negative state" (Lazarus, 1991, p. 83). Amsel (1992) points out that frustration "may facilitate persistence or the tendency to pursue goal-directed activity in the face of any kind of negative indication" (p. 54). Thus, if frustration is characterized as pre-emotional appraisal, the user's initial response may involve the coactivation of both positive and negative valence systems. If resolution of the impediment is forthcoming within acceptable parameters of time and effort for the user the outcome might well be ambivalent – that is, mildly annoying but at the same time exhilarating. On the other hand if a solution is not forthcoming users may find themselves in a vicious feedback loop where each successive failure results in increased nonspecific arousal. At some point the level of arousal will increase beyond upper limit on Hebb's performance curve in Fig. 1. At that time the arousal caused by the problem becomes a problem in and of itself. The novice user who responds to an error statement by simply repeating the original inappropriate command time and time again, generating the same error message on each attempt, serves as an example.

Research into television has shown that highly intense levels of arousal by their very nature are negative (see Lang, 1990; Newhagen & Reeves, 1992). That research indicates viewers of highly compelling negative images, such as scenes of death and suffering, experience the same emotional responses they would if the images were real and present. Thus emotion systems developed over the millennia to respond to ecologically "real" circumstances can be triggered by technology to generate maladaptive or inappropriate responses.

Such a mismatch between the evolutionary mandate of frustration as an emotional heuristic to "real world" problems and the reality of the human–computer interface may explain why outcomes to computer frustration are so frequently maladaptive and negative. Computers solve problems differently than humans. Newell's (1990) discussion of representational symbol processing systems contrasts humans as rule or heuristic problem solvers with computers, which are situation or search knowledge driven. Thus the native skills with which humans are endowed are a bad match for understanding the kind of strategies employed by computer programs. This can especially be a problem for machine-centric interfaces designed within the mindset of what Shneiderman (2002) calls "old computing." Here, the user may encounter arcane error messages that fail to offer the slightest clue of how to overcome a local obstacle and proceed to the intended global task. This mismatch opens the discussion of the importance of dispositional attributes such as goal commitment, knowledge, and self-efficacy to the frustration model.

1.5. Knowledge, skill, and self-efficacy

If frustration is the result of a block in the path toward goal achievement, an examination of the factors that can influence the level of frustration experienced by an individual as a result of this obstacle is warranted. These blocks to goal achievement can come in the form of either internal blocks or external blocks. Internal blocks consist of deficiencies within the individual such as a lack of knowledge, skill, or physical ability. External blocks could include the physical environment, social or legal barriers such as laws or mores, or the behavior of other people. The level of frustration experienced by an individual clearly can differ depending on the circumstances surrounding the frustrating experience and on the individuals themselves.

One major factor in goal formation and achievement is goal commitment, which refers to the determination to try for and persist in the achievement of a goal (Campion & Lord, 1982). Research on goal theory indicates that goal commitment has a strong relationship to performance and is related to two factors: (1) the importance of the task or outcome and (2) the belief that the goal can be accomplished (Locke & Latham, 2002). Individuals will have a high commitment to a goal when it is important to them and they believe that it can be attained (Locke, 1996). The importance of the goal, in addition to the strength of the desire to obtain the goal (Dollard, Doob, Miller, Mowrer, & Sears, 1939), will affect the level of goal-commitment as well as the strength of the subsequent reaction to the interruption.

Self-efficacy, the belief in one's personal capabilities, can also affect goal commitment (Locke & Latham, 1990) in that the belief about how well a task can be performed when it involves setbacks, obstacles, or failures may affect how committed individuals are to that goal (Bandura, 1986). Judgments of efficacy are related to the amount of effort expended, how long they persist at the task, and resiliency in the case of failure or setback (Bandura, 1986, 1997b). Self-efficacy affects emotional states as well; how much stress or depression people experience in difficult situations is dependent on how well they think they can cope with the situation (Bandura, 1997a). The level of frustration that people experience, therefore, would be affected by how important the goal was to them, as well as how confident they are in their abilities. "Because goal-directed behavior involves valued, purposeful action, failure to attain goals may therefore result in highly charged emotional outcomes," including frustration (Lincecum, 2000). Two final factors that may affect the force of the frustration are the severity of the interruption and the degree of interference with the goal attainment (Dollard et al., 1939). All obstructions are not equally frustrating, and the severity and unexpectedness of the block will also factor into the strength of the response. In addition, if individuals perceive that the thwarting was justified by socially acceptable rules, as opposed to being arbitrary, the frustration response may be minimized (Baron, 1977). This may be due to the lowering of expectations because of extra information available to the individual. As stated above, it is the anticipation of success that affects frustration, and not the actual achievement of the goal. Therefore, if individuals expect to be thwarted or have a low expectation of success, frustration may be minimized.

1.6. Computer attitudes and anxiety

The reactions of people to computers have been studied extensively, particularly attitudes toward the computer (Loyd & Gressard, 1984; Murphy, Coover, & Owen, 1989; Nash & Moroz, 1997; Reeves & Nass, 1996), computer anxiety (Cambre & Cook, 1985; Cohen & Waugh, 1989; Glass & Knight, 1988; Maurer, 1994; Raub, 1981; Torkzadeh & Angulo, 1992), and computer self-efficacy (Brosnan, 1998; Compeau & Higgins, 1995; McInerney, McInerney, & Sinclair, 1994; Meier, 1985). Each of these variables can affect how frustrated individuals will become when they encounter a problem while using a computer. The number of times a problem has occurred before can affect their perception of the locus of control, and therefore influence their reaction as well. This may be related to anxiety: people with low computer self-efficacy may be more anxious (Brosnan, 1998; Meier, 1985) and more likely to view the computer suspiciously and react with great frustration when something occurs, especially when they have encountered it before. Different levels of anxiety will affect performance when something unforeseen or unknown occurs, causing anxious people to become more anxious (Brosnan, 1998).

On the other hand, the level of experience may temper this if the prior experience increases computer self-efficacy (Gilroy & Desai, 1986) by lowering anxiety and reducing frustration when a problem occurs. The perceived ability to fix problems on the computer, as well as the desire to do so, may also affect levels of frustration. If problems are seen as challenges rather than problems, they may not be as frustrating, which is most likely directly related to level of prior experience as well as computer self-efficacy. This may be due to the perception of locus of control; these individuals understand and can attempt to control the "problem space" they encounter.

1.7. Mood as a lasting outcome

One final piece of the puzzle, which has not come under much scrutiny in the study of computer frustration, is user mood. Mood is generally defined as a broader or more generalized and longer lasting state than emotion (Bower, 1987). Including mood in the study of computer frustration moves the window of its effects further out in time. Thus the user's affective state can be conceptualized at three points in time, at the initial frustrating incident, that may only last a few seconds; at the point the frustrating incident feeds back on itself, becoming a full emotion lasting a few minutes; to a longer term mood state that might last hours.

1.8. Computer frustration model

Fig. 2 shows a proposed Computing Frustration Model based on situational and dispositional factors surrounding the interruption of goal attainment, and their relationships to immediate and overall frustration.

1.9. Situational factors

The incident specific, or situational factors that affect the level of frustration experienced by users include the level of goal commitment, measured as task importance; the severity of the interruption, measured as time lost; and the strength of the desire to obtain the goal, measured as anticipation expectations. Bessiere, Ceaparu, Lazar, Robinson, and Shneiderman (2003) found that situational factors were correlated with incident level frustration but not with the overall effect of the frustrating incidents. This outcome would fit the theory of frustration as a short-lived pre-emotional state typified mainly by increased non-specific arousal. This leads to the following predictions:

Hypothesis 1a. Situational factors, such as the importance of the task, the frequency of occurrence, and the severity of the interruption (measured as time lost and time to fix the

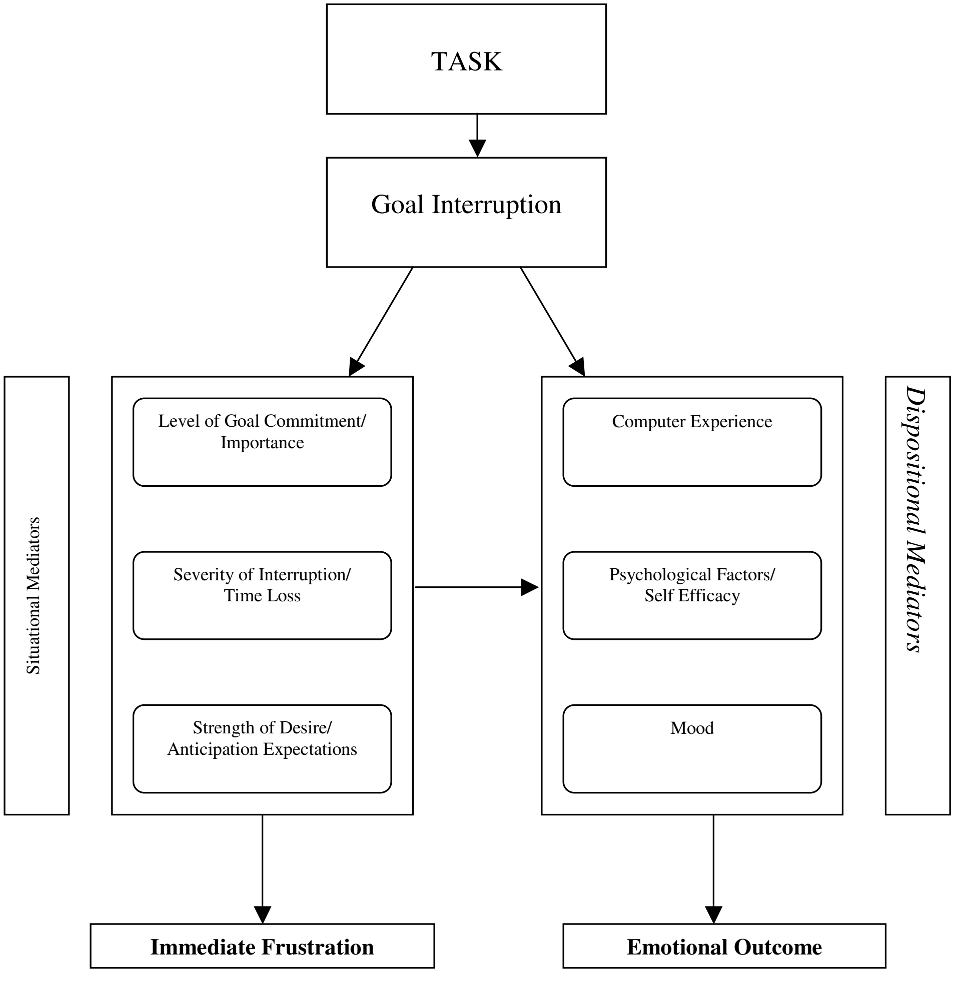

Fig. 2. The computer frustration model.

problem), and how typical the problem was (measured as frequency of occurrence) will be associated with incident level frustration.

Hypothesis 1b. Dispositional factors, such demographic characteristics, experience, mood, and computer attitudes and self-efficacy will be associated with incident level frustration.

1.10. Dispositional level factors

Dispositional level factors affecting the strength of the frustration include computer experience and self-efficacy, mood and other psychological factors such as tendency toward negative affect, and the cultural and societal capital the individual brings to the computing experience. These dispositional factors were found to correlate with the effect of session frustration, but not with incident level frustration. This again would coincide with the theories of emotion discussed here in that dispositional factors would be expected to emerge later in time, especially if the frustrating incident were not easily solved. This leads to the predictions that:

Hypothesis 2a. Dispositional factors such as experience, measured as years of use and hours per week spent computing; computer attitudes/self-efficacy, measured as computer anxiety; comfort; perceived experience; perceived ability to fix the problem; inclination to stick with the problem; thinking about the problem if unresolved; and self-reported mood will all affect the level of session frustration, post-session mood, and expected effect of the problem on mood on the day.

Hypothesis 2b. Situational factors will not affect the level of session frustration, post-session mood, and expected effect of the problem on mood on the day.

1.11. Self-efficacy as a prominent dispositional mediator

The range of domains in which self-efficacy is a factor in subject assessment of successful goal outcome is so broad, it can be argued that it constitutes one of the most basic and generalized of all psychological dispositions. Because computing requires such a unique – even alien – set of skills (at least from the standpoint of functional evolution) it ought not be surprising that self-efficacy stands out as a particularly prominent dispositional factor. Bandura (1973) catalogues a broad range of problem solving and goal oriented task domains in which self-efficacy play a prominent role. Self efficacy has been shown to be important in the assessment perceived media interface interactivity (Newhagen, 1997); the use of call-in radio and television programs (Newhagen, 1994a); as a predictors of domain specific knowledge by college undergraduates (Newhagen, 1994b); and of the successful use of the Internet (Newhagen & Bucy, 2004). While self-efficacy may be a factor at all stages of the frustrating computer experience, it should be especially important in what the final emotional outcome of such an event is. Thus the initial frustrating incident is a simple state of heightened arousal, where user valence assessment, both positive and negative, is co-activated. However, if the event persists, self-efficacy should be an important factor in determining the final hedonic valence of the user's emotional state. Thus, it is predicted that:

Hypothesis 3. Users with especially high self-efficacy, measured as their determination to fix a problem causing a frustrating computer incident, will assess the incident to be emotionally positive, while those with low self-efficacy will judge it to be negative.

2. Method

This project employed episode report methodology to capture data relating to actual frustrating computer events as they occurred. Diaries taken as users worked at their everyday tasks yield detailed data about the problems they encountered and included information about session length and an estimate of the time lost due to the experiences. In order to examine typical computer usage, each subject was asked to work on the computer for a minimum session of an hour on tasks of their own choosing. Because self-set goals are meaningful to individuals, they should be more typical than assigned goals that may be unclear or be rejected (Locke, Shaw, Saari, & Latham, 1981) and should be important to these individuals. Subjects also filled out short online questionnaires both before and after their work session.

Thus, subjects would first go to the research website and fill out the pre-session questionnaire. They would then begin the working session of an hour or more, during which they would fill out paper and pencil reports describing anything that frustrated them. In some cases the subject verbally reported the episodes to a session observer, who recorded the incident. Immediately following the session, the user would return to the website to fill out the post-session survey and enter their frustration reports into the online database.

The pre-session questions asked subjects for demographic data, computer experience and attitudes, level of computer anxiety, self-efficacy, and mood. Questions were chosen based on the Computer Aptitude Scale, assessing computer attitudes, computer anxiety/confidence, and computer liking (Loyd & Gressard, 1984; Nash & Moroz, 1997). Three questions dealt with overall life satisfaction, general mood, and frequency of getting upset over things.

The post-session survey consisted of five questions to assess mood after the session, how frustrated overall the individuals were after the session, how they expect these frustrations would affect the rest of their day, and the frequency and nature of the frustrating experiences during the session. A one-page paper and pencil form was used by subjects to report each frustrating episode in order to minimize the amount they spent recording data during the hour-long work session. After the session, subjects returned to the website, filled out the post-session form, and then entered their incident reports into the database via a form on the website.

2.1. Qualitative assessments of frustrating episodes

Subjects were asked to explain the causes of their lost time in a few lines. The descriptions of frustrating episodes fell into four distinct categories:

- Problems that forced subjects to give up what they were doing because they were unable to fix them. Some actually gave up using the computer altogether for that period of time, while others gave up on the program or website they were using in favor of an alternative.
- Frequently occurring problems that either took no time to fix (because the individuals had run into them before), or were very frustrating despite the fact that they did not take a lot of time.
- Larger problems that caused a lot of work to be lost or programs (or operating systems) to be reinstalled.
- Problems that had few consequences in and of themselves, but caused other consequences as a result, including (1) loss of concentration, (2) anger or hatred toward the computer or developers of the software, or (3) being late somewhere as a result.

2.2. Participants

A total of 144 subjects were recruited from students attending two large Mid-Atlantic universities on a volunteer basis from their classes. Subjects for the observation sessions followed the same methodology as those who filled out the reports themselves. However, instead of filling out the frustration experience report forms themselves, the observers filled them out, asking the subjects to recount orally their experience. Post session data were unavailable for 16 subjects due to equipment problems. Because subjects were randomly assigned a time for participation, the loss of data did not constitute a threat of systematic bias to results.

There were a total of 483 frustrating experiences reported. Subject gender for the study was approximately equal. The distribution of subject age shows 3, or 2% were under 18, 70, or 49.6% were from 18 to 21; 54%, or 38.2% were from 22 to 30; 12%, or 8.5% were from 31 to 50; and 5%, or 5.5% were over 51. The remaining half ranged from age 22 to 80. Subjects reported high levels of perceived computer experience. A total of 35.4% of the subjects reported either being a computer professional or student in the area. Age is negatively correlated with experience in our study ($r = -0.248$, $p = 0.003$) indicating that younger users were more experienced with computers, an expected result.

3. Results

This study tests how situational, or technology-based, and dispositional, or user-based, factors affect user frustration and mood at four points in time: during the initial incident; during the entire work session; at the end of the session; and for the rest of the day. Situational factors include task importance, time to fix a problem, time lost, and the frequency of occurrence of the problem. Dispositional factors include as demographics, computer experience, attitudes toward computers, self-efficacy, and mood.

Hierarchical regression was employed to test the various hypotheses. This regression technique allows for the examination of variance explained by theoretically determined blocks of independent variables. In this case, the first block of variables entered in each model measured demographic factors, including age, gender, and education. The second block measured computer experience, including the number of hours per week using a computer and the years subjects reported computing. The third block measured incident or episodic variables, including the importance of the task, the time to fix the problem, time lost, and the frequency of occurrence of a problem. The fourth block measured computer attitudes and self-efficacy, such as computer anxiety, comfort, perceived experience, perceived ability to fix the problem, perceived intention to stick with a problem, and the amount of thought given the problem if unresolved.

Table 1 summarizes hypotheses.

Table 1
Hypotheses

H1. The importance of the task and the severity of the interruption, measured as time lost, will be significantly correlated with incident level frustration, but experience, computer self-efficacy, and mood will not be correlated.
H2. Hypothesis: Experience, computer self-efficacy, and mood will all influence the level of overall frustration, mood, and effect on the day of the individual, but the average importance of the tasks and the severity of the interruptions will not.
H3. Reactions to frustration will primarily be extrapunitive as opposed to intrapunitive. This will be mediated by computer self-efficacy: greater self-efficacy will lead to anger towards the computer or a determination to fix the problem, whereas less self-efficacy will lead to anger towards the self or resignation.

Table 2
Incident level frustration

	R^2 change	F change	Sig. F change
Demographic variables Age, female, education	0.001	0.15	ns
Computer experience Hours per week, years of use	0.01	1.39	ns
Situational variables Importance of task,*** time to fix,* time lost,*** occurrence*	0.16	21.66	<0.001
Mood variables Satisfaction with life, upset often,** pre-mood	0.02	3.64	0.013
Computer attitudes/self-efficacy Computer anxiety, comfort,*** perceived experience, ability to fix, stick with problem,*** think about problems if unresolved	0.05	4.63	<0.001

$F(17,482) = 7.53$, $p = 0.001$, $R^2 = 0.23$.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

3.1. Incident level frustration

Table 2 shows that the full model for incident level frustration was statistically significant, $F(17,482) = 7.53$, $p = 0.001$, and accounted for 23% total variance. Situational factors accounted for 16% of total variance. Dispositional factors accounted for 8% of total variance.

These results support Hypothesis 1a, predicting situational factors would be associated with incident level frustration. Results for Hypothesis 1b were partially supported. Some dispositional factors, such as demographic factor and computer experience were not associated with incident, or episodic level frustration, as predicted. However, mood, computer attitudes and self-efficacy were associated with incident level frustration, accounting for 5% of the variance in this model.

3.2. Session frustration

Table 3 shows the full model for session level frustration was statistically significant, $F(17,143) = 2.45$, $p = 0.002$, and accounted for 29% total variance. Dispositional factors accounted for 22% of total variance, while situational variables accounted for 7% of total variance.

These results partially support Hypothesis 1b, predicting dispositional factors would be associated with session level frustration, computer attitudes and self-efficacy accounted for 14% of total variance. While other dispositional variable blocks were not statistically significant, they did account for a total of 8% of total variance. Hypothesis 2b was supported, where the block of situational variables was not statistically significant.

3.2.1. Post session mood

Table 4 shows the full model for post-session mood was statistically significant, $F(17,143) = 3.31$, $p < .001$, and accounted for 35% total variance. Dispositional factors

Table 3
Session level frustration

	R^2 change	F change	Sig. F change
Demographic variables	0.03	1.22	ns
Age, female, education			
Computer experience	0.02	1.50	ns
Hours per week, years of use			
Situational variables	0.07	2.27	ns
Avg. importance of task, total time to fix, total time lost, typical			
Mood variables	0.03	1.48	ns
Satisfaction with life, upset often, pre-mood			
Computer attitudes/self-efficacy	0.14	3.46	0.004
Computer anxiety, comfort,* perceived experience, ability to fix, stick with problem,*** think about problem if unresolved			

$F(17,143) = 2.45$, $p = 0.002$, $R^2 = 0.29$.
* $p < 0.05$.
*** $p < 0.001$.

Table 4
Post-session mood

	R^2 change	F change	Sig. F change
Demographic variables	0.06	2.45	ns
Age, female, education			
Computer experience	0.02	1.07	ns
Hours per week, years of use			
Situational variables	0.004	0.13	ns
Avg. importance of task, total time to fix, total time lost, typical			
Mood variables	0.15	7.73	<0.001
Satisfaction with life, upset often, pre-mood***			
Computer attitudes/self-efficacy	0.12	3.44	0.004
Computer anxiety, comfort, perceived experience, ability to fix, stick with problem,*** think about problem if unresolved			

$F(17,143) = 3.31$, $p < 0.001$, $R^2 = 0.35$.
*** $p < 0.001$.

accounted for over 34% of total variance, while situational variables accounted for less than 1% of total variance.

These results support Hypothesis 2a, predicting dispositional factors, especially mood and computer attitudes and self-efficacy would be associated with post-session mood, with those two blocks of variables accounted for over 34% of total variance. Hypothesis 2b also was supported, with none of the other variable blocks in the model being significant and accounting for less than 1% of total variance.

3.3. Effect on day

Table 5 shows the full model for post-session mood was statistically significant, $F(17,127) = 3.56$, $p < 0.001$, and accounted for 36.8% of the total variance. Dispositional

Table 5
Effect on day

	R^2 change	F change	Sig. F change
Demographic variables	0.04	1.65	ns
Age, female, education			
Computer experience	0.04	2.94	0.057
Hours per week, years of use			
Situational variables	0.18	6.97	<0.001
Avg. importance of task, total time to fix, total time lost, typical			
Mood variables	0.06	3.34	0.022
Satisfaction with life, upset often, pre-mood			
Computer attitudes/self-efficacy	0.05	1.53	ns
Computer anxiety, comfort, perceived experience, ability to fix, stick with problem, think about problem if unresolved			

$F(17, 127) = 3.56$, $p < 0.001$, $R^2 = 35.6$.

factors accounted for over 18.8% of total variance, while situational variables accounted for 18% of total variance.

These results support Hypothesis 2a, predicting dispositional factors, especially computer experience, and mood would be associated with the effect on the rest of the day, with those two blocks of variables accounting for over 10% of total variance. While demographics and computer attitudes and self-efficacy were not statistically significant, they accounted for a total of 9% of total variance. Hypothesis 2b was not supported, with situational variables accounting for 18% of total variance.

3.4. Self efficacy and end response valence

A careful analysis of results shows that the one factor in frustration across all dependent variables is the desire to stick with the problem until it is resolved – a measure of computer self-efficacy. The prominence of self-efficacy as a dispositional factor was anticipated, and raises questions about the relationship between frustration – as an arousing pre-emotional state – and subsequent emotional reactions. Hypothesis 3 predicts that, according to the coactivation theory of valence, a factor such as efficacy could determine the user's emotional state as either positive or negative if a problem persists beyond a few seconds.

To test this idea a factor analysis was performed on the individual level variables to find the variables that would best represent self-efficacy. The analysis resulted in one factor with an eigenvalue of 3.4. An index variable was created by first selecting variables with factor loadings over 0.60. A new variable was then created by multiplying each variable by its factor loadings, and summing all the resultant scores. The factor, named self-efficacy, included the variables representing computer anxiety, comfort with the computer, perceived experience, and ability to fix a problem. Another variable asked the respondents how they felt after each frustrating incident. The possible answers were: angry at the computer, angry at myself, determined to fix it, helpless or resigned, and other. That variable was recoded with dichotomous outcomes reflecting response valence; where the negative category, including "angry at the computer," "self," and "helpless/resigned," was combined to form one response, and the positive category included "determined to fix."

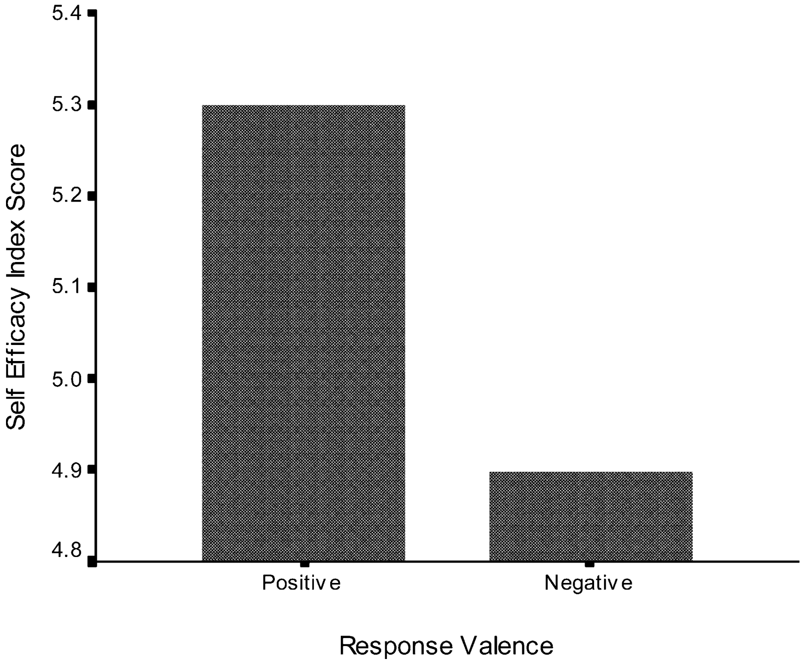

Fig. 3. Self-efficacy index and outcome valence.

Fig. 3 shows the relationship between self-efficacy and response valence $F(1,143) = 10.15$, $p = 0.01$. As Hypothesis 3 predicted, the group including negative outcomes registered lower self-efficacy index scores ($M = 4.9$) than the group with positive outcomes ($M = 5.3$).

3.5. Summary of results

Table 6 shows a summary of the hierarchical regression findings. Generally predictions concerning the effects of situational variables on incident frustration were borne out. Predictions concerning the effects of dispositional variables also were detected. However,

Table 6
Summary of findings

Independent variables	Dependent variables			
	Incident frustration	Session frustration	Post-session mood	Effect on day
Dispositional variables				
Demographics				
Computer experience				*
Mood	*		*	*
Computer attitudes/self-efficacy	*	*	*	
Situational variables	*			*

* indicates $p < 0.05$.

dispositional variables were associated with incident level frustration at a level that was more than predicted. This was especially the case for mood, computer attitudes and self-efficacy. It is interesting to note that demographic variables were not a significant predictor in any of the models tested. Finally, self-efficacy did prove to be a predictor of outcome valence.

The strength of the effects sizes in the regression models is noteworthy. The amount of variance explained by key blocks of variables usually ran between 20% and 30% or more. Hierarchical regression represents a conservative approach to measuring multivariate relationships, and significant effect sizes of 10% or less are typical. In that vein, some of the blocks of variables that were predicted to be significant but were not, registered variance in the range of 10%. A power analysis of those results would surely show that they would become significant if the N of the study were sufficiently increased.

4. Discussion

Focusing on frustration in the study of maladaptive computing seems obvious – it is synonymous with a user-computer interaction gone badly. Having said that, it is curious the concept has not been explicated more formally. A review of research into user frustration usually finds the concept described in the vernacular of daily experience or – at best – in terms of fifty-year-old behaviorist psychology.

This study looks at frustration from an information processing perspective. This approach demands some sort of functional explanation about how frustration is, or was, an adaptive response to the environment. While the literature in cognitive psychology has not focused much attention on frustration, combining what has been done with work from behaviorists yields a plausible explanation. Frustration represents a pre-emotional psychological heuristic intended to slightly increase an organism's nonspecific arousal when an impediment or obstacle blocks task or goal directed activity. At least initially, the heuristic works in the background, below conscious awareness. Indeed, its function may be to pull the attentional spotlight off the task at hand just long enough to deal with some annoying obstacle. At this initial stage both positive and negative valence assessment systems may be coactive. This is important to note, because traditionally frustration is almost universally associated with negative outcomes. The current perspective allows for either positive or negative emotion to evolve from the frustrating experience, depending largely on the duration of the event and the self-efficacy of the individual. That is, the longer the obstacle persists, the longer the user will experience low levels of nonspecific arousal. This is important because at some point the internal state becomes as much of a problem as the external obstacle. This can lead to maladaptive user states such as anxiety and anger, mediated by the user's computer self-efficacy.

Understanding the importance of the duration of the frustrating event casts attention on the specificity of its underlying causes. Here, a distinction is made between situational factors and dispositional factors. Situational factors have to do with the circumstance of the particular frustrating incident, such as the importance of the task, the time lost, and how typical the problem was. Thus situational factors are largely external to the user. On the other hand dispositional variables describe important factors located within the user, such as demographic characteristics, the user's mood, and sense of self-efficacy.

It was generally predicted that situational variables would predict short-term outcomes, while dispositional variables would predict long-term outcomes. This follows from the theory of frustration in the sense that situational variables would have to do with the annoyance generating the state in the first place, while disposition variables would better describe how well the user coped with the problem. Those predictions were generally supported by this study with some exceptions worth noting.

First and foremost, user self-efficacy proved to be important at nearly all stages of the experience, at the incident, session and post-session level. Retrospectively this ought not to be surprising because self-efficacy has been shown to be such a powerful predictor of human performance across such a broad domain of problem solving. Thus, the user's sense of being able to cope with computing technology appears to be a pervasive factor in how frustrated he or she becomes. This idea should again have a great deal of face validity for anyone who has dealt with both experts and novices to computing technology. This speaks strongly to Snow's (1991/1959) notion of a vast chasm in our society between what he calls scientific and literary thinking. How often have we seen an otherwise smart and productive individual, intimidated by the arcane workings of computers, simply turn away from the challenge and opportunity this new technology has to offer and say "I am not a computer person." In the early days of the technology's diffusion this problem could be brushed aside with the promise that as it matured it would become more "user friendly." However, usage data from a number of sources is beginning to show that 25% or more of our society has not and does not intend to connect to the Internet. That fact becomes even more worrisome when we take into account the fact that perhaps 10–15% of people who have connected later abandoned its use, usually citing problems that have frustrating outcomes at their underpinnings. Further, the problem becomes even more daunting in the face of the fact that self-efficacy is extremely deeply rooted in the user's psychological makeup and a reflection of the social capital he or she brings to the computing experience – it is very hard to change.

On a brighter note it was interesting that demographic factors were not a significant predictor in any condition studied by this project. While factors such as age and gender played a significant role in explaining computer use early in its diffusion into mass society, it may be that they are beginning to recede.

Finally, the appearance of mood as a factor at both the incident, session and post-session level reinforces the notion that the interaction between emotion and higher order cognitive processes is essential to fully understanding the complex relationship between users and computers.

An examination of results also yields some proscriptive advice to those who design, use, and manage computer technology:

For users. While virtually everyone experiences annoying frustration while using computers, dispositional factors, rather than situational factors, may prove to be of the most concern. Previous experience, attitudes toward the computer, computer self-efficacy all have an effect on the experience of the user with the computer. In order to have the best experience, it appears that a positive attitude toward the computer and development of skills is essential.

For developers. Software engineers should employ strategies for reducing the frequency of user frustration. More reliable software, better user interfaces, clearer instructions, and improved training could reduce and prevent problems. All this can be summed up in the idea of *universal usability*.

For managers. While it is hard to extrapolate from our sample to the business world, there are some clear possible effects. First, each frustrating experience will cost the company in minutes and work lost. Second, the aggregate effect on the individual is to lower the mood and increase the likelihood of having a bad day, which can adversely affect work performance as well. Clearly, it would behoove businesses to invest in both the technology and the training of their staff in the technology in order to improve productivity. A follow-up study on workers, now in progress, should help to bring forward these issues with a more appropriate sample.

For policy makers. If, as suggested, attitudes toward the computer and computer self-efficacy all have an effect on the user experience on the computer, then the development of skills is essential to the elimination of frustration. Government should not turn its back on the digital divide, but rather it should devote resources to giving access and training to underserved populations. If frustration is such a large part of the user experience, and experience and perceived efficacy can help eliminate this frustration, then it is vitally important that the low-income and disadvantaged communities receive as much help in this arena as possible. Training and exposure are clearly vitally important to the user experience. It is quite possible that new users with substandard equipment, a lack of knowledge and training, and no access to help will simply never have the opportunity to advance their skills, simply because of the frustrations involved. Since it has been shown that developing computer skills is vital in today's society, this frustration can only serve to exacerbate the digital divide in existence today.

Finally, an interesting extension of this research would be to look at a broader population of computer users, including such groups as industry professionals and home users to compare the robustness of the results reported here.

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