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Evaluation of Etiquette Strategies to Adapt Feedback In Affect-Aware Tutoring

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The purpose of this research is to investigate how to mitigate user frustration and improve task performance in the context of human-computer interaction (HCI). Even though user frustration plays a role in many aspects of HCI and studies have looked into the consequences of frustration in various fields, the ways to mitigate frustration are less deeply examined. Once the system has the ability to understand and include user emotions as factors in HCI, the interaction between the user and the computer system could be adapted if the computers are able to modify its behavior with users in appropriate ways to further joint performance. Specifically, a preliminary study was conducted to explore the task performance, motivation, and confidence implications of changing the interaction between the human and the computer via different etiquette strategies. Participants solved a total of twenty mathematics problems under different frustration condition with feedback given in different styles of etiquette. Changing etiquette strategies in tutoring led to changes in performance, motivation, and confidence. The most effective etiquette strategies changed when users were frustrated. This work provides the foundation for the design of adaptive intelligent tutoring system based on etiquette strategies.

INTRODUCTION

Computers are becoming increasingly complex, sophisticated, involved in daily activities, and endowed with critical responsibilities. As computers become more complex, the interactions between humans and computers become critical to the overall success of the human-computer system. The cost of communication breakdown or misinterpretations between humans and computers can have serious ramifications (Dennerlein et al., 2003; Parasuraman & Miller, 2004). For instance, misinterpretations between pilots and automated air traffic control systems have been identified as a contributing factor in some aviation accidents (National Transportation Safety Board, 1991). Thus, designing seamless interactions between humans and automated systems is an area of investigation in human-computer interaction (HCI).

Human Emotion in Human-Computer Interaction

Human emotion plays a role in many aspects of HCI. Emotion is a key factor in communication since it can drive the way humans convey information (Ferdig and Mishra, 2004). Previous studies have found that both positive emotions (e.g. motivation) and negative emotions (e.g. frustration) are key components of learning (Woolf et al., 2009; Fisher & Noble, 2009). This study focused on negative emotions, especially frustration, because frustration is a significant factor which lead to lower task performance (Waterhouse & Child, 1953; Soloff, Todd, & Screven, 1964; Spector, 1975; Klein, Moon, & Picard, 2002; Powers, Rauh, Henning, Buck, & West, 2011), longer time of decision making (Toda, 1980; Bechara, 2004; Lerner et al., 2015), and lower learning efficiency (Graesser et al., 2005; Fisher & Noble, 2009). These studies looked into the consequences of frustration on various fields. However, mitigation of frustration through adaptive changes in system behavior has been less explored, given the complexity of the interplay of frustration.

In human-human interaction, people interact differently when they detect the emotional states of others (Ekman, 1970; Picard et al., 2004). Likewise, computers could potentially react differently when they notice user frustration. By changing the interaction style of the computers, users' feeling could also be changed (Woolf et al., 2009). Some initial studies have been conducted to explore the effect of different interaction styles and the concept of etiquette to see how different feedback could enhance human-human tutoring (Pearson et al., 1995), situation awareness (Wu et al., 2010), and reliability of the system (Parasuraman & Miller, 2004).

Etiquette and Human-Computer Interaction

Human-human interaction strategies can provide inspiration for the design of HCI. When humans interact with each other, their social behaviors are governed by expectations based on conventional norms. These expectations for human-human interaction would be from speaker to hearer, and vice versa (Miller, Wu, & Funk, 2008; Hayes & Miller, 2010). It is possible to have these expectations when people interact with computers. For example, people expect that computers have an ability to follow the manners of social interaction when they communicate with users (Miller & Funk, 2001; Miller et al., 2004; Hayes & Miller, 2010).

Etiquette is a code of conventional requirements for social behavior (Oxford English Dictionary, 2015). Interactions with inappropriate etiquette may be confusing, unproductive, or even dangerous since people who share the same model of etiquette have specific expectations and interpretation of behaviors (Wu et al., 2010). Misunderstandings may go undetected initially, or surprise one party or the other. In order to prevent these kinds of misinterpretations, Brown and Levinson (1978) established etiquette strategies.

The study of etiquette strategies between humans is also as known as politeness strategies. Etiquette strategies mitigate or soften direct expressions of desire or intention between

humans. Goffman (1967) defined 'face' as the self-image that people want to claim as themselves, thus human face could be an element of etiquette within human society. Brown and Levinson (1987) developed a model of politeness called face threatening acts (FTAs) which show strategies of politeness from individual's self-esteem (face). Etiquette strategies were developed to redress the affronts to the face posed by FTAs to addressees. These are also the ways for the speakers to mitigate face threats carried by certain FTAs to hearers (Brown & Levinson, 1978; Mills, 2003).

Etiquette strategies were used to facilitate cooperation which is needed amongst the speakers and hearers to maintain each other's faces since the positive and negative faces are the basic desires in any social interaction (Foley, 1997; Brown & Levinson, 1978). Brown and Levinson (1978) identified four types of etiquette strategies: bald, negative politeness, positive politeness, and off-record. A bald strategy is a direct way for a speaker to say something without any consideration to the level of imposition on the hearer. For example, "Pass me the hammer." It does nothing to minimize threats to the hearer's face. Positive politeness minimizes the social distance between speaker and hearer by expressing statements of friendship, solidarity, and compliments. For instance, "That is a nice hat, where did you get it?" Negative politeness attempts to be respectful; however, the speaker also assumes that he or she is in some way imposing on hearer. Examples would be to say, "I don't want to bother you but..." or "I was wondering if..." Off-record utterances use language to give indirect feedback. One says something that is rather general. For example, when the speaker insinuates the listener would turn up the thermostat, saying "Wow, it's getting cold in here." In this case, the hearer must make some inference to recover what was intended in the feedback (Brown & Levinson, 1978).

There have been studies of the linguistic aspects of etiquette within human-human interaction. For example, Kasper (1990) investigated linguistic etiquette and identified variables of it from data-based studies such as social power (i.e., containing an interlocutor's relative positions in social hierarchies, age, gender, and language impairment), social distance (i.e., politeness appears to be expended in negotiable relationships with familiars, but decreases within both intimates and strangers), and imposition (i.e., including requesting, urgency, apologizing, thanking, indebtedness, and complaining). Whilst the social power and the social distance between two people need time to be changed, the imposition from speaker to hearer can be easily adjusted to mitigate FTAs, thereby forming the basis of different etiquette strategies (Brown & Levinson, 1978; Kasper, 1990).

Tutoring and Intelligent Tutoring Systems

Having a system which interprets users' states could possibly help to enhance learning experiences (Fisher & Noble, 2009). Advances in tutoring could be combined with human-computer interfaces that incorporate more empathy and affect, enabling technology to move ever closer to authentically embodying the richness of the social interactions between humans (Picard et al., 2004; Woolf et al., 2009).

Human-human tutoring is effective in guiding students through the learning process. It can support students' studying by responding to questions, analyzing answers, and providing customized feedback. Intelligent tutoring systems (ITSs) are computer-based instructional systems whose purpose is to provide customized feedback to users and enable learning in an effective manner (Wenger, 1987; Murray, 2003; Gilbert et al., 2015). ITSs attempt to implement the best methods acquired from the traditional tutoring with human tutors and move beyond it to discover new strategies for teaching and learning (Murray, 2003; Broderick, 2011; Koedinger & Tanner, 2013). However, ITSs have rarely been developed with the ability to adjust behavior based on the emotional state of the student. This is in contrast to human tutors, which have the ability to adapt their behavior to appropriately meet the needs of the student (Woolf et al., 2009).

Recent studies have started to include user emotions as factors within ITSs. A companion learning system provides adaptive feedback to adjust the level of task difficulty of the problems in order to consider the user's emotions (Kort et al., 2001). These type of systems are called affect-aware systems or affective systems. Affect-aware systems are any kind of systems that contains an ability to consider a user's emotions as an element of the system. These are traditionally implemented to render appropriate feedback to users based on their emotional states (Picard et al., 2004; Picard, 2006). The idea of affect-aware systems offers an approach to design a system which has the ability to adjust its behavior to match the users' needs when they feel frustrated.

The objective of this study was to establish the effects of etiquette strategies on task performance, motivation, and confidence in tutoring. In addition, this study asked whether etiquette strategies can be used to mitigate user's frustration.

METHOD

Hypothesis

The hypothesis of this study is that changing etiquette strategies in tutoring leads to higher performance, motivation, and confidence. Furthermore, these changes will be larger in high frustration than they are in low frustration conditions.

Participants

A total 25 university students (16 males, 9 females) participated in the experiment. The participants' average age was 20.56 (range: 18 – 26). All subjects were experienced computer users who have been using computers on average 5.06 hours (range: 1 – 15) a day. Also, all participants had normal or corrected-to-normal vision in order to exclude the possibility of diminished attention due to vision problems.

Task

Participants were asked to solve mathematics problems. In six different subjects: algebra, geometry, trigonometry, calculus, probability, and statistics. All problems were from practice books of the Graduate Record Examination (GRE). A total of twenty problems were provided and one problem was counted as one trial. All problems were chosen from similar GRE correct rates of 30% – 40% in order to provide same level of task difficulty. The problems were displayed on a

computer monitor with a small stopwatch (Figure 1). Scratch paper and pencils were provided.

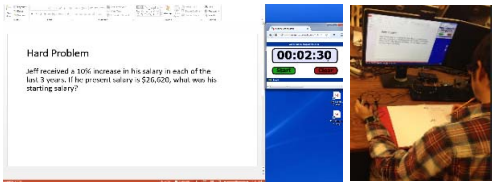

Figure 1. An example problem of the experiment.

Independent Variables

The two independent variables were *Frustration* (high, low) and *Etiquette Strategies* (bald, positive politeness, negative politeness, off-record, no feedback).

Frustration can be induced by interfering with the ability of a person to attain a goal (Lawson, 1965; Dollard et al., 1939). Frustration was elicited by changing the description of level of task difficulty on the problems and imposing a time constraint (Wahlström et al., 2002; Dennerlein et al., 2003). Even though all problems had same level of difficulty, half of the twenty problems that were labeled as 'easy' problems to induce frustration. Recognizing a difference between the level of difficulty and the expectation of the difficulty level can cause frustration (Hone, 2006). By labeling a hard problem as easy, a person has unrealistic expectations of the ease of attaining the goal. The average time of solving five practice problems from the training session, which had same level of difficulty, was used to set an individual time constraint for each participant. Both frustration manipulations are examples of an integral emotion, where the cause of the emotion is from the task. This is contrasted with an incidental emotion, where the emotion is caused by something outside the task (Bodenhausen, 1993; Jeon et al., 2014).

Four different etiquette strategies were used to communicate with people, as well as a no feedback condition as a baseline to compare the other four etiquette strategies. Table 1 shows the same feedback being presented in the four different etiquette strategies.

Table 1. Example sentences of etiquette strategies.

Etiquette Strategies	Example sentences
Bald	Use appropriate formula.
Positive Politeness	Why don't you try other formulas? Let's check them together!
Negative Politeness	If it's alright with you, Could you please check other formulas as well?
Off-Record	Various formulas are provided.

Dependent Variables

The dependent variables were task performance, motivation, and confidence. In addition, frustration and time pressure were measured in order to verify the independent variable manipulations. Finally, appropriateness and effectiveness of feedback were also measured. Table 2 shows the measurements of dependent variables.

Table 2. Dependent variables and associated metrics.

DV	Metric	Measurement	Frequency
Emotion	Questionnaire	Likert Scale 0 – 10	After each trial
Performance	TLX Performance	Scale 0 – 10	After each trial
	Problem Score	0 – 100 (%)	After each trial
Motivation	Questionnaire	Likert Scale 0 – 10	After each trial
Confidence	Questionnaire	Likert Scale 0 – 10	After each trial

Experiment Design

This experiment was a 2 (frustration: low/high) x 5 (etiquette strategy: bald/positive politeness/negative politeness/off-record/no feedback) within-subject design. Each condition was tested twice (20 trials). Trials were counterbalanced to account for learning effects.

Procedure

The experiment began with the consent process, a short briefing, and demographics survey. Participants first practiced problems in order to help to recall their previous knowledge of mathematics. Between trials, the participants were asked to complete a post-trial survey and a NASA TLX. Two questions of the post-trial survey measured motivation and confidence of the participants. After finishing all 20 trials, the participants were asked to fill out a post-experiment survey to gather their opinions about the task itself, strategies that they used to solve the problems, and suggested ideas to improve future studies.

Data Analysis

Shapiro-Wilk tests were used for normality; Bartlett's tests were used for homogeneity of variance. ANOVA results are reported as significant for alpha <.05. Post-hoc analysis was conducted by using Tukey's test for pairwise comparisons. Cohen's d was calculated to check an effect size which provides a standard measure that expresses the mean difference between two groups in standard deviation units. The Cohen's d results are reported as small effects for d <.20, medium effects for d<.50, and large effects for d <.80.

RESULTS

Task Performance

Participants significantly ($F(1,24)=37.8$, $p<.0001$, $d=0.57$) solve the problems more correctly when they were in low frustration condition ($M=68.4\%$, $SD=73.4$) than high frustration condition ($M=36.5\%$, $SD=31.9$). The effects of etiquette strategies were marginally significant ($F(4,95)=1.83$, $p=.0810$). Post hoc analysis showed that the bald strategy ($M=94.2\%$, $SD=42.3$) led to higher score than positive politeness ($t(191)=2.77$, $p=.0060$, $d=0.91$, $M=58.2\%$, $SD=36.4$), negative politeness ($t(191)=2.96$, $p=.0034$, $d=0.79$, $M=63.2\%$, $SD=35.8$), off-record ($t(191)=2.83$, $p=.0052$, $d=0.74$, $M=64.1\%$, $SD=38.0$), and no feedback ($t(191)=3.48$, $p=.0006$, $d=0.96$, $M=57.4\%$, $SD=33.5$) in low frustration condition (see Figure 2). However, the effect of etiquette strategies was not significant in high frustration condition. Not all participants had enough time to complete the problems. The average number of uncompleted problems was 4.64 (range: 2 – 8) out of 10 problems and standard deviation was 1.89. The time constraint provided in high frustration condition may have created a ceiling effect on performance.

Self-assessed performance which was rated by NASA TLX performance subscale, high frustration condition ($M=5.64$, $SD=3.25$) significantly ($F(1,24)=40.18$, $p<.0001$, $d=0.62$) led to lower performance than low frustration condition ($M=7.43$, $SD=2.42$) (see Figure 2). The effects of etiquette strategies were significant ($F(4,95)=5.44$, $p=.0005$).

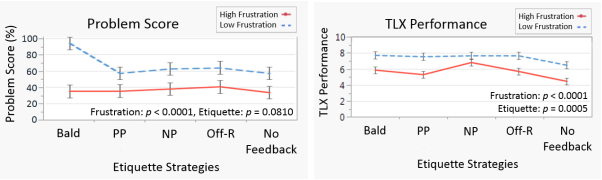

Figure 2. The mean plot and standard error of problem score (left) and TLX performance (right).

Post hoc analysis showed that all four strategies which are bald (t(183)=3.15, p=.0014, d=0.44, M=6.81, SD=2.75), positive politeness (t(183)=2.27, p=.0179, d=0.31, M=6.45, SD=3.03), negative politeness (t(183)=4.21, p<.0001, d=0.58, M=7.26, SD=2.81), and off-record (t(183)=2.84, p=.0033, d=0.38, M=6.69, SD=2.98) led to higher performance than no feedback condition (M=5.49, SD=3.18) in both high frustration and low frustration condition. In addition, negative politeness strategy significantly (t(183)=1.92, p=.0451, d=0.27) led to higher performance than positive politeness strategy in high frustration. However, the interaction between frustration and etiquette strategies was not significant.

Motivation and Confidence

Motivation. Participants were significantly (F(1,24)=4.41, p=.0465, d=0.19) more motivated to continue the task when they were in low frustration condition (M=7.49, SD=2.18) than high frustration condition (M=7.04, SD=2.36). The effects of etiquette strategies were significant (F(4,96)=3.52, p=.0100). See Figure 3.

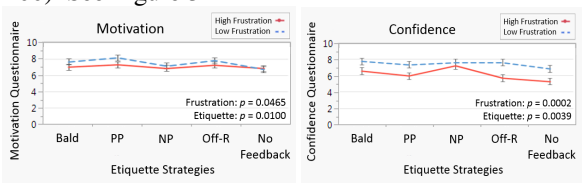

Figure 3. The mean plot and standard error of motivation (left) and confidence (right).

Post-hoc analysis test was conducted. Only the positive politeness strategy (M=8.15, SD=3.91) led to significantly (t(183)=2.92, p=.0156, d=0.38) higher motivation than no feedback (M=6.73, SD=3.49) in low frustration condition (see Figure 3). The interaction between frustration conditions and etiquette strategies was not significant.

Confidence. Participants had significantly (F(1,24)=19.9, p=.0002, d=0.48) more confidence about their tasks when they were in low frustration condition (M=7.41, SD=2.35) than high frustration condition (M=6.13, SD=2.92). Also, the effects of etiquette strategies were significant (F(4,96)=4.14, p=.0039). Post-hoc analysis showed that the negative politeness strategy (M=7.18, SD=2.76) led to significantly (t(183)=3.49, p=.0154, d=0.66) higher confidence than no feedback (M=5.27, SD=2.97) in high frustration condition (see Figure 3). However, the interaction between frustration conditions and etiquette strategies was not significant.

DISCUSSION

The results of the study showed that etiquette strategies significantly influenced performance, motivation, confidence. The hypothesis stated "Changing etiquette strategies in tutoring lead to higher performance, motivation, and confidence" and it was partially supported.

Considering the performance, scores from the mathematics problems were higher when the bald strategy was provided in low frustration condition whilst there was no differences of the scores between any etiquette strategies in high frustration condition. This may be due to the time constraint creating a ceiling effect in the high frustration condition. Some participants did not have enough time to solve the given problems. However, looking at the self-assessed NASA TLX performance results, all four etiquette strategies significantly lead to higher performance than no feedback in low frustration condition. In the high frustration condition, negative politeness lead to higher performance than positive politeness and no feedback.

Positive politeness led to higher motivation than no feedback in the low frustration condition. Providing feedback with negative politeness showed higher confidence about their own work than people who were not given any feedback in high frustration condition. These mean negative politeness and positive politeness effectively worked to increase motivation and confidence. These results demonstrated that user's performance, motivation, and confidence vary depending on which etiquette strategies was used.

In this study, we found that three etiquette strategies: bald, positive politeness, and negative politeness were effectively used to improve participants' performance, motivation, and confidence in different conditions. These results showed that providing feedback with a different interaction style to users based on their emotional states can vary the results of tutoring. However, it does not mean that one strategy was obviously better across all three dependent variables. It indicates that different strategies impact the three dependent variables in different ways. Further studies need to establish the interaction of strategy influences. The results of this study can be used to guide the HCI between an intelligent tutoring system and a student in the domain of math tutoring. Future work can expand to study the effectiveness of etiquette strategies over a wide variety of tasks.

Frustration is one of the most frequently occurring emotions in situations where people use computers (Ceaparu et al., 2004) and learn (Woolf et al., 2009). There are two ways to address user frustration in HCI. One is to find the cause of user frustration in the system and eliminate it. This case is usually related to technical problems, and it is not applicable to every system. In these cases, understanding user states and adapting the behavior of the system could be used to mitigate frustration, improve interactions between the human and the system, and potentially improve task performance. Once users experience frustration, the system could detect the emotion and trigger changes to diminish it. For instance, adaptive systems could mitigate user frustration by changing the way it communicates with users, much in the same way a human tutor would change his or her feedback when a student becomes frustrated. The ways of interpreting the characteristics of user frustration and its influences need to be scrutinized in order to investigate the methods to mitigate frustration.

Mitigating user frustration during learning can be valuable to prevent a decrease of their performance. This study provided a basic understanding of the role of different interaction styles of feedback and form the basis of an adaptive tutoring system. Different strategies can be used if a tutoring system is interested in increasing performance, motivation, or confidence. This study is the first step in understanding these differential effects and the results of this study will be used to inform the design of an adaptive tutoring system.

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