

WHY AM I CONFUSED: AN EXPLORATORY LOOK INTO THE ROLE OF AFFECT IN LEARNING

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The role that emotions play in learning was investigated in a constructivist learning framework. We observed six different affect states that occur during the process of learning introductory computer literacy with an intelligent tutoring system, called AutoTutor. Observational analyses revealed a significant relationship between confusion (present versus absent) and learning, as manifested in learning outcome measures (effect size = 1.34 sigma). The link between confusion and learning is consistent with a model that assumes that cognitive disequilibrium is one precursor to deep learning.

1 Introduction

Scientific investigations of emotions fell out of fashion for most of the 20th century in the fields of experimental psychology, education, and other social sciences, but there has been a renewed interest in emotions, moods, and subtle affect states since the mid-1970's (Ekman & Friesen, 1978; Mandler, 1976; 1984, 1999; Picard, 1997; Rozin & Cohen, 2003a). Ekman and Friesen (1978) highlighted the expressive aspects of emotions with their Facial Action Coding System that allowed for "basic emotions" to be identified by coding specific features and muscles of the face. These prototypical facial patterns were used to identify the emotions of happiness, sadness, surprise, disgust, anger, and fear (Ekman & Friesen, 1978; Efenbein & Ambady, 2002). The coding system was tested primarily on static pictures rather than on changing expressions over time. Unfortunately, for those researchers interesting in the role of emotions in learning, it is doubtful whether these 6 emotions are frequent and functionally significant in the learning process (Russell, 2003). More generally, some researchers have challenged the adequacy of basing a complete theory of emotions on these "basic" emotions (Ellsworth, 2003; Hess, 2003; Rozin & Cohen, 2003a)

The question of the role of emotions in the learning process is not entirely devoid of experimental exploration. In his book *Emotional Intelligence*, Goleman (1995) reported that expert teachers are able to recognize emotional states of their students and respond in ways that positively impact learning. While Goleman does not describe how this is accomplished precisely, Csikszentmihalyi (1990) described an ideal learning state in which learners receive materials and challenges at just the right level of difficulty to the point of becoming totally absorbed in the material. Time disappears; fatigue disappears. He called this state the "Zone of Flow," the direct antithesis to boredom.

According to constructivist theory, a person's affective state is expected to systematically influence the processing of material. The intrinsic motivation literature has identified affective states such as curiosity as indicators of motivation level and learning (Harter, 1981, Stipek, 1998). Learners with more intrinsic interest display greater levels of pleasure, more active involvement in tasks (Harter, 1992; Tobias, 1994), more task persistence (Miserandino, 1996), lower levels of boredom (Miserandino, 1996), less anxiety and less anger from tasks (Patrick, Skinner, & Connell, 1993). Since a person's affective state is linked to their motivation level, the intrinsically motivated learners who are affectively engaged should demonstrate more active involvement in tasks and more task persistence. A deeper understanding of the material should be one important consequence (Jonassen, Peck, & Wilson, 1999).

One class of cognitive models has postulated the important role of "cognitive disequilibrium" in comprehension and learning processes (Graesser & Olde, 2003; Otero & Graesser, 2001). Deep comprehension occurs when learners confront contradictions, anomalous events, obstacles to goals, salient contrasts, perturbations, surprises, equivalent alternatives, and other stimuli or experiences that fail to match expectations (Jonassen et al., 1999; Mandler, 1976; 1999; Maturana & Varela, 1992; Schank, 1986). Cognitive disequilibrium has a high likelihood of activating consciousness, effortful cognitive deliberation, questions, and inquiry until cognitive equilibrium is restored. The affective states of confusion and perhaps frustration are likely to occur during cognitive disequilibrium (Kort, Reilly, & Picard, 2001). Recent

research has pointed to confusion as an important affective state for scientific study (Rozin & Cohen, 2003b). The identification of confusion indicates an uncertainty about what to do or how to act (Keltner & Shiota, 2003, Rozin & Cohen, 2003a), which occurs often when confronted with cognitive disequilibrium. The state of perturbation and hesitation can be seen as an indication of a need for clarification or more information (Rozin & Cohen, 2003a; Smith, Chase, & Leiblich, 1974).

The current exploratory study investigated the role that confusion and other affect states play in the learning process. College students learned about introductory computer literacy by interacting with an intelligent tutoring system called AutoTutor (Graesser, K. Wiemer-Hastings, P. Wiemer-Hastings, Harter, Kreuz, & TRG, 1999; Graesser, Person, Harter, & TRG, 2001). AutoTutor helps students learn by holding a conversation with them in mixed initiative dialog. It has an animated conversational agent with synthesized speech, gestures, and facial expressions that display emotions. AutoTutor facilitates learning with an effect size of .8 sigma compared with reading a textbook for an equivalent amount of time (Graesser et al., 2003). The present exploratory study tracked the learners' emotions while they interacted with AutoTutor during training. These emotions were then correlated with learning outcome measures. If the constructivist theory and the claims about cognitive disequilibrium are correct, we should observe a significant relationship between confusion and learning gains. However, it is conceivable that other emotions play an important role in learning, so other emotions will also be tracked during the course of learning.

2 Methods

2.1 Participants

The participants were 15 college students drawn from the subject pool in the Department of Psychology at the University of Memphis. Students volunteered for course credit.

2.2 Materials

2.2.1 Electronic materials. Participants interacted with a computer program called AutoTutor on the topic of computer literacy. AutoTutor asked questions about hardware. The questions were deeper questions (such as *why*, *how*, *what-if*) that required about a paragraph of information to answer correctly. AutoTutor holds a mixed initiative dialog to assist the students in answering each question. The conversation typically takes 30-100 conversational turns. In addition to giving students short feedback on their contributions, AutoTutor gives hints, asserts missing information, and corrects misconceptions of the student.

2.2.2 Coding system. The coding system used in this study consisted of one sheet of paper with a formatted table. The left column of the table was broken into 5-minute intervals and started with 0 (e.g. 0, 5, 10, etc.). The top row listed the emotions of interest for the study, along with a space to record participant's point during the learning session (i.e., the subtopic and question being answered). The emotions were listed in the following order: Frustration, boredom, flow/interest, confusion, eureka, and neutral.

The six emotions were functionally defined for the coders. Frustration was coded if participants seem angry or agitated. Boredom was coded if participants seem uninterested in the activity or responded slowly to the system and did not appear motivated. Flow was coded when participants showed interest in the interaction or were paying attention and responding quickly. Confusion was coded if participants seemed puzzled and not sure how to continue, or were struggling to understand the material. Eureka was coded if participants were observed to transfer from a state of confusion to a state of intense interest, as manifested by typing in answers very quickly after a period of inactivity. Neutral was coded if participants show a void of emotion and no facial features, or if no emotions could be determined.

2.2.3 Outcome materials. Two 24-item multiple-choice tests on computer hardware were administered during this experiment. These two tests were alternated between participants to serve as either a pretest of domain knowledge or a posttest of learning gains. These two tests have been shown to be equivalent in past research (Craig, Driscoll, & Gholson, in press).

2.3 *Procedure*

During this investigation, the 15 undergraduate participants were observed individually while they worked with AutoTutor. Every 5 minutes during this interaction, one experimenter observed the interaction for 30 seconds and recorded any noticeable emotion. In order to prevent bias reporting from the experimenters, they were given a list of 6 affective states to choose from along with a short description of each. These states were confusion, frustration, boredom, flow/interest, eureka, or neutral. There were a total of 3 different experimenters used for this study.

A pretest-posttest design was used for the learning portion of the study. Two alternating 24-item tests on the material were used as the learning measure as described above in section 2.2.3. The analysis was calculated based on the change score from these two tests (posttest score - pretest score).

3 **Results**

Confusion showed a significant strong positive correlation with the learning change score, $r(13) = 0.72, p < 0.01$. None of the other affect states significantly correlated with change scores, ranging from -.38 to .19. A list of the correlations for all emotions with change scores can be found in table 1. A multiple regression analysis was performed on the data to investigate if there were a combination of significant predictors of the observed learning gains. The multiple regression formula predicted a significant 68% of the variance, $F(4,12) = 4.26, p < .05$. Whereas all emotions were entered into the regression analysis, the only affective state which reached significance was confusion, $t(13) = 3.48, p < .01$.

Table 1. Correlations between change score and each emotion. Significant correlations marked with an asterisk (*)

	Boredom	Confusion	Eureka	Flow	Frustration	Neutral
Change score	-.12	.72*	.032	.19	-.38	-.319

We conducted an analysis on participants who did versus did not exhibit confusion during the learning session. There was a significant difference between the two groups of participants, $F(1,14)=6.75, p < .05$. The difference showed that learning gains were higher in sessions where confusion was observed ($M=7.3, s=1.7$) than when confusion was not observed ($M=4.7, s=2.3$). This resulted in a Cohen’s D effect size of 1.34. Means and standard deviations can be found in table 2.

Table 2. Means and standard deviations

	Mean	Standard Deviation
Confusion observed	7.3	1.7
Confusion not observed	4.7	2.3

4 Discussion

These results provide insight into the predictions of this exploratory study. The affective state of confusion plays an important role in the learning process. While the affective state of confusion does not play the only role in learning, it does appear to play an important part. In fact from the effect size gain of 1.34 for participants when confusion was observed, it would seem that some level of confusion is critical for optimal learning as predicted by constructivism.

This finding provides validation to the claims of many researchers that emotions (Goleman, 1995; Jonassen, et al, 1999) and more specifically confusion (Kort et al, 2001) plays an important role in the learning process. Kort and colleagues (2001) describe confusion as an important part of the learning process. According to their model, confusion should naturally occur during the learning process as the learners are confronted with information that is inconsistent with existing knowledge and they are forced to discard misconceptions before they can move forward in the learning process. This would be consistent to moving from a state of cognitive disequilibrium to a state of cognitive equilibrium which is essential for learning to take place (Mandler, 1984; 1999; Otero & Graesser, 2001; Stein & Levine, 1991).

While this study in itself does not explain the full role of affect in the learning process, it does highlight the importance that affective states can play in learning. While we focused mainly on confusion, the role of other affective states also needs scientific investigation. Furthermore, the investigation of the interplay of affect and learning could provide valuable insight into the human learning process.

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