

Towards Emotional Regulation in Intelligent Tutoring Systems

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Abstract: The emotional factor has been never taken into account in Intelligent Tutoring Systems (ITS) until recently. However, emotions play a crucial role in cognitive processes particularly in learning tasks (Isen, 2000). Thus, our purpose in this research study was to analyse the effect of some tutoring actions on the learner's emotional state in order to ascertain the feasibility of positive emotions inducing in ITSs. To achieve this aim, we developed a data structure web course and a virtual tutor using different pedagogical actions to induce positive emotions in the learner. We have conducted an experiment to collect, among other, participants' physiological responses after the tutoring actions. The results of this experimental study showed that certain actions have significant positive effects on the learner's emotional state.

1 Introduction

Traditionally, educational research on learners' performances has supposed that cognition and emotions are two separable mental processes. It has concentrated on cognition more than emotions. One reason for this is the domination of cognitive psychology over educational research. Another reason may be the difficulty in recognition of the learners' emotional states. But this way of looking at learners' behaviour has shown its limits (Morselli, 2004). Recent educational researches have shown that cognition and emotions processes are closely linked (Dalglish, 1999, Forgas, 2000, Storbeck, 2007). Emotions are clearly present in learning tasks. According to Pekrun et al. (2002), during a task, the learner can feel boredom, despair, anxiety, but also pleasure to perform the task or learning, or the joy of an early success or hope of success (Pekrun, 2002). However, after the task, he can evoke feelings of sadness, disappointment, shame, guilt, but also joy of having succeeded, satisfaction, pride and relief. In addition, other studies attempt to understand and measure the effect of emotion felt by the learner on his performance during learning tasks. For instance, Govaerts and Grégoire (2006) analyzed the relationship between the emotions experienced by students (such as hope, anxiety, shame or stress) and their performances in the task (Govaerts, 2006). The results of these studies showed that emotions play a significant role in cognitive learning tasks. Indeed, the learner will experience a variety of emotions during a session of learning - such as joy, frustration, anxiety or boredom - which will not only be a clue the effectiveness of education, but will also strongly influence the cognitive abilities of the learner. Learners' current emotions influence the way they think, perceive events, remember and make decisions.

Intelligent Tutoring Systems (ITS) are generally characterized by their individualized learning, they adapt instruction according to the learner's knowledge degree in order to improve learning. In ITS, tutor must take into account the learner's emotional state. The type of emotions which the learners feel in the learning activity seems to be very significant: the negative emotions decrease their performances, whereas the positive ones ensure cognitive engagement and support their performance (Isen, 2000). Thus, the tutor must have capabilities to regulate the learner's emotional state. He can by this way assign to learners suitable actions and achieve consequently instruction in the best conditions.

Recently, the issue of emotion regulation drew interests from several fields including neuroscience, psychology, education, computer science, etc. Indeed, emotion regulation concerns the ability to reduce high levels of emotion arousal and the capacity to change our feelings (Gross, 1998). Nonetheless, emotion coping differs from emotion regulation by its focus on reducing negative emotion experience (Blair, 2004). Researchers distinguish in general between two types of emotion coping strategies. The first strategy is the problem-focused coping strategy which is intended to solve the problem that causes the emotional situation. The second strategy is the emotion-focused coping strategy which is intended to regulate the negative emotion aroused. In this research work, we

present emotion coping in intelligent tutoring systems. We study the effect of the tutor's actions on the learner's emotion regulation.

The rest of the paper is organised as follow: After reviewing some related works in connection with emotional regulation in Intelligent Tutoring Systems field, we present, in section 3, the experiment conducted in order to study the effects of some tutorial actions on the learner's emotional state. Then, the results are shown in section 4 and discussed in section 5. Finally, the last section concludes the paper.

2 Related Work

As defined by (Folkman, 1980), coping strategies refer to the specific efforts, both behavioral and psychological, that people employ to master, tolerate, reduce, or minimize stressful events. Emotion coping provides negative emotion regulation. During human-computer interaction it seems possible that user's negative emotions are recognized and influenced in order to reduce related negative effects. In this paper, we focus on previous work dealing with emotion regulation in computer science.

Regulating learner's emotion helped teaching effectiveness goals. Tutor supposes the emotional regulation very crucial to his instruction. He uses a variety of preventative and responsive emotional strategies to help him regulate the learner's emotion. Animated pedagogical agents for instance, proposed by (see e.g. (Conati, 2002, Elliott, 1999), communicate appropriate emotions and provide consequently many educational benefits to learners. These agents generate suitable interventions aimed at stimulating the student to learn better from the game. In addition to the learners' cognitive states, these agents need to take into account the learners' affective states when they want to intervene. Indeed, they are sensitive to learners' emotions (for instance boredom or frustration) and can provide feedback that lets students be more interested to learning. It seems possible to make learning more enjoyable for the learner by using this kind of agents.

In addition, active Listening, empathy, sympathy and venting may be strategies aimed at reducing negative effect (Klein, 2002). By playing a computer game, user indicated on a scale the level of frustration that he experienced with the system. Then a support agent offers an affective feedback by sending the user some text that mirrored the level of frustration that the user reported. It has been shown that some of the user's negative feelings are reduced and the tendency of people to interact with computers is boosted.

According to (Prendinger, 2007), human-computer interaction would become more productive by offering help and assistance to confused user. The authors study the effect of empathic embodied feedback on deliberately frustrated users. They conceived an educational agent (empathic companion) that supports job seeks preparing for a job interview. Firstly, the empathic companion could recognize the user's emotion using physiological data (skin conductance and electromyography) and then try to cheer up a frustrated user relying on affective feedback communicated by means of interfaces that employ embodied agents or lifelike characters. The results showed that users receiving empathic feedback are less stressed when being asked an interview question.

Similarly, 0(Partala, 2004) focus on human-computer interaction, but they study especially the effects of affective interventions using synthetic speech with emotional content. The interventions were given when subjects' problem solving had been interrupted by mouse delays. Compared to no intervention condition, the results showed that the use of positive worded affective intervention has improved the smiling activity. At the same time frowning activity was clearly decreased during affective intervention.

3 Experiment

Aiming to study the effect of some tutoring actions on the learner's emotional state, we developed an experiment in which we tried to detect the participants' emotional responses after some tutoring actions in a data structure web course.

3.1 Subjects

Twenty-nine volunteer students, aged between 22 and 40 years ($M = 31$ years, $SD = 9$), participated in the experiment as test subjects. All the participants are graduate students in computer science at the University of Montreal and have basic knowledge in data structure.

3.2 Experimental procedure

In this experiment, the virtual tutor attempts to influence the learner's emotional state in two situations: the first one when the learner needs help to understand a sorting algorithm (initial actions) and the second one when the learner obtained his mark after passing an evaluation test (final actions).

The need for help. In this situation the tutor used two kinds of actions trying to mitigate the effect of any negative emotion produced when the learner didn't understand a sorting algorithm principle:

- The first kind named the problem-focused actions. These actions attempt to act on the problem that is causing the emotional situation. In this case, the tutor tried to change the situation that is causing the emotion by using an example or a definition to help participants for understanding the course.

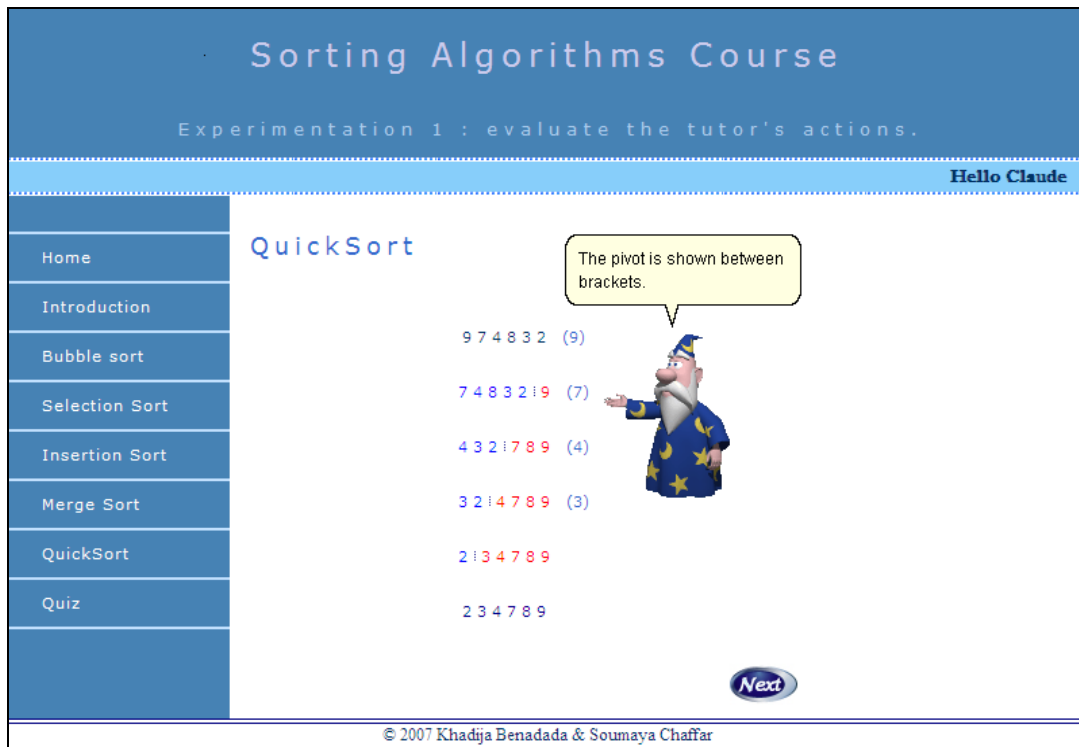


Figure 1: Screenshot of the experimentation environment: the tutor is giving an example.

- The second kind named the emotion-focused actions. These actions attempt to regulate the learner's emotions generated by the situation. In this case, the tutor acts in order to allow participants to change their way of perceiving the situation - without changing the reality itself - by encouraging them to make an effort to understand the course alone for example.

Viewing marks. When the participants obtain their mark after the evaluation test, the tutor uses three emotion-focused actions: the first action (encouragement) is to encourage participants to make more efforts to improve their knowledge in sorting algorithms, the second action (recommendation) consists in providing recommendations to participants in order to improve their mark and the third action (congratulation) concerns only the participants who had excellent marks (a mark greater than eight).

Initial actions	Final actions
Definition } (problem-focused)	Encouragement }

Example	Recommendation (emotion-focused)
Encouragement (emotion-focused)	Congratulation

Table 1: Tutoring actions used in the experiment.

In order to detect the learner's emotional changes after the tutor's actions, the electromyography sensor (EMG) was used because it is the most studied and validated physiological measure for indicating the valence. Moreover, it is used to detect the valence even in the absence of facial expressions (Hazlett, 2007).

In fact, the EMG sensor serves to measure muscle activity. Based on previous studies, EMG signal is correlated either with valence or arousal depending on the muscle where it is measured. For example, signal measured from the zygomatic muscle has a significant positive quadratic correlation with valence, dimensional $r = .90$ (Lang et al., 1993). While EMG signal measured from the corrugator varies linearly negative with the valence, dimensional $r = -.90$ (Lang et al., 1993). In this experiment we used only EMG signals measured from the zygomatic because our aim is to verify if a particular tutoring action has a positive effect on valence.

4 Results

4.1 EMG Signal Processing

We recall that our aim is to analyze the effects of some tutoring actions on the learners' emotional reactions. According to the appraisal theory, an emotional reaction occurs as a result of events' cognitive appraisals (Ortony, 1988). The cognitive appraisal's duration depends on each individual and remains unknown like the emotion's duration. According to (Levenson, 1988), an emotion persists between 0.5-4 seconds. Thus, we considered the signals recorded during the tutoring actions and about five seconds after each action. To detect changes in participants' emotional states, we considered also the signals recorded during the five seconds preceding the action. With these signals we can check whether there are significant variations due to the virtual tutor's actions.

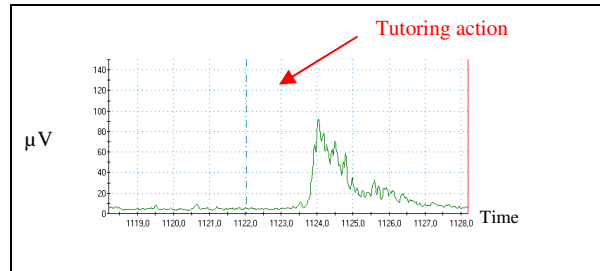


Figure 2: An example of the EMG signal changes before and after the tutoring action.

After having sampled the physiological data derived from the EMG, we used a smoothing technique in order to reduce or remove random fluctuations and noise in data. In this work, we used the moving average technique for smoothing the physiological signals derived from the EMG sensor. The formula used for a simple moving average is as follows:

$$\bar{y}_t = \frac{(y_t + y_{t-1} + \dots + y_{t-n+1})}{n} \quad (1)$$

Where y is the variable, t is the current time period, and n is the number of time periods in the average called also averaging factor. As recommended by BioGraph Infiniti™ software, we have chosen n equal to 100.

Then, a normalisation seems to be important for reducing individual differences in physiological responses. The EMG signal was then normalised using the following formula:

$$signal_{normalised} = \frac{signal - baseline}{baseline} \quad (2)$$

Where $signal$ represents the sampled signal and $baseline$ refers to the sampled signal collected in the relaxation phase.

4.2 Tutoring Actions Effects

73 instances were used to study the effects of the tutor's actions on the participants' emotional responses. For this purpose, we performed a statistical study using analysis of variance (a single factor ANOVA) test. For each tutor's action, we compared the recorded signal before the action with the one recorded during and after 5 seconds of this action. This allowed us to verify if the tutor's action explained significantly a part of the EMG physiological signal changes.

Action Definition. This action aims to provide a clearer explanation on a sorting algorithm (bubble sort, selection sort, insertion sort, merge sort or quick sort). To verify if the action *Definition* had a positive effect on the learner when he asks for help, we performed an ANOVA between the two data sets (see table 2).

		Average	F	P
EMG signal	Before	1.83	10.10	0.00
	During and after	15.51		

Table 2. Descriptive data and results of the ANOVA for the *Definition* action.

The results of the ANOVA showed a statistically significant difference between the EMG signals peaks before the definition and those recorded during and after the action ($F(1,31)=4.49$, $F=10.10$, $p=.00<.05$).

Action Example. This action attempts to explain the principles of a sorting algorithm by using an example. The table 3 below presents an ANOVA analysis which attempts to ascertain if the *Example* action had a positive effect on the learner when he asks for help.

		Average	F	P
EMG signal	Before	1.544	29.174	0.00
	During and after	7.986		

Table 3. Descriptive data and results of the ANOVA for the action *Example*.

The table above shows that the difference between the EMG peaks observed before the *Example* action and those observed during and after this action is significant ($F(1,41)=7.31$, $F=29.17$, $p=.00<.05$).

Action Encouragement_Comprehension. This action is intended to encourage the learner for understanding the course alone. The results of the ANOVA test, trying to study the *Encouragement_comprehension* effects, are presented in table 4.

		Average	F	P
EMG signal	Before	2.045	3.289	0.088
	During and after	7.375		

Table 4. Descriptive data and results of the ANOVA for the *Encouragement_Comprehension* action.

As described in the table above, we note that the difference, between the EMG peaks taken before the tutor's action and those taken during and after it, is not significant ($F(1,17)=4.49$, $F=3.28$, $p=.08>.05$).

Action Recommendation. The tutor uses this action to give recommendations to the learner in order to get good marks in the next time. The results of the ANOVA test, attempting to study the effect of the *Recommendation* action, are presented in the table 5.

		Average	F	P
EMG signal	Before	2.046	6.036	0.025

	During and after	12.516		
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Table 5. Descriptive data and results of the ANOVA for the *Recommendation* action.

As shown in the table above, there is a significant difference between the EMG peak taken before the *Recommendation* and those recorded during and after this action ($F(1,17)=4.49$, $F=6.03$, $p=.02<.05$).

Action Encouragement_Note. This action tries to encourage the learner for working harder if he gets a bad or an average mark. To verify if the action *Encouragement_Note* had a positive effect on the learner when he obtained his mark, we performed an ANOVA (see table 6).

		Average	F	P
EMG signal	Before	1.763	20.359	0.00
	During and after	6.673		

Table 6. Descriptive data and results of the ANOVA for the *Encouragement_Note* action.

The table above shows that there is a significant difference between the EMG signals peaks taken before *Encouragement_Note* and those observed during and after this action ($F(1,27)=4.22$, $F=20.359$, $p=.00<.05$).

Action Congratulation. This action concerns only the participants who had a mark between 9 and 10. It consists in congratulating the participants for their performance in the evaluation test. To study the effect of this action, an ANOVA test was performed. The results of the ANOVA are shown in the table 7 below.

		Average	F	P
EMG signal	Before	0.948	4.681	0.162
	During and after	15.432		

Table 7. Descriptive data and results of the ANOVA for the *Congratulation* action.

As described in the table above, there are no significant differences between the EMG peaks observed before the *Congratulation* and those observed during and after this action ($F(1,3)=18.51$, $F=4.68$, $p=.16>.05$).

5 Discussion

As shown in the experimental study section, the tutor attempts to influence the learner's emotional state in two situations: when the learner did not understand a sorting algorithm and when he obtained his mark after passing an evaluation test.

In the first situation, the results of the ANOVA test (Table 1 and 2) showed that the problem-focused actions have significant positive effects on the variation of the EMG signals. However, the results of the emotion-focused actions (Table 3) showed that the *encouragement* has no effect on the learner's emotional state. So, the learner needs for helping him to understand the course (definition, example) rather than encouraging him when he did not understand the course. During the comprehension activity, we can conclude that it is recommended to use a problem-focused action in order to induce positive emotions in the learner. These actions attempt to change the problem that is causing the emotional reaction by explaining the course using an example or a definition for instance in order to change the learner's misunderstanding state and improve his emotional state.

In the second situation, when he learner obtained his mark after passing an evaluation test, we used only emotion-focused actions. The results of the ANOVA showed that *Recommendation* and *Encouragement* actions (Table 4 and 5) have positive effects on the learners' emotional states (learners who have middle and low marks) while the *Congratulation* action (Table 6) does not affect the emotions of good learners. In this situation, it is recommended to use emotion-focused actions. These actions have a great effect especially for learners who have medium and low marks.

These results can be explained by the fact that the learner requires actions attempting to help him for improving his skills and achieving his learning objectives. We believe that this is the reason why the participants expressed positive emotions after certain actions.

6 Conclusion

Emotions play an important role in the cognitive processes and particularly in learning tasks, since emotions through the limbic system of the brain have a connection with long-term memorizing (Damasio, 1994). Our main goal is to place the learner in good conditions ensuring a better learning performance. To reach this goal, we have to regulate the learner's emotional state when we expect that he is feeling bad. This is one of the tutor's main concerns in Intelligent Tutoring Systems (ITS) because positive affects are fundamental in cognitive organization and thought processes; they also play an important role to improve creativity and flexibility in problem solving (Isen, 2000). For these reasons, it is fundamental for an ITS to have a capacity for regulating emotions and inducing positive ones in learners.

In this paper, we have studied the effect of tutoring actions (in a data structure web course) on the learner's emotional state. For this purpose, we have used the EMG signals, which are much correlated with the valence, in our experimental study. We conclude, with 95% of confidence, that there is a significant positive effect of these actions on participants' emotional state. Thus, we conclude that it is possible for an ITS to induce positive emotions in learners.

It remains for future research to study the effect of these actions on the emotional intensity. For instance, do these actions have a high effect or a low one?

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