Modeling Cognition-Emotion of Users for Improved Interaction With Software Systems

Christine Lisetti

Department of Information Systems and Decision Sciences, University of South Florida, USA

Abstract. In this article, a strong case for the need to include emotions in the user model is developed and documented.

1 Introduction

New theories of cognition emphasize the tight interface between affect and cognition. Given the increasing use of computers which support the human user in many kinds of task, issues in affective computing (Picard, 1997) – " computing that relates to, arises from, or deliberately influences emotions" – necessarily begin to emerge. Indeed, there is now plenty of evidence in neuroscience and psychology about the importance of emotional intelligence for the overall human performance in tasks such as rational decision-making, communicating, negotiating, and adapting to unpredictable environments. As a result, people can no longer be modeled as pure goal-driven, task-solving agents: they also have emotive reasons for their choices and behaviour which (more often than not) drive rational decision-making (Mandler, 1975). We presently propose that user models need to include affective phenomena and model *both* the user cognitive *and* affective processing resources .

In the remainder of this article, we document why the interface between affect and cognition needs to be acknowledged in user modeling.

2 User Modeling, Affect and Cognition

As a result of recent findings, emotions are now considered as associated with adaptive, organizing and energizing processes. We mention a few already identified phenomena of interaction between affect and cognition, which we expect will be further studied and manipulated by building intelligent interfaces which acknowledge such an interaction. We also identigy the relevance of these findings about emotions for the field of User-Modeling.

- *Organization of memory and learning*: we recall an event better when we are in the same mood as when the learning occured (Bower, 1981). Hence eliciting the same affective state in a learning environment can reduce the cognitive overload considerably. User models concerned with reducing the cognitive overload (Kalyuga et al., 1997) – by presenting information structured in the most efficient way in order to eliminate avoidable load on working memory – would strongly benefit from information about the affective states of the learners while involved in their tasks.
- *Focus and attention*: emotions restrict the range of cue utilization such that fewer cues are attended to (Derryberry and Tucker, 1992);

• *Perception*: when we are happy, our perception is biased at selecting happy events, likewise for negative emotions (Bower, 1981). Similarly, while making decisions, users are often influenced by their affective states. Reading a text while experiencing a negatively valenced emotional state often leads to very different interpretation than reading the same text while in a positive state. User models providing text tailored to the user need to take this affective information into account to maximize the user's understanding of the intended meaning of the text.

• *Categorization and preference*: familiar objects become preferred objects (Zajonc, 1984). User models which aim at discovering the user's preferences (Linden et al., 1997), also need to acknowledge and make use of the knowledge that people prefer objects that they have been exposed to, even when they were shown these objects subliminally.

• *Goal generation and evaluation*: patients who have damage in their frontal lobes (cortex communication with limbic system is altered) become unable to feel, which results in their complete dysfunctionality in real-life settings where they are unable to decide what is the next action they need to perform (Damasio, 1994), whereas normal emotional arousal is intertwined with goal generation and decision-making.

• *Decision making and strategic planning*: when time constraints are such that quick action is needed, neurological shortcut pathways for deciding upon the next appropriate action are preferred over more optimal but slower ones (Ledoux, 1992). Furthermore people with different personalities can result in very distinct preference models (Myers-Briggs Type Indicator). User models of personality (Paranagama et al., 1997) can be further enhanced and refined with the user's affective profile.

• *Motivation and performance*: an increase in emotional intensity causes an increase in performance, up to an optimal point (inverted U-curve Yerkes-Dodson Law). User models which provide qualitative and quantitative feedback to help students think about and reflect on the feedback they have received (Bull, 1997), could include affective feedback about cognitive-emotion paths discovered and built in the student model during the tasks.

• *Intention*: not only are there positive consequences to positive emotions, but there are also positive consequences to negative emotions – they signal the need for an action to take place in order to maintain, or change a given kind of situation or interaction with the environment (Frijda, 1986). As described later in this paper, pointing to the positive consequences – the functional attributes – of the emotions experienced during interaction with a specific software could become one of the roles of the user modeling agents.

• *Communication*: important information in a conversational exchange comes from body language (Birdwhistle, 1970), voice prosody, facial expressions revealing emotional content (Ekman and Friesen, 1984), and facial displays connected with various aspects of discourse (Chovil, 1991).

• *Learning*: people are more or less receptive to the information to be learned depending on their liking (of the instructor, of the visual presentation, of how the feedback is given, or of who is giving it). Moreover, emotional intelligence is learnable (Goleman, 1995), which opens interesting areas of research for the field of user modeling as a whole.

Given the strong interface between affect and cognition on the one hand (Leventhal and Scherer, 1987), and given the increasing versatility of computers agents on the other hand, the attempt to enable our tools to acknowledge affective phenomena rather than to remain blind to them appears desirable. In a future paper, we will present the prototype of a user-model which combines the results of our current research project to partially model the user's emotional states

(see Lisetti et al., 1998 for a explanation of the overall architecture, and Lisetti and Schiano, 1999, and Lisetti and Rumelhart, 1998 for extracting information based on facial expressions , and Lisetti, 1997 for identifying relevant emotional components).

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