Designing Affective Pedagogical Agents: How learners' and agents' gender and age influence emotion in an online tutoring task

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Abstract: In designing pedagogical agents, it is important to understand what factors stimulate the learner's affect to enhance learning motivation. To do so, the present study investigated the influence of affective mood on gender types of the (1) learner and the (2) pedagogical agent through an online tutoring activity. Affective states were ascertained using a questionnaire constructed on the basis of Russell's (1980) two-dimensional affective model data for 16 times during the tutoring activities. The participants were 290 psychology students, who were made to perform a homework activity. The results of two experiments consistently revealed that male students were sensitive to the pleasantness bipolar and female students were sensitive to the activation bipolar.

Keywords: Web-based tutoring, Embodied agents, Affective learning, Gender

Introduction

Past studies on pedagogical agents show that their presence is sometimes sufficient in promoting learners' affective states, such as motivation (Kim, Baylor, & Shen, 2007). One approach is to build tutoring systems that encourage learners, based on their most suitable affective state. The present study investigates the types of agents most suitable for students with personal characteristics and affects during an online learning activity.

1. Related work and research questions

1.1 Affective learning and tutoring systems

Recently, affective learning has become a popular topic in learning sciences and several studies have reported that affective factors are especially important in learning activities (Baylor, Kim, 2005; Hayashi, 2012). For example, Bower and Forgas (2011) revealed that positive moods can increase recall. Psychological studies in communication indicate that social embodied cues such as gaze, gesture, facial expression, and posture are good for facilitating teaching effectiveness (Mehrabian, 1966). Unfortunately, it is quite difficult for a teacher tutoring a large class to provide different types of cues suitable to each learner's preferences and needs. A solution is to use communication technologies such as tutoring systems and pedagogical agents. Then, the following research questions arise: "How do the most effective agents improve student learning?". The present study investigates the kind of factors related to one's affective state. This investigation has implications for designing effective tutoring systems that are capable of presenting information based on the user's

affective state. The results of such as study will provide new ideas for designing an online tutoring system that would prove to be effective for teachers, motivators, and collaborators. The present study uses Russell's two-dimensional theory of emotion as a dependant variable to discover affective states relevant to mood during learning activities (Russell, 1980). Pleasure-displeasure (or valence) is a dimension of experience that refers to a hedonic tone. Activation is a dimension of experience that refers to a sense of energy. The vertical axis shows that a person could be somewhere on a continuum ranging from sleep (at the lower end), through drowsiness, relaxation, alertness, hyperactivity, and, finally, frenetic excitement (at the opposite end). The present study uses this model to analyze students' affective states during learning activities.

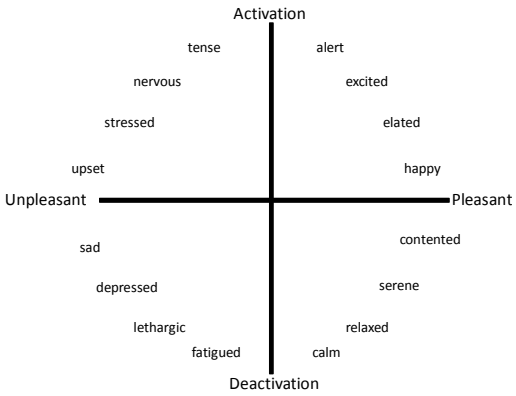

Figure 1. A schematic description of the two-dimensional structure of affect, adapted from Russell (1980)

1.2 Influence of personal status and social cues on affective learning

Studies in human-computer interaction show that people attribute personality traits to non-humans as well, that is, to animals or artificial agents such as robots (see Nass & Moon, 2000 for overviews). It is, therefore, assumed that the social verbal and non-verbal cues that facilitate motivation as discussed above are important factors in tutoring with computer agents. On the other hand, studies have focused on the user's prior knowledge and characteristics during interactions with artificial agents and robots. Research suggests that the effects of gender assigned to humans influence different impressions (Carpenter, Davis, Erwin-Stewart, Lee, Bransford, & Vye, 2009). Previous studies focusing on the use of virtual agents in pedagogical settings also show that these personal elements are important factors that influence interaction (Choi & Clark, 2006). The studies explained above show that personal statuses influence interaction with pedagogical agents. Unfortunately, little is known about the specificity of the influence of the learner's affective states, moreover, such are the activation level indicated in the vertical axis in the two-dimensional affective model (Figure 1). Moreover, little is known about the relationship between individual status and external social cues of the agents. The present study investigates this through an integrative experimental design shown in Figure 2.

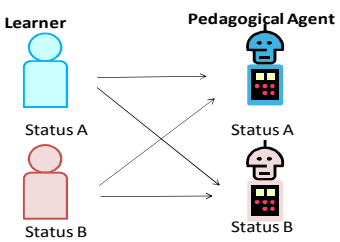

Figure 2. An interactional approach to investigate human-agent interaction

1.3 Aim of this study

The goal of the study is to understand the nature of learners' affective states due to their social status and the effects of the types of embodied agents. This study attempts to answer the following questions: (1) How do personal traits such as gender influence the user's affective mood during online learning activities?, (2) How do representations of agents influence affective mood during online activities?

2. Method

This study constructed a system that guides the learner in a simple web-based tutoring program. Students in a psychology class used the system to review key terms taught in a class, as homework. They were guided by a pedagogical agent who encouraged students by providing metacognitive suggestions and searches about the term on the Web for further understanding. Based on Russell's (1980) emotional models, the present study collected emotional variables as dependent variables. A total of 290 students participated in two evaluation experiments. The participants were all undergraduate students who were taking a psychology course and undertook a web-based tutoring task as part of the course work. The task was to read about a single topic, about key psychological terms, and answer a short quiz based on the literature. The study was conducted through two experiments as a two factorial between subject designs. In both experiments, the two actors, shown in the integrated design model in Figure 2 were investigated. Table 1 shows the experimental design. One hundred and thirty-five undergraduates participated in experiment 1 (male = 66, female = 69, *M* age = 19.72 years) and one hundred and fifty-five undergraduates participated in experiment 2 (male = 72, female = 83, *M* age = 19.49 years).

Table 1. Experiment design

	Male (Student)	Female (Student)
Male (agent)	H(M)/A(M)	H(F)/A(M)
Female (agent)	H(M)/A(F)	H(F)/A(F)

2.1 Materials and settings

In this study, a web-based tutoring system was developed only for the class. The system was constructed using the Web server, database, and rule-based program scripts. It was managed as a member-only system and its main operation was to tutor key terms taught in the class by presenting descriptive content. A total of 30 different key terms (e.g., Gestalt, long-term memory, cognitive dissonance) were extracted from an introductory psychology textbook and its explanations were entered in the system database. Students were randomly assigned to work on one key term. The tutoring sessions comprised 17 short passages, and students proceeded by clicking on to the next page (trial). During the task, there were four short quizzes on the key terms. Students were encouraged to go beyond a mere reading of these passages, to try and search through the web page to further understand the terms. Due to the experimental conditions, these suggestions were made by different types of pedagogical agents. The average time for this activity was approximately 30 minutes. The avatars used in the study were created using a 3D-image/animation-design tool called Poser 8 (www.e-frontier.com). Figure 3 shows an example of the arousal expressions of the avatars that were used in the study. While students participated in the task, they were also required to choose and click on one of the eight emotional icons (emoticons) intended to gauge their mood while undertaking the task. This was the dependant variable for this study: to

ascertain affective states related to motivation towards learning activities. These eight emotional icons were depicted from Russell's two emotional dimensions presented in Figure 1 (Russell, 1980). This evaluation was presented at each trial of the passage.

Figure 3. Avatars used in the two experiments: The ones on the left were used in experiment 1 (male and female, respectively) and the ones on the right were used in experiment 2 (male and female respectively)

3. Results

Figure 4 (left) indicates the average of each participant's ratio of evaluation for experiment 1. To investigate the relationships between the gender types of the agent and the participant an analysis was conducted using the ANOVA. A 2 x 2 x 8 ANOVA was conducted on the average scores with the agents' gender (female agent vs. male agent) and participants' gender (female participant vs. male participant) as a between-subject factor, and affective state (pleasure vs. excitement vs. arousal vs. distress vs. displeasure vs. depression vs. sleepiness vs. relaxation) as a within-subject factor. The second-order interaction was not significant ($F(7,917) = 0.217$, $p = .98$). There was significant interaction between the participants' gender factor and the factor of affective state ($F(7,917) = 52.093$, $p<.01$). Consequently, an analysis of the simple main effect was conducted. Focusing on the affective state, the rating score at participant male conditions was significantly higher than at the participant female conditions in the pleasure state ($p<.01$). Results also show that the rating score at participant female conditions was significantly higher than at the participant male conditions in the arousal state ($p<.01$).

Figure 4 (right) indicates the average of each participant's ratio of evaluation for experiment 2. A 2 x 2 x 8 ANOVA was conducted as in experiment 1. The second-order interaction was not significant ($F(7, 1057) = 1.484$, $p = . 17$). There was significant interaction between the participants' gender factor and the factor of affective state ($F(7, 1057) = 3.879$, $p < .01$) and the effect between the factor of agents' gender and affective state ($F(7, 1057) = 2.796$, $p =.05$). Given the significant interaction between the factor of participants' gender and the factor of affective state, an analysis of the simple main effect was conducted. Focusing on the affective state, the rating score at participant male conditions was significantly higher than at the participant female conditions in the pleasure state ($p < .01$). Results also showed that the rating score at participant female conditions was significantly higher than at the participant male conditions in the arousal state ($p < .01$). Now, we look at the simple main effect between the factor of the agents' gender and affective state. Focusing on the affective state, the rating score at agent male conditions was significantly higher than at the agent female conditions in the pleasure state ($p < .01$). Results also show that the rating score at agent male conditions was significantly higher than at the agent female conditions in the excitement state ($p < .01$).

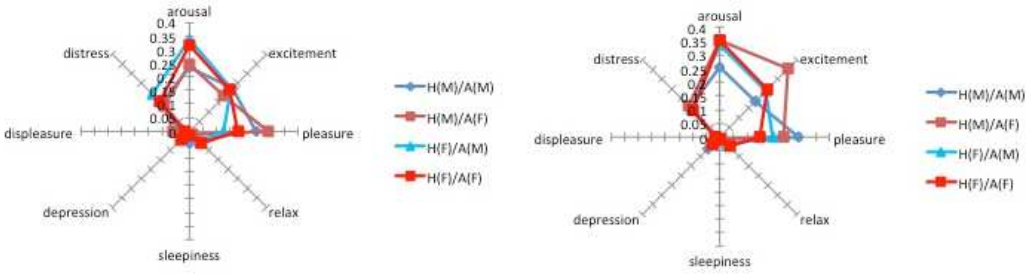

Figure 4. Results of the summary of all data in experiment 1 (left) and 2 (right)

4. Conclusion and Discussions

The present study captured the nature of the affective state based on Russell's (1980) two-dimensional model on an online tutoring activity. The focus of the study was to investigate how affective states may differ due to personal characteristics and factors such as agents that embody character. Results of the large-scale online experiment showed that females are more sensitive to the activation dimension than males and males are more sensitive to the pleasure dimension than females. In experiment 1 and 2, male learners had stronger pleasure ratings than female learners. Results also show that in experiment 1 and 2 female learners had stronger activation ratings than male learners. Consistent results on both experiments indicate that females tend to have more affective states on the vertical axis in Russell's (1980) model. On the other hand, males have more affective states on the horizontal axis. In experiment 2, the interaction between the agents' gender and affective state became significant. This indicates that the affective expressions of the agent appeared only in the child. This indicates that the 'age' of the character strongly influences the affective mood of the learner. The results of the present study may contribute to designing agents that use different types of affective expressions during pedagogy.

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