

Influence of pedagogical agents' and learners' social status on an online tutoring task: Investigation on affective states

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Abstract: Affect is related to the motivational factors of learning. It is vital that designers of a tutorial system know how learners' affective states may be influenced by the system. Previous studies dealing with human-agent interactions have shown that internal factors such as gender of the user and external factors such as the agent's gender and ethnicity may influence the affective states of the user. The present study will focus on the factors related to the affective state of learners during pedagogy by conversational agents. The main research questions are as follows: (1) How do male and female learners' emotions differ in terms of sensitivity, based on Russell's (1980) bipolar model of emotion, and (2) how are male and female students' affective states and interpersonal impressions influenced by the gender and ethnicity of the agent? Three experiments were conducted with students enrolled in an undergraduate psychology class that included an online-tutoring activity. Results suggested that (1) male students demonstrated stronger affective effects than female students did when tutored by the female agents, and (2) learners' level of activation was higher when they were interacting with agents of the same gender.

1 Introduction

Studies assessing computer-supported learning systems have suggested that the use of pedagogical agents can enhance learner motivation (Kim, Baylor, & Shen, 2007). While the inclusion of pedagogical agents may have a positive impact on learners' affective states, leading to a higher motivation for learning, several important aspects should be considered when designing such a system. Affect is influenced by several complex factors. Unfortunately, only a few studies have been conducted on this topic. The present study focuses on one such factor—the gender of the pedagogical agent—and aims to determine if and how the gender of a pedagogical agent influences learners' affective states during an online tutoring task.

2 Related work and questions

2.1 Influence of personal status and social cues on learning

2.1.1 Internal factors: Learners gender

Studies have focused on a user's prior knowledge and characteristics during interactions with artificial agents and robots. These are referred to as "internal factors". Previous studies have investigated how users' educational background, prior experience with robots, and gender affect psychological aspects of these interactions (Weiss, Bernhaupt, Tscheligi, & Yoshida, 2009). Research suggests that the effects of gender assignment 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 the interaction. Choi and Clark (2006) investigated learner prior knowledge and found that learners with low prior knowledge performed better on retention tasks. In another study related to prior knowledge, Kim (2007) considered students' academic competency as indicated by their GPA scores. The study investigated the influence of the competency level of the agent (high vs. low) and interaction control (agent-control vs. learner-control). Results indicated that high-competency learners showed

higher motivation and retention scores when working with a high-competency agent; for low competency learners, an agent with low competency was more beneficial. However, this study did not include the gender of the participant as a mediator, and substantially more females than males were in the study sample; its findings are hence questionable. However, few studies have focused on the use of pedagogical agents and the effect of these agents on an individual's affective state. The present study will focus on learners' gender to determine if females have stronger reactions in response to affective feedback as compared to males.

2.1.2 External factors: Agents' gender and ethnicity

Past studies on human-computer interactions show that people attribute personality traits to non-humans, such as animals or artificial agents (i.e. robots; see Nass & Moon, 2000; Kiesler, Powers, Fussell, & Torrey, 2008, for overviews). This suggests that when a computer agent is capable of producing effective social cues, learners' mood and motivation could be manifested. Thus, the embodied cues represented by the agents may facilitate certain affective states. This is referred to as the "external factor" during interaction with the pedagogical agent.

Boucher, Hancock, and Dunham (2008) suggest stereotypes during an on-line task may influence individuals' perception of others. These authors conducted a controlled experiment to assess the accuracy of interpersonal perceptions on computer-mediated conversations. Results showed that interpersonal perceptions do not differ across computer-mediated, face-to-face interactions. One possibility for this result is that social status cues may be intensified within some computer-mediated settings. Perhaps pedagogical agents' social status (i.e. gender) may foster certain stereotypes among the learners. Kim, Baylor, and Shen (2007) examined how positive and negative comments expressed by conversational agents affected learning performance as a function of gender. Results showed that learners provided more positive impressions toward male agents with positive expressions than toward female agents. In this case, perhaps social stereotypes in the real world are applied to the agent-learner relationship.

The current study assesses some aspects of gender, though it lacks in detail regarding the relationship between the learner's gender and the agent's gender. There are few studies on how social cues affects

interpretations of agents. Some studies, such as Soto and Levenson (2009), examined the empathic accuracy between others with same/different cultural backgrounds. Soto and Levenson found that individuals rated the emotions of members of their own ethnic/cultural group compared to a different ethnic/cultural group with greater empathic accuracy and greater physiological linkage. The authors suggest that the cultural similarity between raters and others facilitates empathic accuracy. These results support the "cultural advantage model." This model argues that individuals process characteristics of people of the same race better than of people from different races. From this work, we predicted that the similarity of social status (i.e. gender and ethnicity) of the tutor agent might better stimulate accurate perceptions of affective states as compared to dissimilar tutoring agents.

2.2 Integration model

The studies explained above show that both internal and external personal status influences interactions with pedagogical agents. Unfortunately, little is known about the specificity of the influence of a learner's affective states during computer-based learning with pedagogical agents during an on-line activity. Moreover, little is known about the relationship between individual status and external social cues of the agents within these environments. The present study investigates this through an integrative experimental design shown in Figure 1.

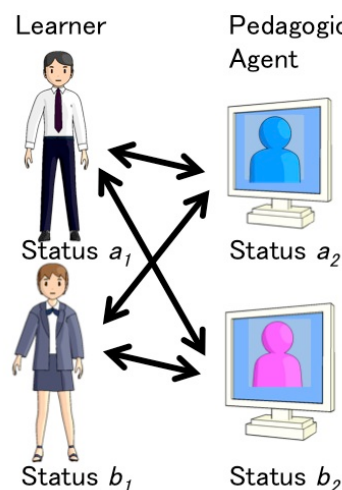


Figure 1. An interactional approach to investigate human-agent interaction

With this approach, the personal status of the learner and the representation of the agent are investigated together. Although there are numerous variations of these factors that can be investigated, the present study focuses on the internal and external factors of "gender" and "ethnicity."

2.3 Affective states during learning: dependant variables

An important consideration in a study involving human learning performance is stimulating learners' affective states. 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. Mayer and Turner (2002) also demonstrated that a positive state of mind can improve text comprehension. 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). It is assumed that these social cues are crucial factors for facilitating affective states during teaching and pedagogy. 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?"; "How do the most effective interaction patterns influence motivation to work harder?" 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. For example, if the system knows that a user is likely to become nervous during a tutoring session, the pedagogical agent can provide information to ease this state and facilitate motivation. The results of such a 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 the Russell's two-dimensional theory of emotion as a dependant variable to discover affective states relevant to mood during learning activities (Russell, 1980) (see Figure 2). 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). To understand learners' motivational states, the dimension of activation is extremely important. If a system knows that the learner is sensitive to the activation bipolar, it can provide messages related to activity levels to enhance his/her motivation. The present study uses this model to analyze students' affective states during learning activities.

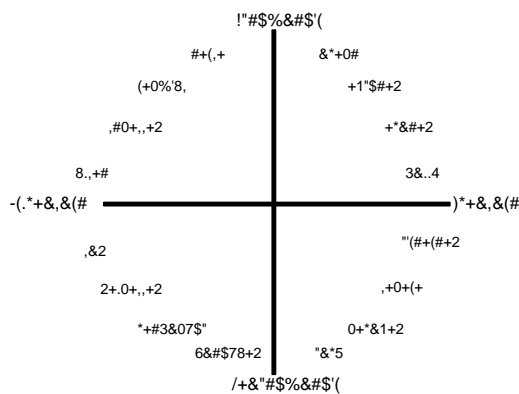


Figure 2. A schematic description of the two-dimensional structure of affect, adapted from Feldman, Barrett, and Russell (1998)

2.4 Aim of this study

The goal of the current study is to understand the nature of learners' affective states as a function of their social status and effects related to the types of embodied agents. This study attempts to answer the following questions using six different types of agents:

- (1) How do male and female learners' emotions differ in terms of affective sensitivity based on Russell's (1980) bipolar emotion model?
- (2) How are male and female students' affective states influenced by the gender and ethnic differences of the agent?

3 Method

This study constructed a system that guides the learner in a simple web-based tutoring system. Students in an undergraduate 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. Details of the experimental method are discussed below.

3.1 Participants

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. In following, we call these participants as ‘learners’. The task was to read about a single topic, about key psychological terms, and answer a short quiz based on the literature.

3.2 Experimental Design

The present study examined the following three independent variables: (1) gender of the learner (male or female), (2) gender of the agent (male or female), and (3) ethnicity of the agent (Asian, White, and Black). Table 1 shows the two factorial designs. One hundred and thirty-four Japanese undergraduates participated in Experiment 1 (male = 66, female = 68, M age = 19.82 years). One hundred and thirty-three undergraduates participated in Experiment 2 (male = 60, female = 73, M age = 19.74 years). Finally, one hundred and seventeen

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

Table 1. Experimental design and labels

undergraduates participated in Experiment 3 (male = 54, female = 63, M age = 19.84 years).

3.3 Materials and settings

A web-based tutoring system was developed for the sole use of the class. The system was constructed using a 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). The materials for the representations of affective states were selected by a preliminary material selection task conducted by 14 participants. These participants were shown 48 random facial expressions and evaluated facial categorization on the 8-dimension version of the emotion model shown in Figure 2. Software was used for generating the expressions. The most frequently evaluated facial expressions were chosen as representative expressions for the current study. An Asian model was used as the avatar for this task. To investigate the ethnicity factor, two other ethnic representations were created. All facial expressions were identical except for the color of the hair, eyes, eyelashes, and skin.

Figure 3 shows an example of the avatars’ arousal expressions. Based on a pilot study, the agents’ expressions were weighted to express positive and encouraging facial expressions. The agents’ verbal suggestions and comments were synchronized with these expressions. Since the students who participated in the study were all Japanese, the Asian avatars in the top row indicate the representations of the same ethnic background. The students were assessed as to whether they had experience being taught by white and/or black teachers. All the students reported that they had few experiences being taught by a white teacher; no one reported being previously taught by a black teacher. 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 main dependent 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. To understand the influence of external factors such as using different size of monitors, the system obtained information on the user's log-in environments.

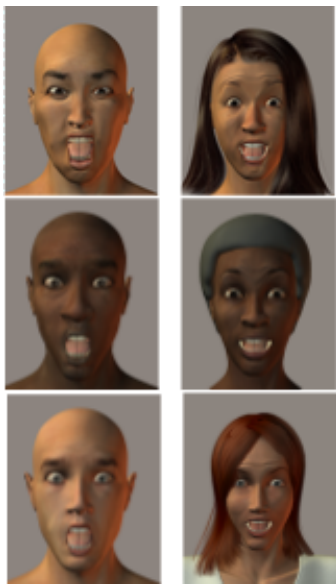


Figure 3. Avatars used in the three experiments: The ones on the top row were used in experiment 1 (male and female respectively), the ones on the middle row were used in experiment 2 and the ones on the bottom row were used in experiment 3.

Using the systems from mobile devices such as smart phones could produce different moods; this will be investigated in another study. All access to the systems was limited to particular LAN environments at a particular period of time in the campus. Therefore, all students were restricted to specific computers in the campus. Learners were asked to log in to their individual page to check their progress. On the first page, the key term assigned to the particular student was presented and the student was told that learning this key term was his/her task for that week. On the next page, the passage was presented with the key terms and the emoticons. In this study, the author does not discuss the results of the quiz; this will be discussed elsewhere.

4 Results

4.1 Affective impressions

To investigate the relationships between the gender types of the agent and the learner an analysis was conducted using the ANOVA. A 2 x 2 x 8 mixed factorial ANOVA

was conducted on the average scores with the agents' gender (female agent vs. male agent) and learners' gender (female learner vs. male learner) 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.

4.1.1 Results of experiment 1:

Asian pedagogical agents

Results of ANOVA show that the second-order interaction was significant ($F(7,910) = 2.203, p < .05$). There was a simple interaction of the agent and humans gender in the affective states of excitement and arousal ($F(1,1040) = 11.444, p < .01$, ($F(1,1040) = 4.872, p < .05$). Second order simple main effects show several differences among conditions. Results show that female learners had stronger evaluation scores than male learners on the 'arousal' and 'excitement' states when interacting with female and/or male agents ($p < .01$; $p < .01$, respectively). Results show that, male learners using male agents rated higher 'excitements' compared to female agents ($p < .01$). Also, female learners using female agents rated higher 'excitement' compared to male agents ($p < .01$). Although, some contradictory results show that male learners using female agents rated higher 'arousal' states compared to male agents ($p < .01$).

4.1.2 Results of experiment 2:

Black pedagogical agents

Results of the ANOVA show that the second-order interaction was significant ($F(7,903) = 3.303, p < .01$). There was a simple interaction of the agent and humans gender in the affective states of pleasure, excitement and arousal ($F(1,1032) = 3.714, p < .05$, $F(1,1032) = 8.139, p < .01$, $F(1,1032) = 15.354, p < .01$). Results show that female learners had stronger evaluation scores than male learners on the 'arousal' and 'excitement' states when interacting with female and/or male agents ($p < .01$; $p < .01$, respectively). Moreover, male learners rated higher 'pleasure' states than female learners when using female agents ($p < .01$). On the other hand, results also show that male learners had stronger evaluation scores than female learners on the 'arousal' states when using male agents ($p < .01$). Male learners rated higher 'arousal' ratings when using male agents compared to female agents ($p < .01$). On the other hand, male learners rated higher

'excitement' ratings when they used female agents compared to male agents ($p < .01$).

4.1.3 Results of experiment 3:

Whitepedagogical agents

Results of the ANOVA show that the second-order interaction was significant ($F(7,791) = 2.653, p < .05$). There was a simple interaction of the agent and humans gender in the affective states of pleasure and excitement ($F(1,904) = 19.313, p < .01$, ($F(1,904) = 7.306, p < .05$). Results show that female learners had stronger evaluation scores than male learners on the 'excitement' states when interacting with a female agent ($p < .01$). Moreover, male learners rated higher ratings than female learners on 'pleasure' states when using a female agent ($p < .01$). This was the only consistent result with experiment 2. It is assumed that male learners could be sensitive to the pleasantness bipolar on the emotion model of Russell(1980). Results show that male learners rated higher 'excitement' when using male agents compared to female agents ($p < .01$). Also female learners rated higher 'excitements' when using female agents compared to male agents ($p < .01$).

4.2 Summary

The results of the impressions of the agents reveal that the synergy of the gender of agent and learner influences different affective states.

On focusing on the "human gender factor" we found some interesting results. It shows that female learners will have a stronger arousal response when provided affective feedback from others as compared to their male counterparts. Some unexpected findings show that male learners rated higher pleasure than female learners when interacting with a female foreign agent (Exp 2 and 3). Interesting results were found on male learners. They rated female agents higher than male agents across the different ethnic agents (Exp. 1, 2, and 3).

On focusing on "agent gender factor", the results show that female learners experienced higher excitements than males when they used an agent with the same gender (Exp. 1 and 3). Also, male students experienced higher excitement (Exp. 1 and 3), and arousal (Exp. 2) than females when they used an agent with same gender. The results show that male pedagogical agents will facilitate stronger affective states than female pedagogical agents.

5 Discussions and conclusions

Results of experiments 1,2, and 3 showed that internal factors such as gender influence different dimensions of affect. More specifically, male learners were more sensitive to the pleasure dimension than female learners when interacting with female agents. On the other hand, females were more sensitive to the activation dimension than males. From the perspective of the Russell's (1980) two-dimensional model, it suggests that the male students were more sensitive to the gender difference of pedagogical agents for the "pleasantness bipolar" (e.g. upset vs. happy) while the female students were more sensitive to it for the "activation bipolar" (e.g. alert vs. calm).

The results of this experiment also reveal important issues on designing online tutoring systems. That is to stimulate learners' affective states during an online activity, it is important to provide adequate affective feeds backs based on the most sensitive affective state of the individual. If the tutoring system can stimulate the learner's most sensitive affective state appropriately, it is expected that it could enhance the learner's motivation more effectively. Unfortunately this point has not been investigated in the present study. As future work, the affective factors of agents such as "pleasantness bipolar" (e.g. upset vs. happy) and "activation bipolar" (e.g. alert vs. calm) should be examined as independent variables. This point will be investigated elsewhere.

One of the interesting findings on the gender types of the pedagogical agents is the interaction between the factors of the two: self and the others' gender. Results in experiment 1 and 3 reveal that the same gender with the learner facilitates higher excitement. This point, from the affective bipolar perspective has not been directly investigated in previous studies. In the study of Moreno and Flowerday's (2006), they investigated how same gender and ethnicity of the learner influence learning effects. Results show that neither similarity of gender nor similarity of ethnicity yields difference in retention or transfer scores. On the other hand, the present study shows more constructive evidence that similarity of gender influences affective states which are potentially valid to enhance motivation towards learning.

5 Conclusions

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: 1) How do male and female learners' emotions differ in terms of affective sensitivity based on Russell's (1980) bipolar emotion model?, and 2) How are male and female students' affective states influenced by the gender and ethnic differences of the agent? The results of the experiments showed that: (1) the male students were more sensitive to the gender difference of pedagogical agents for the "pleasantness bipolar" (e.g. upset vs. happy) while the female students were more sensitive to it for the "activation bipolar" (e.g. alert vs. calm), (2) the male students had stronger affective effects than the female students when they were tutored by the female agents (3) the level of activation of learners was higher when they were interacting with the agents of the same gender, and (4) for both the male and female students, male pedagogical agents exerted more positive effects than the female pedagogical agents. The results are valuable in designing pedagogical agents capable of providing instruction based on personal characteristics.

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References

- [1] Baylor, A. L., & Kim, Y. Simulating instructional roles through pedagogical agents. *International Journal of Artificial Intelligence in Education* Vol. 15, No. 1, pp. 95-115, (2005)
- [2] Boucher, M. Eliane., Hancock, T. Jeffrey., Dunham, J. Philip, Interpersonal sensitivity in computer-mediated and face-to-face conversations, *Media psychology*, Vol. 11, pp. 235-258, (2008)
- [3] Bower, G. H., & Forgas, J. P. Mood and social memory. In: Forgas, J.P. (ed.) *Handbook of Affect and Social Cognition*, LEA, NJ. pp. 95-120, (2001)
- [4] Carpenter, J., Davis, J, Erwin-Stewart, N., Lee, T, Bransford, J, & Vye, N, Gender representation and humanoid robots designed for domestic use, *Int. J. Soc. Robot.*, 1, pp. 261-265, (2009)
- [5] Choi, S., & Clark, R. E, Cognitive and affective benefits of an animated pedagogical agent for learning English as a second language. *Journal of Educational Computing Research*, Vol. 34, No. 4, pp. 441-466, (2006)
- [6] Hayashi, Y., On pedagogical effects of learner-support agents in collaborative interaction. In S.A. Cerri and B. Clancey (Eds.): *Proceeding of the 11th International Conference on Intelligent Tutoring Systems (ITS2011)*, Lecture Notes in Computer Science, Springer-Verlag, Vol. 7315, pp. 22-32, (2012)
- [7] Hays, R. B., The development and maintenance of friendship. *Journal of Personal and Social Relationships*, Vol. 1, pp. 75-98, (1984)
- [8] Kim, Y. Desirable characteristics of learning companions. *International Journal of Artificial Intelligence*, Vol. 17, No. 4, pp.371-377, (2007)
- [9] Kim, Y., Baylor, A. L., & Shen, E. Pedagogical agents as learning companions: The impact of agent emotion and gender. *Journal of Computer Assisted Learning* Vol. 23, No. 3, pp.220-234, (2007)
- [10] Mayer, D. K., & Turner, J. C. Discovering emotion in classroom motivation research. *Educational Psychologist*, Vol. 37, No. 2, pp. 107-114, (2002)
- [11] Mehrabian, A. Immediacy: An Indicator of Attitudes in Linguistic Communication. *Journal of Personality*, Vol. 34, No. 1, pp. 26-34, (1966)
- [12] Moreno, R., & Flowerday, T. Student's choice of animated pedagogical agents in science learning: A test of the similarity-attraction hypothesis on gender and ethnicity. *Contemporary Educational Psychology*, Vol. No. 31, pp. 186-207, (2006)
- [13] Russell, J. A. A circumplex model of affect. *Journal of Personality and Social Psychology*, Vol. 39, pp. 1161-1178, (1980)
- [14] Schlosberg, H. A scale for the judgment of facial expressions. *Journal of Experimental Psychology*, Vol. No. 29, pp. 497-510, (1941)
- [15] Soto, A. Jose., & Levenson, W. Robert., Emotion recognition across cultures: The influence of ethnicity on empathic accuracy and physiological linkage. *Emotion*, Vol. 9, No. 6, pp.874-884, (2009)
- [16] Graham, J., & Heywood, S. The Effects of Elimination of Hand Gestures and of Verbal Codability on Speech Performance. *European Journal of Social Psychology*, Vol. 5, No. 2, pp.189-195, (1975)
- [17] Nass, C., & Moon, Y. Machines and mindlessness: Social responses to computers. *Journal of Social Issues*, Vol. 56, pp.81-103, (2000)
- [18] Kiesler, S., Powers, A., Fussell, S., & Torrey, C. Anthropomorphic interactions with a robot and robot-like agent. *Social Cognition*, Vol. 26, pp.69-181, (2008)
- [19] Weiss, A., Bernhaupt, R. Tscheligi, M. , & Yoshida, E. Addressing user experience and societal impact in a user study with a humanoid robot, in 1st Symp. *New Frontiers in Human-Robot Interaction*, pp. 150-1, (2009)