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# Robot Mood is Contagious: Effects of Robot Body Language in the Imitation Game[1]

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**Abstract**

We have designed a framework for bodily mood expression of a robot that integrates affective cues with functional behaviors without interrupting these behaviors. The framework is based on a parameterized behavior model in which the parameters control the poses and motion dynamics of a behavior. Modulating those parameters results in different behavior appearance through which robot mood is expressed. This study addresses the question whether robot mood displayed during an imitation game can (a) be recognized by people and (b) produce contagion effects. The gestures performed by the robot in the game were modulated to display either a positive or a negative mood. The task difficulty was also varied. The results show that participants are able to differentiate between positive and negative robot mood. Moreover, self-reported mood matches the mood of the robot in the easy task condition. Additional evidence for mood contagion is provided by the effect of robot mood on participants' task performance.

## 1 Introduction

Expression of internal states (e.g., affect, intention, or rationale) through body language is an important ability of social robots [1]. It has in particular been a challenge to express mood by body language at an arbitrary time during the execution of a task. To address this, we have designed behavioral cues and integrated them with functional behaviors needed to perform the task. Our approach is to "stylize" behaviors by modulating behavior parameters [2], [3] instead of using additional body movements, which have typically been used to express bodily emotion in research. Mood is a relatively long-lasting and stable affective state. Integrating mood into the body language of a robot provides the robot with not only an alternative but also a more stable channel for communicating affective information.

To figure out which behavior parameters have the potential to express mood and how to modulate these parameters to express a specific mood, we conducted a user study [2] in which participants were asked to modulate behaviors to match given valence levels by adjusting the parameters. The video clips of the resulting design can be found on our website[2]. The resulting settings were evaluated in a recognition experiment [4] in a laboratory setting without a context. The results showed that not only valence but also arousal can be well recognized.

This paper addresses the following research questions: 1) can people, while interacting with a robot, recognize mood from robot behaviors that are modulated to express positive or negative mood? 2) What are the effects of robot mood on someone who is interacting with that robot?

## 2 Affective Body Language in the Imitation Game

The mood expression was integrated with the gestures used in an imitation game [5], in which a human player imitates the gestures performed by the robot in a laboratory environment. A video clip of the gestures used in the experiment and gestures modulated by a continuously changed mood is available on

[1] The full paper [5] has been published in *Proceedings of the international conference on Autonomous Agents and Multi-Agent Systems (AAMAS)*, pages 973–980, 2014.
[2] http://ii.tudelft.nl/~junchao/moodexpression.html

our website[3]. Results not only confirmed that people can recognize robot mood from the body language in an interaction context, even when they were not primed to pay attention to the expression, but also shows evidence of a "mood contagion" effect [6]: participants' own mood matches with the mood of the robot in the easy task condition. Moreover, the robot mood had an effect on game performance: in the negative mood condition participants performed better on difficult tasks than in the positive mood condition. As a behavior measure, this result further supports the contagion effect.

## 3 Conclusion and Future Work

This study shows that it is feasible to use parameterized behavior to express a robot's mood in an HRI interaction scenario. Results show that people are clearly able to distinguish between positive and negative robot mood. Our results also suggest that mood contagion takes place between the robot and the human. The evidence for this contagion effect consists of: 1) participants self-reported mood matching that of the robot, and 2) participants' task performance being lower in the positive robot mood condition compared to the negative robot mood condition replicating a well-known mood-cognition effect.

Another interesting aspect that we found in our study is that participants attributed the robot mood to various factors that were not manipulated. In a more complex interaction scenario, even more factors could influence the results. An ongoing effort is to apply mood expression in a robotic tutor application, in which the robot NAO gives a lecture and interacts with audiences using quiz questions in a university classroom. The co-verbal gestures are modulated to express the robot mood. The robotic tutor scenario is close to real life and the robot mood is expressed through a broad range of modulated robot gestures over a longer period of time (30 min), and the robot interacts with a large group of individuals instead of a dyadic interaction. We have tested the mood expression of the robotic tutor in a positive and a negative mood condition [7], and observed the differences of participants' own valence and arousal between conditions, which suggests that the mood expression can be used to shape the interaction affectively. Moreover, the audiences' ratings of the lecturing quality and gesture quality of the robot are higher in the positive condition, suggesting body language of a robotic teacher is important for the rating of the robot's teaching quality. Additional materials including videos are available on our website[4].

## References

[1] C. Breazeal, A. Takanishi, and T. Kobayashi, "Social Robots that Interact with People," *Springer Handb. Robot.*, pp. 1349–1369, 2008.

[2] J. Xu, J. Broekens, K. Hindriks, and M. A. Neerincx, "Mood expression through parameterized functional behavior of robots," in *RO-MAN, IEEE*, 2013, pp. 533–540.

[3] J. Xu, J. Broekens, K. Hindriks, and M. A. Neerincx, "The Relative Importance and Interrelations between Behavior Parameters for Robots' Mood Expression," in *ACII, Geneva*, 2013, pp. 558–563.

[4] J. Xu, J. Broekens, K. Hindriks, and M. A. Neerincx, "Bodily Mood Expression: Recognize Moods from Functional Behaviors of Humanoid Robots," in *ICSR, Bristol, UK*, 2013, pp. 511–520.

[5] J. Xu, J. Broekens, K. Hindriks, and M. A. Neerincx, "Robot Mood is Contagious: Effects of Robot Body Language in the Imitation Game," in *Autonomous Agents and Multi-Agent Systems (AAMAS)*, 2014, pp. 973–980.

[6] R. Neumann and F. Strack, "'Mood contagion': the automatic transfer of mood between persons.," *J. Pers. Soc. Psychol.*, vol. 79, no. 2, pp. 211–223, 2000.

[7] J. Xu, J. Broekens, K. Hindriks, and M. A. Neerincx, "Effects of Bodily Mood Expression of a Robotic Teacher on Students," in *IROS*, 2014.

[3] http://ii.tudelft.nl/SocioCognitiveRobotics/index.php/ImitatGameMood

[4] http://ii.tudelft.nl/SocioCognitiveRobotics/index.php/RoboTutorMood