Improving Aspects of Empathy and Subjective Performance for HRI through Mirroring Facial Expressions

Barbara Gonsior[1], Stefan Sosnowski[1], Christoph Mayer[2], Jürgen Blume[3], Bernd Radig[2], Dirk Wollherr[14] and Kolja Kühnlenz[14]

Abstract— **In this paper, the impact of facial expressions on HRI is explored. To determine their influence on empathy of a human towards a robot and perceived subjective performance, an experimental setup is created, in which participants engage in a dialog with the robot head EDDIE. The web-based gaming application "Akinator" serves as a backbone for the dialog structure. In this game, the robot tries to guess a thought-of person chosen by the human by asking various questions about the person. In our experimental evaluation, the robot reacts in various ways to the human's facial expressions, either ignoring them, mirroring them, or displaying its own facial expression based on a psychological model for social awareness. In which way this robot behavior influences human perception of the interaction is investigated by a questionnaire. Our results support the hypothesis that the robot behavior during interaction heavily influences the extent of empathy by a human towards a robot and perceived subjective task-performance, with the adaptive modes clearly leading compared to the non-adaptive mode.**

I. Introduction

In human-human interaction, empathy is crucial for socialization. This ability is already developed in infants [1] and dysfunctions in feeling empathy might lead to social deficits, as observed in autism [2]. In the course of several social psychological studies investigating inter-human empathy, the experimentally induced extent of empathy has successfully been manipulated via similarity of personal attitudes between the subjects [3], [4]. Additionally, studies on nonconscious mimicry present findings on the importance of facial mimicry in social interaction. Chartrand and Bargh [5] were able to experimentally show that behavioral mimicry ("the chameleon effect") happens in conversations, has a significant effect on the interaction and increases empathy towards the interaction partner. There is evidence that feeling empathy for others can be traced back to the mirror neuron system [2], [6], [7], which triggers emphatic emotion by deriving the emotional state from facial expressions, and thus involves neural activity in the thalamus and cortical areas responsible for the face.

In this paper, we apply facial mimicry in a human-robot communication scenario. The proposed system recognizes facial expressions from camera images, processes the information encoded in the facial expression according to the facial action coding system and reacts with facial expressions of the robotic head EDDIE. Furthermore, we equip the robot head with speech recognition and text-to-speech output to provide natural communication between the robot and a human user. This architecture is embedded in an experiment, in which a user plays a game called "Akinator" (www.akinator.com) with the robot. In this game, the user chooses a person which the robot tries to guess by asking questions related to the chosen person.

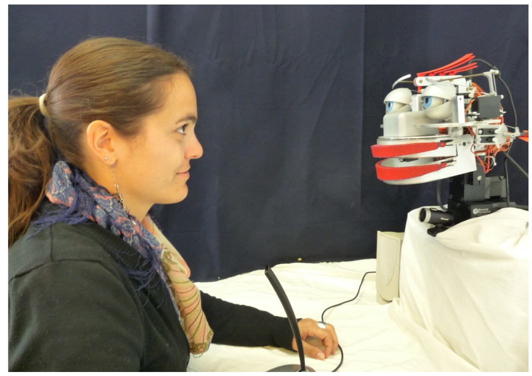

Fig. 1. Experimental HRI setup.

The core idea is to induce empathic emotion towards a robot during interaction by combining and implementing both approaches of social psychology and research on mirror neurons. In a first step, the approach is to generate similarity between user and robot by means of mirroring the facial expression a user shows in the course of a communicative task. In a second step, the thereby conveyed impression of a shared emotional state between user and robot should trigger the mirror neuron system of the user and thus evoke empathy for the robot. In order to meet the arising question if this approach improves HRI, an experiment is conducted to evaluate the "five key concepts in HRI" according to Bartneck [8]: anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety. Furthermore, user acceptance is evaluated according to the analytic measures of Heerink [9]. A measure for empathy and subjective task-performance experienced by the user is added to the chosen evaluation tools in order to reveal possible correlations. We conduct a study in which the participants are asked to rate empathy and task performance of the robot after playing a game of Akinator, with the varying conditions of no mirroring, mirroring and a social motivation model.

[1] Institute of Automatic Control Engineering (LSR), TU München sosnowski@tum.de, bg@tum.de
[2] Intelligent Autonomous Systems Group, TU München mayerc@in.tum.de, radig@in.tum.de
[3] Institute for Human-Machine-Communication, TU München blume@tum.de
[4] Institute for Advanced Study (IAS), TU München dw@tum.de, koku@tum.de

A. Related Work

The influence of behavioral mimicry has been subject to studies in the field of human-human-, human-agent- and human-robot-interaction. A number of previous works has already shown the transferability of inter-human-findings to virtual agentsand social robots.

Gratch [10] reports on "virtual rapport" with virtual agents, showing benefits of mirroring head movement and posture shifts through increased speaker engagement and improvements on the behavioral and interactional level compared to unresponsive agents.

The work of Bailenson and Yee [11] on "digital chameleons" concludes that embodied virtual agents mimicking head movements are viewed as more persuasive and likeable compared to agents with prerecorded movements.

In the field of social robotics, Kanda et al. [12] could improve route guidance interactions with a robot by incorporating cooperative body movements (e.g. synchronization of arm movements), enhancing both reliability and sympathy.

Riek et al. [13] studied the effect of automatic head gesture mimicking with a chimpanzee robot. The robot would listen to participants while either mimicking all head gesture, only nodding or no mimicking, resulting in different levels of interaction satisfaction.

This work extends the state of the art by explicitely evaluating facial expression mirroring in contrast to head, arm or body gestures. Additionally, the facial expression mirroring happens automatically and online during the human-robot-interaction. Furthermore, the evaluation includes an extension of the pure direct mimicking in form of a social motivation model, that incorporates a temporal and modulating influence on the mirroring.

The remainder of this paper is structured as follows: Section II gives deeper insight into the various modules of the presented system. Section III includes a detailed description and discussion of the evaluation method, the evaluation and test. First deduced findings are given in Section IV, concluding with a brief outlook on future work.

II. System description

The proposed system consists of several modules, as can be seen in Figure 2, that are described in more detail in this section. A facial expression recognition and a facial expression display module work continuously and in parallel, permanently adapting the robot's facial expression to the user's facial expression. Furthermore, the robot head turns the neck to focus on the user's face. Text-to-speech is integrated to "read" Akinator's questions to the user. The robot head parses the question to generate adequate lip movements. A speech recognition module determines the human's verbal responses to the robot's questions, which is sent back to the Akinator via a web API.

The modules are interconnected with a suitable communication backbone based on the Real-time Database (RTDB) introduced by Goebl and Färber [14]. It provides a shared-memory implementation with integrated data storing and is able to handle large amounts of data in real-time, which is required for instance by the vision-based components.

A. Robotic face

The robot head EDDIE is used as an interaction partner (see Figure 1). EDDIE is an emotion display with 23 degrees of freedom, mixing anthropomorphic and zoomorphic features. With this head, 13 out of the 21 emFACS [5] action units can be displayed.

EDDIE can be operated on various levels of it's control hierarchy, ranging from high-level control of the emotional state to directly sending motor commands. In this case, direct control of the action units is used to achieve mirroring of facial expressions. The visualization of speech is done by parsing the text-to-speech and generating a set of visemes to accompany the speech output.

For tracking the interaction partner's face and thus showing the focus of attention, the robot has a pan-tilt unit by *Directed Perception* as a neck.

B. Facial expression analysis

This module determines the human's facial expression from camera images, see Figure 3. Facial components are considered separately to determine intra-face movements like raised eyebrows or an opened mouth. Our approach calculates activation intensities of several FACS action units during the interaction. Furthermore, the user's face position in 3D space is determined which allows the robot head to focus on the user by turning the head at the neck.

We rely on a model-based technique to determine the exact location of facial components such as eyes or eye brows in the image. The Candide-3 face model is a wireframe model consisting of 116 anatomical landmarks [15]. Its parameter vector describes the face pose in 3D space and the face shape. To extract action unit activations for a single image, model parameters that match the image content are calculated. For instance, if the user visible in an image is smiling, the model parameters should reflect raised lip corners. Our approach requires a neutral reference image of the user to calculate corresponding model parameters. Please note, that no prior knowledge of the image content or user is available here. In subsequent images, the model is tracked and model parameters are compared with the neutral face to determine action unit activations.

The action units recognized by the analysis components and synthesized by the robot are AU2 (outer brow raiser), AU4 (brow lowerer), AU5 (upper lid raiser), AU7 (lid tightener), AU13 (lip corner depressor), AU26 (yaw drop), AU42 (eyes closed). Based on this information, the robot face calculates a corresponding facial expression for displaying an appropriate reaction.

[5] emFACS is a subset of the facial action coding system, including only action units which are involved in emotional facial expressions

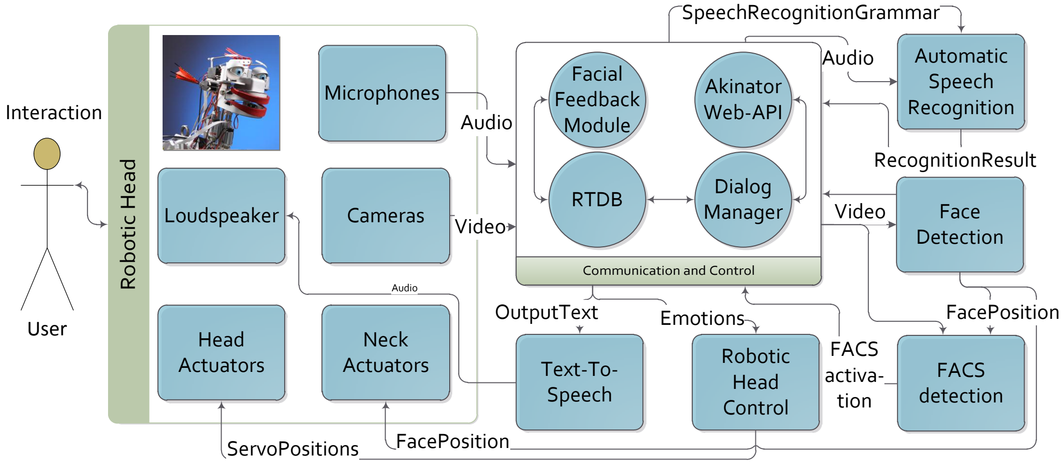

Fig. 2. Overview of integrated Modules

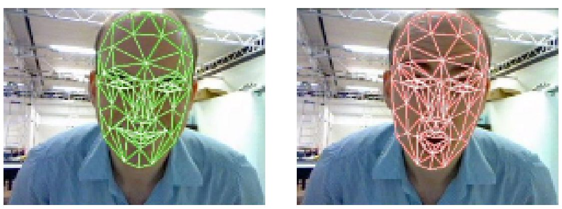

Fig. 3. The face model is fitted to each image in order to estimate the currently visible facial expression.

C. Social Motivation Model

The implementation of the social motivation model is based on a reduced version of the Zurich Model of Social Motivation [16] and can describe the effect of smiling and other facial expressions based on the motivational and emotional state of a human or agent [17]. In a concise description, the model combines three motivational subsystems regulating security, arousal, and autonomy. These systems are homeostatic. The autonomy regulation has a special role, since it is coupled to security and arousal. One of the main assumptions in this model is that smile reactions are the result of a decline in autonomy, meaning that smiles are a reaction to external disturbances of the homeostasis, like social distance changes, environmental changes or conflicts, etc. Changes in the respective subsystems lead to characteristic facial expressions, which in superposition result in the overall facial expression. With this model, an agent is able to react to various, even unknown, situations as long as the parameters for security, arousal and autonomy can be extracted. For more detailed information on the composition of the social model, please refer to [17]. For this experiment, the model was extended to use the interaction partner's facial expressions as an input. Smiling at the robot increases the security state, thus resulting in a smile reaction of the robot. Detected arousal increases the level of arousal in the system and angry or very stern looks can be interpreted as a challenge to the autonomy. All these inputs provoke a reaction of the robot that is quite similar to the input signal, but the reaction is delayed by about one second, due to the frame-rate of the facial analysis and model-internal time constants, and influenced by the actual motivational state of the robot.

D. Dialog and Akinator

In order to provide structure and context to the ongoing dialogue, an interface to the "Akinator" (see www.akinator.com), a web-based application that is usually executed in a browser, is integrated. To participate in this application, first, the user is asked to choose a person. Then, the computer tries to guess this person by asking several questions. The person may be a real or fictional person, currently living or historical, taken from literature, the media or public live. To answer Akinator's questions, a set of fixed answers is presented by the system. The set of answers is the same for every question and consists of: "Yes", "Probably" / "Partially", "I don't know", "Probably not"/ "Not really", and "No". Example questions asked by the Akinator are: "Is your character a girl?", "Does your character live in America" or "Does your character really exist?".

To create a dialog with the robot head, text-to-speech is used to present Akinator's questions acustically to the participant and speech recognition is utilized to determine the participant's answers.

E. Dialog Manager

A dialog manager keeps track of the ongoing communication to estimate when a response of the human user or the machine is expected by the dialog partners. The complete dialog structure is implemented in a first-order logic representation. Tasks to be solved are represented by predicates with variables. These variables represent information which is to be determined during the dialog. Equivalence rules on these predicates are specified to navigate through the dialog by splitting a task into several subtasks.

Evaluating predicate truth values and binding variables models real-world interaction.

III. Experimental validation

In order to evaluate whether mirrored facial expressions improve HRI or not, a human-robot-interaction experiment is designed. The introduced robotic system EDDIE is set up to a communicative task, playing Akinator with a participant and guessing the thought-of person. During this interaction, EDDIE speaks and tracks the person while acting according to one of three possible conditions. Subjects are divided in different groups depending on the following conditions applied:

1) Neutral: EDDIE displays no facial expressions
2) Mirror: Eddie displays the subject's facial expressions
3) Social motivation model (SMM): EDDIE displays facial expressions according to its internal model, indirectly mirroring the subject's expression.

After interaction each subject fills in a computer-randomized questionnaire described in Section III-B.

The goal of the study is to reveal if mirroring in conditions 2 and 3 induces empathy towards a robot and if the user grades the subjective performance of the robot accordingly higher than in condition 1, The study aims to unveil if mirroring improves HRI regarding the five key concepts anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety [8] on the one hand, and how mirroring influences user acceptance [9] on the other hand. Accordingly, the assumed interrelations with and between empathy and subjective performance of the system are investigated.

A key assumption for this experiment is, that the facial expressions of the robot are interpreted correctly by the human and perceived as matching expressions for the mirroring. This assumption is strengthened by the findings of a preevaluation, which is described in detail in Mayer et al. [18] and Sosnowski et al. [19].

A. Experimental setup

For the experimental setup a quiet room with controlled lighting conditions was chosen. The robotic head was placed on a table to be at approximately eye-level with the participants. Participants were seated in front of the robot, with a microphone placed in front of them on the table to ensure a low error rate in speech recognition. Since the task rating and enjoyment would depend on the ability of the robot to correctly understand the answers, the external microphone was preferred over the interal, which would have added to the illusion of speaking to the robot directly. The instructor greeted the person and gave a short introduction on the task and how to interact with the robot. To begin the experiment, the instructor asked the participant to think of a person of his/her own choice and give a start signal, when done. From this point, the robot started the akinator game, speaking the questions provided by the akinator API and listening for the answers. A sample round of akinator can be seen in Table I.

Question	Answer	
	given	expected
Is your character a male?	No	No
Is your character a singer?	No	No
Does your character really exist?	No	No
Does your character fight?	Not really	No
Is your character from an anime?	No	No
Does your character live in America?	No	No
Is your character a human being?	No	No
Is your character an animal?	No	No
Does your character have hair?	No	No
Is your character visible?	Yes	Yes
Is your character a robot?	Yes	Yes
Has your character played in 'Star Wars'?	Yes	Yes
Is your character yellow?	No	No
I guess you were thinking of: R2D2		

TABLE I
SAMPLE DIALOGUE OF A GAME OF AKINATOR, LOOKING FOR R2D2

After the game was finished by either the robot guessing the correct person or giving up after to many trials (dependent on the akinator API, having a threshold influenced by the confidence and the number of trials), the subjects were asked to fill in a computer based questionaire.

B. Questionnaire

The computer-randomized questionnaire consists of two different parts which can be analyzed independently.

The first part consists of five selected constructs based on a "limited model for studies on social abilities or social presence" out of a toolkit for measuring user acceptance of social robots [9]. These constructs are adapted to the requirements of experimental setting and kept constant with regard to a consistent number of items, i.e. four questions for each construct. Additionally, these five constructs are enhanced by two more constructs, which are proposed to measure the induced scope of empathy towards a robot, and the subjective system-performance perceived by the user. These additional constructs are to reveal supposed interrelations to the other constructs on user acceptance thus are proposed to enhance this excisting toolkit.

The second part of the applied questionnaire consists of the "godspeed" questionnaires [8] to evaluate the "five key concepts of HRI": anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety.

Hence, the questionnaire evaluates the interaction on three different dimensions: 1) Empathy and subjective performance as proposed extension of 2) user acceptance, and 3) the key concepts of the godspeed questionnaires.

In the following the two parts of the questionnaire are decribed in detail.

1) Empathy and Subjective Performance: For measuring both constructs, the scope of induced empathy on the one hand, and subjective performance on the other hand, this part of the first questionnaire is divided into two different paths depending on objective task performance, i.e. if EDDIE was successful (a) or not (b) in guessing the thought-of person. Thus, subjective performance can be compared to objective performance in order to draw conclusions on possible interrelations due to the scope of induced empathy. Therefore, subjects are asked to respond to different statements including positive, negative or inverted formulations for sharing happiness or sadness with EDDIE corresponding to the task-success or -failure of EDDIE as shown in Table II.

Users can reply to these statements on a five-item Likert scale from one (strongly disagree) to five (strongly agree). For analyzing the answers correctly, the scale for negatively formulated items, e.g. questions 4a) and 4b), has to be inverted afterwards.

2) User acceptance: Heerink et al. [9] extended the UTAUT (Unified Theory of Acceptance and Use of Technology) model [20] by several constructs in order to adapt this model to the specific requirements of evaluating social robots. Given experimentally validated interrelations between several constructs, the five selected constructs include:

- *Trust*: The belief that the system performs with personal integrity and reliability.
- *Perceived Sociability*: The perceived ability of the system to perform sociable behavior.
- *Social Presence*: The experience of sensing a social entity when interacting with the system.
- *Perceived Enjoyment*: Feelings of joy or pleasure associated by the user with the use of the system.
- *Intention to Use*: The outspoken intention to use the system over a longer period in time.

The questionnaire evaluates each construct by four different statements, as presented in Table II. In order to reduce acquiescence bias some items are negated and thus invert the scale.

Again, the subjects rate the randomized statements on five-item Likert scales from one (strongly disagree) to five (strongly agree). As the statements for user acceptance and their constructs are independent from the system performance this questionnaire is not divided into different paths if EDDIE was successful (a) or not (b) in guessing the thought-of person. Nevertheless, it will be analysed if interrelations to subjective task performance.

3) Godspeed key concepts: [6] "A series of questionnaires to measure the user's perception of robots" combines five consistent and validated questionnaires based on 5-point semantic differential scales as a standardized metric for the "five key concepts in HRI" [8]:

- *Anthropomorphism*: rates the user's impression of the robot on five semantic differentials.
- *Animacy*: rates the user's impression of the robot on six semantic differentials.
- *Likeability*: rates the user's impression of the robot on five semantic differentials.
- *Perceived Intelligence*: rates the user's impression of the robot on five semantic differentials.
- *Perceived Safety*: rates the user's emotional state on three semantic differentials.

[6]Open source version, see http://www.bartneck.de/2008/03/11/the-godspeed-questionnaire-series

	Empathy
1a)	I am happy that Eddie guessed my person.
1b)	It's a shame Eddie didn't guess my person.
2a)	I would have been proud if Eddie hadn't guessed my person. (inverted)
2b)	I'm proud Eddie didn't guess my person.
3a)	It would have been a pity if Eddie didn't guess my person.
3b)	It would have been nice if Eddie had guessed my person.
4a and b)	I would feel sorry for Eddie if someone tried to destroy it at that moment, thus I would try to prevent it.
	Subjective Performance
1a)	I was impressed by how fast Eddie has guessed my person.
1b)	I had the feeling that Eddie nearly guessed my person.
2)	Eddie has shown a good performance.
3)	I think that Eddie has worked efficiently.
4a)	It took Eddie long to guess my person. (negated)
4b)	It took Eddie too long to guess my person. (negated)
	Trust
1)	I would believe Eddie if he gave me advice.
2)	Eddie is inspiring confidence.
3)	I feel that I can trust Eddie.
4)	I do not trust Eddie's statements. (negated)
	Perceived Sociability
1)	I like Eddie.
2)	Eddies mimic and verbal statements fit together well.
3)	Eddie was good conversation partner.
4)	Eddie's behavior was inappropriate. (negated)
	Social Presence
1)	I had the feeling that Eddie really looked at me.
2)	I could imagine Eddie as a living being.
3)	Sometimes it felt like Eddie had real feelings.
4)	Eddies behavior was not humanlike. (negated)
	Perceived Enjoyment
1)	It was fun to interact with Eddie.
2)	The conversation with Eddie was fascinating.
3)	I consider Eddie to be entertaining.
4)	It's boring when Eddie interacts with me.(negated)
	Intention to Use
1)	I would like to interact with Eddie more often.
2)	I would take Eddie home with me.
3)	I would like to play again with Eddie within the next few days.
4)	I could imagine interacting with Eddie over an extended period of time.

TABLE II

QUESTIONNAIRE FOR USER ACCEPTANCE EXTENDED BY TWO CONSTRUCTS ON EMPATHY AND SUBJECTIVE PERFORMANCE

As recommended, the items are randomized so as to hide the different concepts and hence mask the intention. However, in order to avoid changes of the subject's emotional state while filling the questionnaire, in this study the emotianal state of the user is measured direcly after the interaction with EDDIE, and thus the three questions of *Perceived Safety* constantly set up the beginning of the overall questionnaire.

The following section provides an overview of the analysis of the so far conducted pretest trials.

C. Results

Results can be deduced from the experimental evaluation including 55 subjects (40 male and 15 female, between 21 to 60 years with an average age of 28.8).
The distribution of the subjects over experimental conditions was 13 for **Neutral**, 17 for **SMM**, and 25 for **Mirror**.

TABLE III

USER ACCEPTANCE: MEAN RATINGS (RATED ON LIKERT SCALES FROM 1 = STRONGLY DISAGREE TO 5 = STRONGLY AGREE) WITH STANDARD DEVIATIONS (IN BRACKETS) OF EACH CONSTRUCT AND TOTAL SCORES WITHIN CONDITIONS

Construct	Condition		
	Neutral	Mirror	SMM
Empathy	3.1(1.3)	3.7(1.1)	4.4(0.8)
Subjective Performance	2.8(1.2)	3.4(1.0)	4.1(0.9)
Trust	3.0(0.6)	3.3(0.8)	3.7(0.5)
Perceived Sociability	3.2(1.0)	3.6(1.0)	3.9(0.7)
Social Presence	2.8(0.6)	2.8(0.7)	2.9(0.7)
Perceived Enjoyment	2.8(1.4)	3.9(1.2)	4.2(0.7)
Intention to Use	3.0(1.3)	3.5(1.0)	3.9(1.0)
Total Score	2.9(1.1)	3.5(1.0)	3.9(0.8)

Regarding reliability, coefficients of internal consistency are calculated with Cronbach's α for the items of the novel constructs on *Empathy* and *Subjective Performance*. As a solid construct should create an Cronbach's $\alpha > .70$ all items of both novel constructs showed good reliability with Cronbach's $\alpha = .82$ for *Empathy*, and Cronbach's $\alpha > .86$ for *Subjective Performance*. Since the selected constructs for user acceptance and of the Godspeed questionnaires are previously evaluated [9], [8] reliability and internal consistency are assumed.

Significance level for all performed tests was set to $\alpha = .05$. According to the results of Kolmogorov-Smirnov tests, normal distribution could be accepted for the total scores of all constructs, except *Perceived Enjoyment*. Thus, this construct has to be analyzed non-parametrically. Parametric comparisons and correlations are performed for all other constructs.

An analysis of variance (ANOVA) revealed significant differences between the conditions for *Empathy* ($F = 5.35, p = .008$), *Subjective Performance* ($F = 6.48, p = .003$), *Trust* ($F = 4.47, p = .016$), and *Likeability* ($F = 3.73, p = .031$). Thus, a post-hoc analysis could be conducted between the three conditions. Accordingly, the assumed significance level was divided by three und thus adjusted to $\alpha = .016$. Paired t-tests revealed significant differences between **Neutral**- and **SMM** conditions for *Empathy* ($t = -3.01, p = .007$), *Subjective Performance* ($t = -3.51, p = .002$), and *Trust* ($t = -3.30, p = .003$). Between **Neutral**- and **Mirror** condition one significant difference was found for the godspeed construct *Likeability* ($t = -2.03, p = .062$), and no significant differences were found between the conditions of **SMM** and **Mirror** due to the α-value adjustment. Means, total scores and standard deviations of the five constructs on user acceptance by Heerink [9], and the two additionally introduced constructs on *Empathy* and *Subjective Performance* are displayed in Table III.

Mean values and total scores for the five key concepts in HRI, as derived from the godspeed questionnaires, are depicted in Table IV.

TABLE IV

KEY CONCEPTS (GODSPEED): MEAN RATINGS (RATED ON LIKERT SCALES FROM 1 = STRONGLY DISAGREE TO 5 = STRONGLY AGREE) WITH STANDARD DEVIATIONS (IN BRACKETS) OF EACH CONSTRUCT AND TOTAL SCORES WITHIN CONDITIONS

Construct	Condition		
	Neutral	Mirror	SMM
Perceived Safety	3.9(0.8)	3.6(0.6)	3.7(0.5)
Anthropomorphism	2.6(0.6)	2.8(0.5)	2.8(0.7)
Animacy	3.1(0.7)	3.3(0.4)	3.3(0.7)
Likeability	3.5(1.1)	4.1(0.5)	4.1(0.7)
Perceived Intelligence	3.5(0.8)	3.8(0.5)	3.9(0.5)
Total Score	1.1(0.7)	3.5(0.5)	3.6(0.6)

Correlation analysis focussed on the five selected constructs on user acceptance, along with the added constructs on *Empathy* and *Subjective Performance*. Correlation coefficients led to the finding that all constructs show significant correlations to each other ($p < .001$), except for *Social Presence* which only correlates significantly to *Trust* ($r = .36, p = .007$).

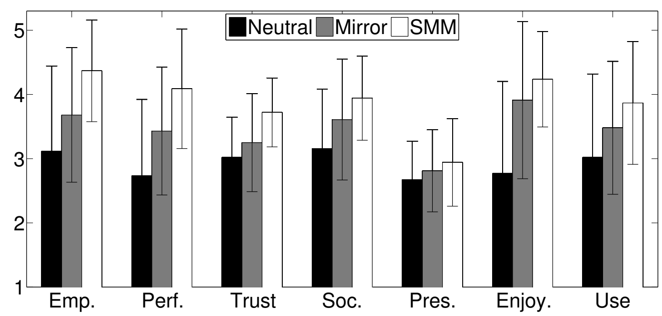

Fig. 4. Mean values of Heerink's 5 and the introduced 2 additional constructs for 3 conditions, : neutral, mirror, and social model on a 5-item Likert scale from 1 (strongly disagree) to 5 (strongly agree).

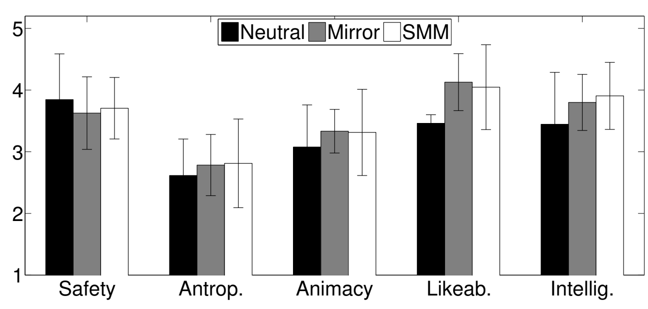

Fig. 5. Mean values of the 5 godspeed constructs for 3 conditions, : neutral, mirror, and social model on a 5-item Likert scale from 1 (strongly disagree) to 5 (strongly agree).

IV. Conclusions

The experimental validation of the presented approach for mirroring facial expressions in terms of similarity and its effects on HRI provides new insight regarding the possibilities and limitations of transferring social psychological principles from human-human interaction to HRI. Three different experimental conditions of facial mimicry were implemented in a robotic system and evaluated in terms of user acceptance and key concepts of HRI. Additionally, two new measures for empathy and subjective performance were introduced in this work and evaluated with regard to their impact on user acceptance. In general, results support the initial hypothesis by showing a trend towards a better rating of the mirroring condition compared to the neutral condition, with the social motivation model being rated even better in most instances. This underlines the importance of social factors to be considered for further refinement of how mirroring should be performed.

Reliability of the new measures for empathy and subjective performance is confirmed and correlations of those with all other constructs on user acceptance, but social presence, are revealed. Also the significance of empathy, subjective performance, and likeability provide evidence for the impact of mirroring facial expressions on the interaction. Since EDDIE has a very machine-like appearance it is possible that this may have dominating effects on the construct of social presence: Mean values show no noticable increase within this construct, and no correlations could be found besides the construct on trust. However, results indicate that social presence, which is very much bound to being human-like, is not crucial in order to induce empathy. It is noteable that according to Bailenson and Yee [11], the effect persists even when the person being mimicked is fully aware that the mimicker is an artificial agent, which indicates that this might also be applicable to the proposed system with a robot, that is perceived as an artificial interaction partner. Future work will re-evaluate the gained insights on induced empathy by extending this approach in order to trigger helpfulness towards autonomous robots in public spaces and reduce mistreatment by means of well-directed employment of mimicry.

V. ACKNOWLEDGEMENTS

This work is supported in part within the DFG excellence initiative research cluster Cognition for Technical Systems CoTeSys, see www.cotesys.org, by the Institute for Advanced Study (IAS), Technische Universität München, see also www.tum-ias.de, and by the project ”Highly Customizable and Flexible Packaging Station for mid- to upper sized Electronic Consumer Goods using Industrial Robots” (CustomPacker) is funded by the European Commission under the 7th Framework Program, see www.custompacker.eu, and by elokence.com, see www.akinator.com. This work is part of the EU-STREP project IURO (Interactive Urban Robot), supported by the 7th Framework Programme of the European Union, ICT Challenge 2 Cognitive Systems and Robotics, contract number 248317, see www.iuro-project.eu

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