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Studying laughter in combination with two humanoid robots

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Abstract To let humanoid robots behave socially adequate in a future society, we started to explore laughter as an important para-verbal signal known to influence relationships among humans rather easily. We investigated how the naturalness of various types of laughter in combination with different humanoid robots was judged, first, within a situational context that is suitable for laughter and, second, without describing the situational context. Given the variety of human laughter, do people prefer a certain style for a robot's laughter? And if yes, how does a robot's outer appearance affect this preference, if at all? Is this preference independent of the observer's cultural background?

Those participants, who took part in two separate online surveys and were told that the robots would laugh in response to a joke, preferred one type of laughter regardless of the robot type. This result is contrasted by a detailed analysis of two more surveys, which took place during presentations at a Japanese and a German high school, respectively. From the results of these two surveys interesting intercultural differences in the perceived naturalness of our laughing humanoids can be derived and challenging questions arise that are to be addressed in future research.[1]

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1 Introduction and motivation

Researchers in the field of Affective Computing [24] believe that human-machine interaction will benefit from a machine's ability to recognize, express, model, communicate, and respond to emotion (e.g. [7], [6]). Computational research on emotion and affect is motivated by the many findings and theories established in psychological (e.g. [22], [28]) and neuro-biological research (e.g., [21], [3]) that suggest an interplay of two conceptually different components in humans: cognition and emotion. In line with these findings the WASABI affect simulation architecture was developed [6] to not only improve the naturalness of human-computer interaction, but also to help with theory construction.

Even without such an internal simulation of affect it seems necessary to design for an artificial agent's emotional expressivity [10] in order to let it appear more social. This is rather easily realized for virtual characters [30], but much more difficult in case of social robots. Either the design itself is aimed at affective expressivity as, e.g., in case of "Kismet" [8], "eMuu" [2], or "WE-4RII" [32], or a robot's expressive abilities at hand have to be exploited effectively. Naturally, facial expressions are the prime target when robotics researchers want to let their robots express emotions. This approach—as reasonable as it is—is very challenging to realize properly, because humans are easily irritated by the tiniest irregularities perceived in someone else's facial movements. Therefore, it might be better to investigate other

[1] This article is an extended version of [4].

means to express emotions first, such as body movement or para-verbal expressions, e.g. laughter.

The remainder of this paper is structured as follows. In the following section the interdisciplinary background and related work from the computing sciences are discussed. In Section 3 two online surveys are described, their results discussed, and arguments for a second set of surveys are given. Section 4 describes the second survey conducted with Japanese high school students and its results are presented. A similar survey conducted with students of a German high school is presented together with a discussion of its results in Section 5. Finally, in Section 6, we compare and discuss the results of all three surveys, before in Section 7 conclusions are drawn, which inform our future work.

2 Background and related work

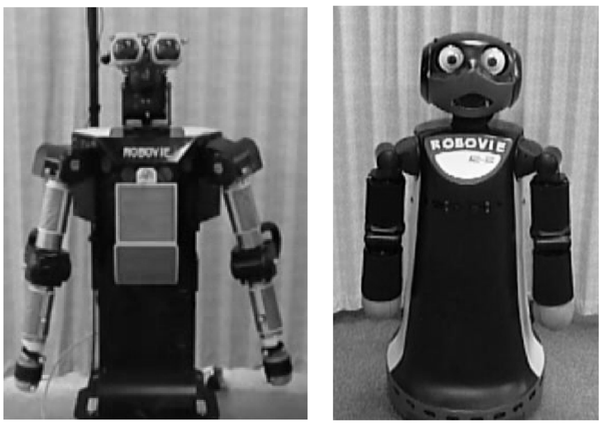
Laughter in humans has a socio-emotional function [26] and two major kinds of laughter can be distinguished, namely, aversive and friendly laughter [15]. Aversive laughter is also referred to as self-generated and emotionless "Non-Duchenne" laughter [11] and can be linguistically described as "laughing at" someone. Accordingly, "emotionless" does only refer to a sender's lack of emotion, but this laughter indeed might give rise to (most likely negative) emotions in the recipient, who is being laughed at. Friendly laughter, on the contrary, (linguistically circumscribed as "laughing with" someone) is characterized as stimulus-driven and emotional "Duchenne" laughter [11]. Based on this distinction it might be seen as important to avoid a human's interpretation of a robot's laughter as negative, i.e. aversive, when aiming at positive human-robot relationships. Results of an empirical study, however, show that in certain situational contexts even the expression of negative emotions can be beneficial in human-computer interaction [25].

The acoustic properties of laughter have been found to be very complex and irregular [19]. Furthermore, the frequency of laughter varies a lot between people [20] and laughter can be evoked by very different actions such as direct tactile interaction (i.e. tickling), automatic response to other people's laughter, or highly cognition-based understanding of verbal humor [23]. In this context another danger lies in unwittingly fueling the impression of a childish robot, because laughter is considered inappropriate in certain situational contexts [23], which might be very difficult to detect automatically. Gender-related differences also play a role in the occurrence of laughter [14], because women behave differently from men when laughing in opposite-sex encounters. People even change their communication strategies depending on the interlocutor's sex and their interest in that person.

Laughter belongs to the more general class of "raw affect bursts", which are less conventionalized and less symbolic than "affect emblems" [27], which in turn consist of a certain verbal content. The humanoid robot "Robovie-II" was allowed to have a slow response time, when it made use of "conversational fillers" such as the Japanese expression "etto" (resembling something similar to "well..." or "uh..." in English) [29].

Furthermore, two of these robots successfully performed a Japanese kind of stand-up comedy enacting more laughter in human observers than a comparable performance by human actors [16]. Although some "affective sounds" have been used to improve affective interaction with a virtual agent [25], to the best of our knowledge, the use of laughter in robots or virtual agents as a powerful, para-verbal, social signal has not yet been investigated systematically.

Thus, the questions underlying the research presented subsequently can be stated as follows: How might a humanoid robot laugh that takes part in a situation, in which such laughter is natural to occur, i.e. that of responding to a joke? Given the variety of human laughter, do people prefer a certain style of a robot's laughter in such a situation? And if yes, how does a robot's outer appearance affect the formation of this preference? Finally, does this preference depend on the observer's cultural background?



(a) Robovie-II (b) Robovie-R2

Fig. 1 The two humanoid robots in their rest postures adopted before and after laughing

3 The online surveys

Humans most often laugh within a social context [12], which in turn influences the style of their laughter [9].

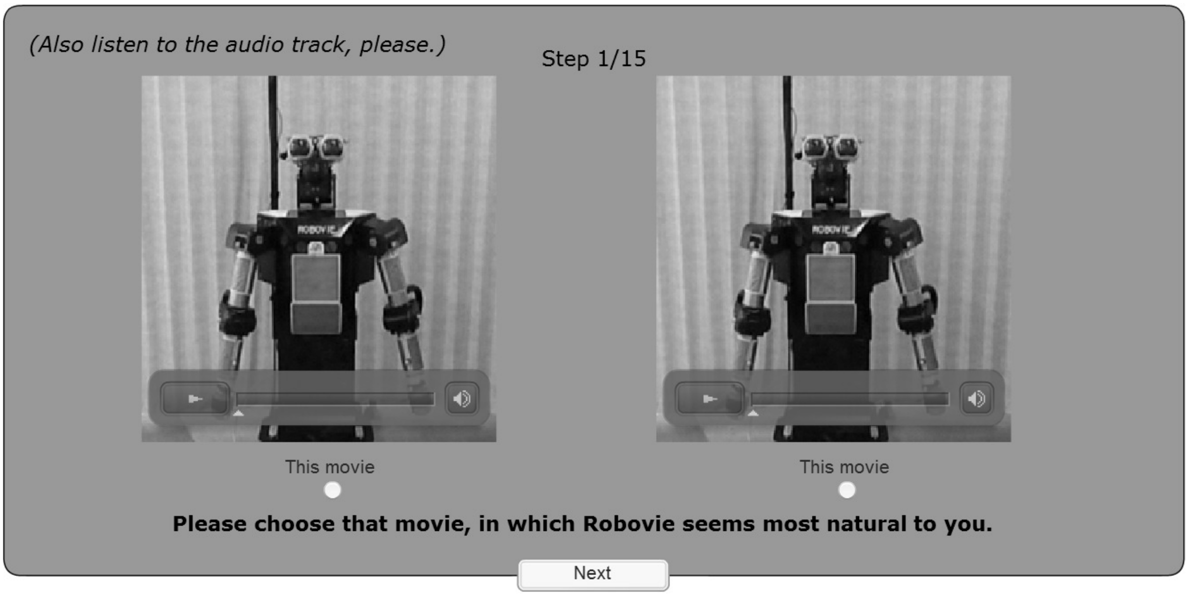


Fig. 2 A screen-shot of the online interface: The presented movies were always different to each other and participants were forced to chose one of them, before they could proceed to the next pairing by pressing "Next".

Accordingly, we decided to establish a precise situational context in which our robots would start laughing by telling the observers that the robots would laugh in response to a joke.

By choosing such a non-serious situational context we also tried to avoid that humans might interpret the robot's laughter as negative, aversive laughter. Thus, we could focus on what kind of recorded human laughter would be judged as most natural when being produced by the two humanoid robots "Robovie-II" [18] and "Robovie-R2" [31] (cp. Figures 1(a) and 1(b) respectively). We used two different Robovie versions in order to check for a possible interaction effect between a robot's outer appearance and the perceived naturalness of its laughter.

3.1 Design

The surveys were conducted online using a flash-based presentation of video clips (cp. Figure 2). The participants, first, had to choose one of the languages German, English, or Japanese, in which the surveys were then presented. Next, the situational context was described in that the participants could read the complete joke and were told that the robot would start laughing in response to that joke. Further written explanations together with a screen-shot of the interface (cp. Figure 2) were given as well and the participants could listen to the last sentence of the joke, which was going to be played in the beginning of each of the video clips.

Next, the participant was requested to provide his or her gender, age, nationality, and email address. The latter was only used to confirm each participant's identity be email and to prevent multiple participations.

Finally, each robot's laughter had to be judged based on the pairwise sequential presentation of a total of six short video clips per robot. The content of these video clips will be described in the following.

Each robot's laughter was followed by the Japanese exclamation "Ariehen!" (meaning "unbelievable"), which was rendered by a speech synthesizer. As explained in Section 2, humans laugh in a multitude of different ways. Therefore, we decided to manually choose five types of laughter for our exploratory study out of a total of 402 female Japanese laughter samples that originate from dyadic smalltalk recordings [17]. In doing so we tried to take care to capture a variety of possible laughter styles. The restriction to female laughter for both robots was motivated, first, by the robot's speech synthesis being based on a female voice and, second, by our belief that there were still enough variations for laughter realization. Because child-like laughter seemed to fit to our humanoid robots as well, we pitched one sample up by 25% (keeping its duration constant using the GoldWave software [13]) to produce an artificial, more child-like laughter[2].

The length of the laughter ranged from 0.9 seconds for laughter number six to a maximum of 1.74 seconds

[2] Videos of the laughing robots can be found at http://www.becker-asano.de.

in case of laughter number five (cp. Table 1). The following characteristics describe the different laughter:

L_1: Very high pitch; artificial, child-like laughter; rather constant pitch contour; six pulses; gender ambiguous
L_2: Same as L_1, but with mid-height pitch; female
L_3: Starting with higher pitch and continuously decreasing to mid-height pitch; seven pulses; female
L_4: Rather low pitch; "smoky" voice quality; eight pulses; female
L_5: Mid-height pitch; quickly alternating in- and exhaling; seven pulses; female
L_6: High pitch; four pulses; rather short; female

Graphical representations of each laughter's amplitude can be found in Table 1.

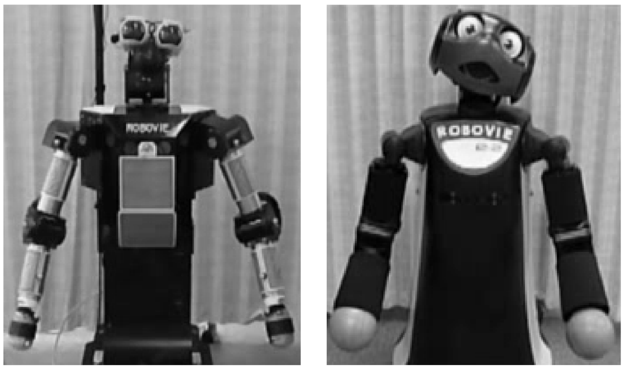
Table 1 Amplitudes, lengths, and number of pulses for each of the six female laughter samples

Laughter 1	Laughter 2	Laughter 3
		
1.25 seconds, 6 pulses	1.25 seconds, 6 pulses	1.47 seconds, 6 pulses
Laughter 4	Laughter 5	Laughter 6
		
1.48 seconds, 8 pulses	1.74 seconds, 7 pulses	0.9 seconds, 4 pulses

These six laughter samples were systematically combined with videos of the two robots, in which they both performed the same movements: after they listened to the last sentence of the joke and while the laughter samples were being played, they moved their heads backward to the left and lifted their arms resembling an "open-hand" gesture (cp. Figure 3). With finishing their laughter they moved back into their initial positions looking straight into the camera with their arms next to their bodies and finally they said "Ariehen!" without moving at all.

3.2 Procedure

The two robots were presented in two independent online surveys, which are subsequently labeled "survey A" for Robovie-II and "survey B" for Robovie-R2. In each survey the videos were presented pairwise in random order, such that each of the corresponding six videos was presented in combination with each other video. Accordingly, both surveys followed a forced-choice design, because in the resulting total of 15 pairs of videos per survey the participants were forced to decide for that video, in which the robot seemed to behave most naturally. We have to admit that answering such a rather general question leaves room for personal interpretation, but as we targeted non-experts for our survey, we found it inappropriate to ask a more complex question.



(a) Robovie-II (b) Robovie-R2

Fig. 3 Head and arm movements of the robots during laughter

Table 2 Distribution of participants' origin per survey

	Asian	European	American	$\sum$
survey A	12	21	17	50
survey B	12	17	5	34
$\sum$	24	38	22	84

Fifty participants took part in survey A (30 male, 20 female) and 34 participants in survey B (25 male, 8 female). Four participants joined both surveys. Of these 84 participants 24 (12 survey A, 12 survey B) originate from Asia, 22 (17 survey A, 5 survey B) from America, and 38 (21 survey A, 17 survey B) from Europe (cp. Table 2). Comparing the age distributions between surveys with respect to the participants' cultural backgrounds no significant differences were found with all mean values between 27 and 32.4 years.

3.3 Results

The different outer appearances of the two robots seem to have no effect (cp. Figure 4 with Figure 5). This assumption is supported by the results of a three-way ANOVA with laughter type (six levels), robot type (two levels), and participants' cultural background (three levels) as factors, which are presented next.

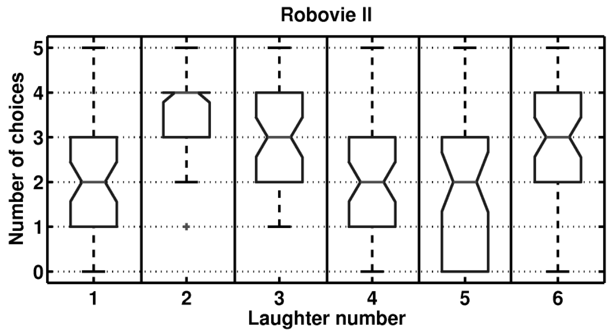


Fig. 4 Boxplot showing the median values of judged naturalness per laughter for Robovie-II acquired in survey A (n = 50)

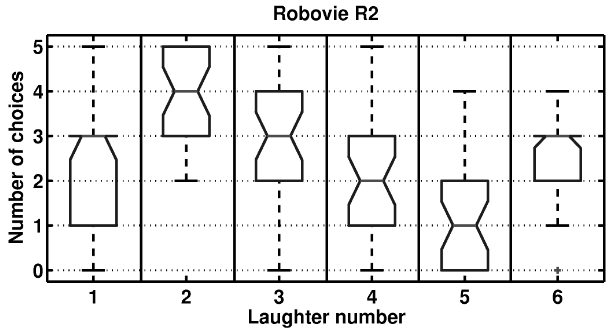


Fig. 5 Boxplot showing the median values of judged naturalness per laughter for Robovie-R2 acquired in survey B (n = 34)

There was a main effect of laughter type on perceived naturalness, F(5,478) = 27.03, p = 0. Participants judged laughter two significantly better (M = 3.6) than laughter one (M = 2.054, 95% CI [-2.14, -0.95], laughter four (M = 2.117, 95% CI [0.88, 2.08]), laughter five (M = 1.484, 95% CI [1.52, 2.71]), and laughter six (M = 2.624, 95% CI [0.38, 1.58]). The naturalness judgment for laughter two did, however, not differ significantly from that of laughter three (M = 3.122, 95% CI [-0.12, 1.08]).

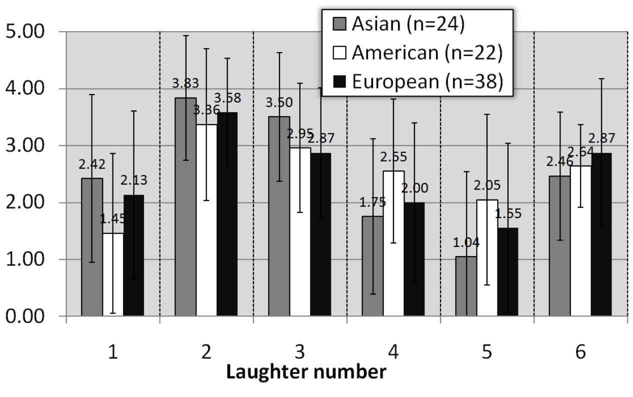


Fig. 6 Mean ratings of judged naturalness with standard deviations split up according to participants' cultural background distinguishing Asian, American, and European origin

There was also a main effect of the participants' cultural background on the judged naturalness of a robot's laughter, $F(10, 478) = 2.09$, $p < 0.025$; cp. Figure 6. The Asian participants evaluated laughter two (M = 3.833) as significantly more natural than all other laughter samples except for laughter three (M = 3.5, 95% CI [-0.97, 1.64]. Laughter two was also evaluated as most natural by the european participants (M = 3.583), but their evaluation of laughter two was not significant different from their opinions about laughter three (M = 2.875, 95% CI [-0.33, 1.76]) and laughter six (M = 2.854, 95% CI [-0.31, 1.77]). Although the american participants also evaluated laughter two as best fitting to either of the two robots (M = 3.383), this evaluation did not differ significantly from their rating of laughter three (M = 2.989, 95% CI [-1.02, 1.81]), laughter four (M = 2.592, 95% CI [-0.63, 2.21]), and laughter six (M = 2.559, 95% CI [-0.59, 2.24]).

Thus, our data suggests that although the same laughter number two is evaluated best by all pariticipants, Asian people seem to have a stronger opinion than european and american people. This assumption is supported by the fact that the Asian people also rated laughter five (M = 1.042) significantly lower than all other types of laughter except for laughter four (M = 1.75, 95% CI [-0.59, 2.01]).

The forced-choice design did not allow for any other significant interactions to occur.

3.4 Discussion

In summary, the robot's outer appearance seems to have a much smaller effect on the perceived naturalness of laughter than we expected. Probably any real differences are dominated by the judged naturalness of the different laughter samples themselves, but some participants also reported that they thought any kind of male laughter would fit better to our humanoid robots than any of the female laughter samples we presented. Furthermore, the forced-choice design of our study might have overshadowed any inter-robot difference in the perceived naturalness of laughter. Aiming to investigate these open questions, we decided to acquire additional data by conducting a second survey.

4 The high school survey in Japan

During a lecture given by the first author at the Kakogawa-higashi high school in Hyogo prefecture, Japan, 36 students were asked to provide their opinions about how well each of the six laughter samples fits to each of the two robots. The laughter samples as well as the robots were the same as in the online surveys described in Section 3.

Fig. 7 The mode of presentation at the Japanese high school

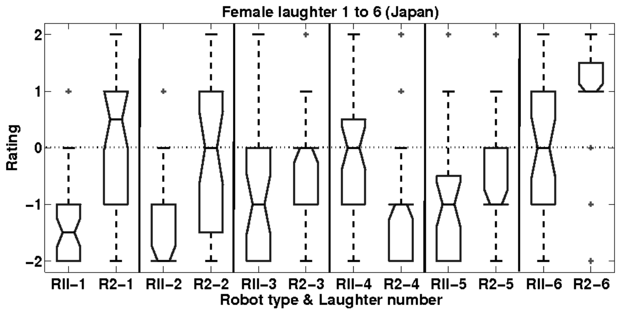


Fig. 8 Boxplot showing the median ratings of judged appropriateness per laughter and robot type for the six female laughter samples judged by the 36 Japanese high school students (RII denoting Robovie-II and R2 denoting Robovie-R2)

4.1 Design and procedure

Although the same six laughter samples in combination with the same movements of the robots had to be judged, the way of presentation was different from the one applied in the online surveys. In the lecture room a projector was used (cp. Figure 7) to present 12 video clips of the laughing Robovies without giving any further context information. The videos were grouped by type of laughter, i.e. six video pairs were shown with each of the pairs consisting of one video for Robovie-II and the according one for Robovie-R2. After each pair the students were asked to independently rate the degree to which the respective laughter fits to each of the two robots. Their rating was based on a five-point scale ranging from minus two (labeled with "did not fit") to plus two (labeled with "did fit"). We also gathered each student's age and gender and invited them to write down comments.

A total of 36 students took part in this survey (26 male and 10 female). Nine were 16 years old (all being male students) and the remaining 27 students were 17 years old.

4.2 Results

Most surprisingly, laughter number two was rated to not fit to either of the two Robovies ($M = -1.56$ and $SD = 0.81$ for Robovie-II, $M = -0.36$ and $SD = 1.29$ for Robovie-R2, cp. Figure 8). This result contradicts the results of the previous online survey, in which the same laughter was judged as most natural.

A two-way ANOVA with laughter type (six levels) and robot type (two levels) as factors reveals a significant interaction between the two factors, $F(5, 420) = 8.85, p < 0.001$. Thus, it is difficult to explain why laughter number six (Robovie-II: $M = -0.19$, $SD = 1.04$; Robovie-R2: $M = 0.89$, $SD = 0.98$) is evaluated positively when combined with Robovie-R2. On the one hand, all types of laughter are judged more positively for Robovie-R2 ($M = -0.19$, $SD = 1.31$) than for Robovie-II ($M = -0.84$, $SD = 1.15$; 95% CI [-0.86, -0.44]), but, on the other hand, laughter number six is judged most positive ($M = 0.35$, $SD = 1.14$) of all laughter regardless of robot type (e.g., laughter number one: $M = -0.56$, $SD = 1.38$; 95% CI [-1.44, -0.37]).

Similar to the comments we got in the online surveys, some Japanese high school students mentioned that they had found male laughter to fit better to both kinds of humanoid robots.

4.3 Discussion

The above results stay in contrast to the results derived from the data of the two online surveys described in Section 3. A number of factors might have caused this difference, for example, (1) the different mode of presentation, (2) the difference in the age of the participants, and (3) the lack of context information about why the robots are laughing in the high school survey. Laughter number six, for example, might have been evaluated so positively for Robovie R2, only because it has been the very last video of the sequence.

Therefore, we decided to conduct a very similar survey at a German high school targeting the following two questions: Is male laughter indeed judged to fit better to the Robovies? Do intercultural differences appear with regards to the perceived naturalness of laughing humanoids?

As we necessarily had to add male laughter to the survey, we could also test our apprehension that the positive evaluation of female laughter number six for Robovie R2 might have been caused by an order effect.

5 The high school survey in Germany

During a presentation, which was very similar to the one given in Japan, the first author collected additional data from 90 German high school students at the "Friedrich-von-Bodelschwing Gymnasium" in Bielefeld, Germany.

5.1 Design and procedure

At first the same six laughter samples (cp. Table 1) were presented in the same way as during the presentation in Japan (cp. Section 4). In addition, however, six male laughter samples were combined with the videos of the two Robovies such that the students were asked to judge the naturalness of a total of 24 video clips, i.e. six female and six male laughter video clips for each robot. Graphical representations of the amplitudes of each additional male laughter can be found in Table 3.

Table 3 Amplitudes, lengths, and number of pulses for each of the six male laughter samples. Although the amplitudes of laughter seven and eight appear to be clipped, no audio sample suffered from distortions during presentation. We also took care that the loudness of all laughter presented was comparable.

Laughter 7	Laughter 8	Laughter 9
		
1.37 seconds, 6 pulses	1.37 seconds, 6 pulses	1.5 seconds, 7 pulses
Laughter 10	Laughter 11	Laughter 12
		
1.85 seconds, 8 pulses	1.31 seconds, 7 pulses	0.73 seconds, 4 pulses

These samples originate from the same recordings as the female laughter samples and were chosen manually to feature similar characteristics. Thus, laughter number seven is similar to laughter number one in that it was artificially created by pitching up laughter number eight by 25%. The features of laughter number eight are similar to laughter number two and so on. Especially laughter number eleven also contains a lot of breathing noise similar to the female laughter number five, which was judged as most unnatural for both Robovies.

A total of 90 students took part in this survey (40 male and 50 female) and they were in average 17.27 years old ($SD = 1.77$).

5.2 Results

Once again, laughter number two was rated as to not fit to either of the two Robovies ($M = -0.65$ and $SD = 0.99$ for Robovie-II, $M = -0.54$ and $SD = 1.04$ for Robovie-R2, cp. Figure 9). A two-way ANOVA with laughter type (six levels) and robot type (two levels) as factors results in a significant interaction between these two factors again, $F(5, 1068) = 5.7$, $p < 0.001$. Thus, it is not clear, if the German high school students indeed preferred Robovie-R2 laughing with a female voice as the analysis weakly suggests (Robovie-II: $M = -0.76$, $SD = 1.06$; Robovie-R2: $M = -0.63$, $SD = 1.13$; $F(1, 1068) = 3.96$, $p < 0.047$, 95% CI [-0.27, -0.002]).

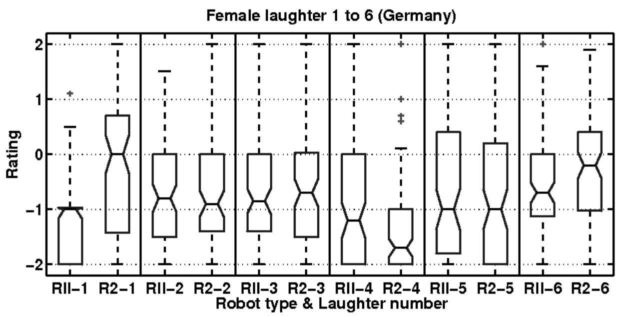


Fig. 9 Boxplot showing the median ratings of judged appropriateness per laughter and robot type for the six female laughter samples judged by the 90 German high school students

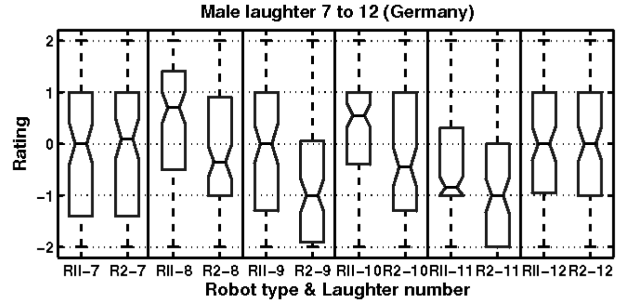


Fig. 10 Boxplot showing the median ratings of judged appropriateness per laughter and robot type for the six male laughter samples judged by the 90 German high school students

When comparing Figure 9 (female) with Figure 10 (male), male laughter seems to be evaluated more positively for both Robovies. This observation is confirmed by the results of a three way ANOVA with robot type (two levels), laughter type (six levels), and laughter gender (two levels) as factors. Although a strong interaction effect between all three factors can be observed, the mean $M = -0.76$ ($SD = 0.05$) for female laughter combined with Robovie-II is not significantly different from the mean $M = -0.62$ ($SD = 0.05$) in case of female Robovie-R2 laughter; cp. Figure 11, left. Both of these means are, however, significantly different from Robovie-II's mean $M = 0.06$ ($SD = 0.05$) for male laughter as well as Robovie-R2's male laughter mean $M = -0.36$ ($SD = 0.05$); cp. Figure 11, right.

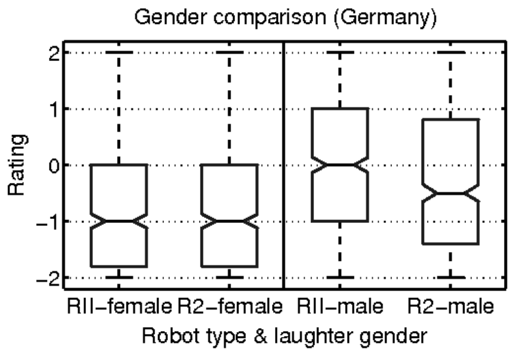


Fig. 11 Global comparison of the interaction between laughter gender and robot type

This preference of male laughter for Robovie-II, however, does not appear to be completely independent of the type of laughter as can be seen in Figure 10. For laughter number seven, eleven, and twelve no significant differences appear in the naturalness judgments between the two robots. In case of the remaining three laughter types, Robovie-II is always evaluated significantly better than Robovie-R2, with laughter number eight and ten gaining the most positive evaluations (laughter number eight: $M = 0.36$, $SD = 1.11$; laughter number ten: $M = 0.4$, $SD = 1.11$). Finally, laughter number eleven was appraised most negatively for both robots (Robovie-R2: $M = -0.9$, $SD = 1.1$; Robovie-II: $M = -0.4$, $SD = 1.11$). The difference between these evaluations is not statistically significant.

6 General discussion

We set out to investigate the perceived naturalness of multi-modal laughter performed by two different types of humanoid robots in the aim to find answers to the following questions:

A. How might a humanoid robot laugh in a situational context appropriate for laughter?
B. Do people prefer certain styles of laughter for visually different kinds of humanoid robots?
C. Does the cultural background of the observer influence the perceived naturalness of a robot's laughter?

In the following we address each of these questions by summarizing the results of all three surveys.

6.1 Laughter and situational context

The acquired data permits very limited conclusions toward answering this question. Only for the online surveys the participants were provided with a concrete situational context, in which the robots would start laughing. In contrast to both high school surveys, the participants of the online surveys appraised laughter number two most positively regardless of the robot type. Thus, this female laughter, which consists of an average number of pulses and a rather flat pitch contour, might be best suited for robots in the special situation of laughing in response to a joke, but we are aware that this difference might as well result from the different experimental setup of the online survey.

More generally, empirical research has shown that the acoustic properties of laughter have different emotional effects on listeners, when they are actively interacting with the laughter producing individual or when this laughter is presented offline [1]. Thus, this question needs to be addressed in future research to allow for stronger conclusions.

6.2 Laughter and the outer appearance of a robot

Interestingly, laughter number five, which was evaluated worst in both online surveys, was also judged negatively by all high school students. Probably, a laughter sample with a lot of breathing noise always appears unnatural in combination with the humanoid robots' movements presented in the video clips. This assumption is supported by the negative appraisal of male laughter number eleven, which features similar characteristics.

As for a difference between the two Robovie robots we found that for Robovie-II male laughter is judged even more appropriate than for Robovie-R2, although in general male laughter was evaluated more natural for both Robovies than female laughter.

6.3 Laughter and intercultural differences

The standard deviation of all of the Asian participants' data ($n = 24$, $SD = 1.61$) is considerably higher than that of all of the European participants's data ($n = 38$, $SD = 1.46$) in the online surveys. Thus, the Asian participants seemed to have stronger opinions about the naturalness of (female) laughter than the European participants. This is supported by the data of the two high school surveys, in which the global standard deviation for the Japanese students' data ($n = 36$, $SD = 1.28$) is also higher than that of the German students' data ($n = 90$, $SD = 1.1$). In addition, only the Japanese students evaluated one female laughter positively for Robovie-R2, but the German students evaluated all female laughter samples negatively for both robots.

Although we have to admit that an order effect might have compromised the data collected from the Japanese students, this difference might have been caused by the fact that the laughter samples themselves originated from Japanese individuals. Thus, Japanese observers might naturally be better at judging the naturalness of this type of laughter.

7 Conclusions

From the general discussion we are confident to draw the following conclusions:

1. Laughter containing a lot of breathing noise seems to be inappropriate for humanoid robots—at least in combination with the movements we programmed for our two Robovies and in the situational contexts we embedded them in. Although a similar negative effect was found before for unvoiced female laughter in general [1], even male laughter with similar characteristics was evaluated very inappropriate for our laughing robots.
2. Male laughter seems to fit better to both Robovies in general and even better to Robovie-II in particular than female laughter. This might, of course, change when we change their mechanical design or start dressing them up.
3. Providing an explicit situational context, in which the robots are explained to start laughing, might influence the type of laughter that is judged appropriate for robot laughter.
4. Asians (and in particular Japanese high school students) seem to have stronger opinions concerning (video clips of) laughing robots than do Europeans (and in particular German high school students).

A number of open questions need to be addressed in future research and the following ones seem most interesting to us:

- Robot laughter in face-to-face interaction: Do people have a different opinion about laughing Robovies when directly interacting with them?
- Robot laughter in different situational contexts: How do different situational contexts change the judgment of appropriatness of robot laughter?
- Artficial robot laughter: Considering the rather poor overall evaluation of recorded human laughter applied to humanoid robots, would it be better to use completely artificially generated laughter?
- Other designs or types of humanoid robots: Do our conclusions also hold for differently designed humanoid robots or even for android robots?

The first three questions can be addressed in combination using the two Robovies at hand. First steps to investigate the last question have been undertaken by letting participants interact with the android robot "Geminoid HI-1", which started to laugh at certain moments during face-to-face interaction [5].

In conclusion, we are confident that pursuing this line of research might help to improve both the sociability of humanoid robots and our knowledge about the social functions of human laughter.

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