

# Towards automated full body detection of laughter driven by human expert annotation

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**Abstract**—Within the EU ILHAIRE Project, researchers of several disciplines (e.g., computer sciences, psychology) collaborate to investigate the psychological foundations of laughter, and to bring this knowledge into shape for the use in new technologies (i.e., affective computing). Within this framework, in order to endow machines with laughter capabilities (encoding as well as decoding), one crucial task is an adequate description of laughter in terms of morphology. In this paper we present a work methodology towards automated full body laughter detection: starting from expert annotations of laughter videos we aim to identify the body features that characterize laughter.

## I. INTRODUCTION

Laughter is a conspicuous but frequently overlooked human phenomenon. Laughter is estimated to be about 14 million years old. It is safe to assume that laughter, like other utterances, such as sighs, groans and cries, was there before man developed speech, serving as an expressive communicative social signal. Laughter can be studied in its morphology (beginning with Darwin in 1872 [1]) in encoding (expressing) as well as decoding (interpreting), its function in human interaction (e.g., laughter in conversations), its occurrence along with emotions (see [2] for the occurrence of laughter in amusement), and its application to foster Human-Computer Interaction (HCI). An important challenge in HCI, which is addressed by the EU FP7 FET ILHAIRE Project, is to endow machines with laughter capabilities (i.e., to create virtual agents able to detect/understand human laughter, and to synthesize it). In this paper, we focus on the automated human laughter detection capabilities, more specifically in the definition of an appropriate human laughter body movements coding schema. This is not a trivial task, as encoding and decoding studies of laughter within the ILHAIRE Project have shown that for certain features of laughter, theorized encoding and the decoding by participants differ, see the case of frowning in intense laughter in [3] and [4]. Further, as any nonverbal signal, laughter has a communicative value (i.e., “I am amused”, “join in with me, it’s fun”), so the features of laughter expression also need to be understood in interactions, see the work described in [5].

In the scope of the ILHAIRE Project, a minimal distinction between amusement laughter and conversational laughter is made, and further classification is aimed at being developed. Although future research will tell how many types of laughter can be distinguished, this paper only focuses on one type of

elicited laughter, namely, amusement laughter, which will be utilized in the laughter condition. Many of the morphological features are well-described and its occurrence has been investigated [2].

## II. BACKGROUND

Laughter is a relevant component in human-human nonverbal communication and it is a powerful trigger for facilitating social interaction. Indeed, Grammer [6] suggests that it conveys signals of social interest and reduces the sense of threat in a group [7]. Further, laughter seems to improve learning of new activities from other people [8] and to facilitate sociability and cooperation [9]. Ruch and Ekman’s [10] overview on the research on laughter (respiration, vocalization, facial action, body movement) illustrated the mechanisms of laughter, and defined its core features. While acknowledging that more variants of this expressive-communicative signal might exist, they focused on the common denominators of some of its forms (by differentiating between spontaneous and fake laughter). Generally, a thorough description of laughter needs to consider lacrimation, respiration, body movements, body posture, and vocalization (phonation, resonance, articulation; e.g., [1][11][12]).

### A. Face

Facial expression and vocalizations have received comparatively much attention compared to knowledge on body movements. For example, the Duchenne laugh or joyful laugh has been well-documented to consist of a Duchenne display [13], the simultaneous and symmetric contraction of the zygomatic major muscle and the orbicularis oculi, pars orbitalis muscle, an open mouth and a laughter-related vocalization (see [14][2]). For this laughter, decoding rates are typically high and its link to amusement (or joy) is well recognized (see for example [4]). Whether morphologically different types of laughter can be found in the face is still discussed. Darwin [1] foresaw different types of laughter, but did not give a list of “states of mind” which might go along with laughter [1].

A pioneering system including automated detection of laughter from facial expression is the Affective Multimodal Mirror [15][16]. This system “tries to induce positive emotions in users by showing a distorted (“funny”) representation of their face”. The system senses and elicits laughter, based on a

vocal and a facial affect-sensing module, whose outputs are integrated by a fusion module. More recently, members of the ILHAIRE Project have started investigating differences in facial expressions in laughter which was elicited in positive emotions and emotion blends [3][4]. Nevertheless, while this research has only just started, it is safe to assume, that at least for one type of laughter (Duchenne laughter) characteristics can be determined reliably.

### B. Voice

In terms of vocal features, Ekman [17] proposed that laughter types might differ in their acoustical structure, and different authors have worked on the decoding of laughter types (e.g., [18]). Furthermore, Bachorowski and colleagues have worked on the perception of voiced and unvoiced laughter in a series of studies [19].

Laughter segmentation was achieved by Knox and Mirghafori [20] by training neural networks on features frames like Mel Frequency Cepstral Coefficients (MFCCs), pitch, and energy. Kennedy and Ellis [21] automatically detected group laughter events in meetings, that is, moments in the meeting in which participants were laughing simultaneously. In recent work within the framework of the ILHAIRE Project, the “Laugh machine” has been developed [22]: virtual agents become capable of laughing more naturally, at the right moment, and with the correct intensity, when interacting with users. The agents extract humans’ speech features, such as power and pitch, and classify them using machine learning techniques to distinguish between silence, pure speech, pure laughter, or speech and laughter.

### C. Body

One morphological feature of laughter, which has been widely neglected in the past, is the body and its movements. Ruch and Ekman [10] observed that laughter is often accompanied by one or more (i.e., occurring at the same time) of the following body behaviors: “rhythmic patterns (e.g., five pulses per second)”, “initial forced exhalation”, “rock violently sideways, or more often back and forth”, “nervous tremor ... over the body”, “twitch or tremble convulsively”. Becker-Asano and colleagues [23] observed that laughing users “moved their heads backward to the left and lifted their arms resembling an open-hand gesture”. Recently, De Melo et al. [24] implemented a virtual agent that “convulses the chest with each chuckle”. Furthermore, Markaki and colleagues [25] analyzed laughter in professional (virtual) meetings: the user laughs “accompanying the joke’s escalation in an embodied manner, moving her torso and laughing with her mouth wide open” and “even throwing her head back”.

Whereas laughter detection has been developed for face and voice, the above studies suggest that it should be possible to develop systems for automatic detection of laughter. The Body Laughter Index (BLI), developed in the framework of the ILHAIRE Project, allows the automated detection of laughter, starting from the analysis of body movement captured by a video source [26]: BLI is computed from shoulders correlation and energy of body movement, integrated with a measure of periodicity of movement.

## III. WORK METHODOLOGY

We now introduce a work methodology, consisting of a sequence of steps, towards automated full body laughter detection. The first two are described in detail in the next sections; the third and fourth steps will be addressed in the near future:

- *Preliminary study*: it consists of a feasibility study in which we test whether humans are able to distinguish laughter from non laughter behavior using a “blind puppet” (i.e., without seeing face) animated with mocap data. Details are provided in Section IV.
- *Intensity rating study*: this stage is devoted to provide ratings of how intense body movements during laughter are (in a corpus of video laughter segments). Details are reported in Section V.
- *Annotation*: the most intensely rated video segments determined by the previous step are annotated by a group of human behavior experts (i.e., psychologists) to identify, for example, which body parts are more involved in laughter (e.g., head, torso, limbs) and which movements are mainly performed (strokes, rockings, nods, and so on).
- *Automated detection*: the automated detection, grounded on the annotation findings of the previous step, is implemented in the EyesWeb XMI platform (<http://www.eyesweb.org>), a software platform that allows researchers to create software modules for user’s expressive movement analysis [27]. The platform includes low-level (e.g., limbs/body speed, smoothness) and high-level (e.g., periodicity, impulsivity) features detection modules that will be extended to include those reported in the annotation.
- *Evaluation*: After generating simplified representations of a human body (samples of laughter and non-laughter behavior) driven by the data acquired in the previous steps, an evaluation will be carried out, targeting the quality of animation, as well as the perception of the laughter. In the planned study, we will assess participants’ assignment of laughter features and qualities. We will apply a variety of rating scales (and controlling for influential personality traits) that participant’s will fill in for each laughter stimulus, and we will investigate how the ratings link to morphological features of the laughs.

## IV. PRELIMINARY STUDY

A brief online perceptual study consisted of displaying 10 stimuli of a “puppet” (see Figure 1) representing a human body, whose movements corresponded to Motion Capture data. The data was organized in 6 sessions, each of them involving a group of 2 or 3 friends (age 20 - 35; 13 males, 3 females; 8 French, 2 Polish, 2 Vietnamese, 1 German, 1 Austrian, 1 Chinese and 1 Tunisian) performing social tasks without a strict protocol to be followed. Activities included, for example, watching funny videos or playing Pictionary game. Participants wore motion capture suits but were free to move and interact in an empty 4 x 5 meters room.

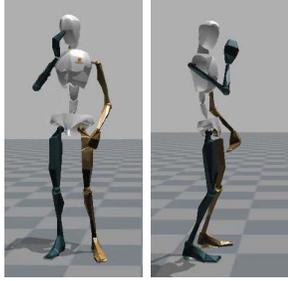


Fig. 1. The “puppet” performing motion captured laughter and non-laughter movements.

Session	Tot duration	Tot laughter	% laughter	Tot segments
1	00:56:35	00:03:37	6.4%	91
2	00:59:07	00:07:55	13.4%	49
3	00:42:49	00:04:22	10.2%	75
4	01:08:14	00:08:11	12.0%	127
5	00:58:29	00:01:42	2.9%	71
6	00:55:08	00:03:58	7.2%	109

TABLE I. SUMMARY OF LAUGHTER SEGMENTATION

#### A. Video segmentation

Each recorded session was segmented by annotators with experience in analysis of movement and gesture. Segmentation includes:

- The social task being performed. This includes one among six tasks (T1 - T6). Tasks T1 and T2 concern watching funny videos together or separately. T3 and T4 are social games. T3 is the *Yes/No game* where one of the participants must respond quickly to questions of the other participants without saying “yes”, “no” or any variation of these. T4 is *Barbichette*, a classic French game, where two participants are facing each other, look into the other person’s eyes, and touch the other’s chin, being allowed to do everything apart laughing. T5 is another game (*Pictionary*) where each participant draws as many key words as possible in two minutes (taking turns), while the other participants are trying to guess the key words. T6 consists of telling tongue twisters in four different languages (French, Polish, Italian, and English).
- The start and end time of each segment where laughter is detected.
- Who is laughing among the participants.
- The videocamera that captured the video used for annotation. This includes either one among two high-frame rate cameras Philips PC webcam SPZ5000, 640x480, 60fps (C1, C2), or one among four webcams Logitech Webcam Pro 9000, 640x480, 30fps (W1, W2, W3, W4), or one among two Kinect cameras, 640x480, 30fps (K1, K2).

Table I summarizes the total time duration of each session, the total duration of laughter segments (also in percentage with respect of the total duration of the session), and the total number of laughter segments.

#### B. Method and Participants

Starting from video segmentation, 5 laughter stimuli were selected. Each movie lasted about 10 seconds. Then, 5 other stimuli showing other types of behavior (e.g., dancing, describing stances) were selected.

In an online survey, 27 participants were randomly presented clips and were instructed to distinguish between laughing behavior (laughs) vs. not laughing behavior (non-laughs). The question asked to participant was: “Do you think that the person in the video is laughing?”. For each answer, they were then asked to indicate their level of confidence on a 7 point Likert Scale (ranging from 1 = “not confident at all” to 7 = “totally confident”). Two participants, considered as outliers, as they performed extremely poor in the judgment task (i.e., answering more than half of the questions wrongly), were excluded from the analysis. Four answers (out of a total of 250) have been omitted by the participants. Therefore, the analysis we presented here bases on a total of 246 ratings.

#### C. Results

1) *Do participants successfully distinguish between laughs and non-laughs?*: As shown in Figure 2, 79.70% of total ratings were successful, revealing that most participants mainly succeed in distinguishing the two conditions (laugh vs. non-laugh). A Chi square test showed significant association of Condition (laugh vs. non-laugh) with the Perceived Condition (Perceived laugh vs. Perceived non-laugh) ( $\chi^2 = 87.639, df = 1, p < .001$ ). The same test was carried out using the participants ratings weighted out by the level of confidence. Also in this latter case, a significant association was found.

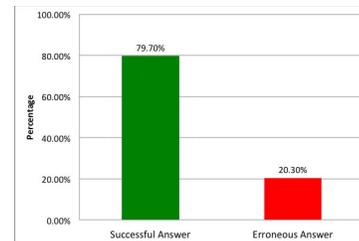


Fig. 2. Bar Chart displaying the relative percentage of successful answers (e.g., judging as “laugh” when the stimulus actually showed a laughing character) vs. erroneous answers.

2) *Is there a condition that is more successfully recognized?*: Further analysis reveals that participants were relatively more successful in recognizing non-laugh behavior with respect to laugh behavior (see Figure 3). One hypothesis to explain this difference could be that participants have specific expectations for identifying laughter behavior (e.g., stereotypical attitudes such as leaning forward, trembling with shoulders, etc.).

3) *How confident are the participants when answering?*: Figure 4 shows that participants answered with the same relatively high level of confidence in both conditions ( $p > .05$ ).

#### D. Discussion

Results confirmed that participants succeed in decoding laughter and non-laughter events from a simplified representation of a human body. These behavioral features are explicit

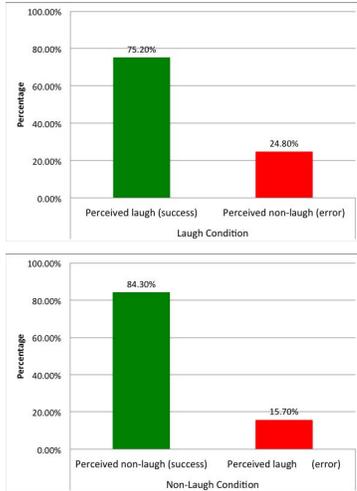


Fig. 3. Bar Charts displaying the participants' ratings (in percentage) for each condition.

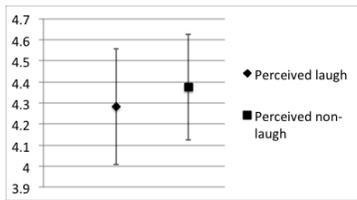


Fig. 4. Error bars showing the mean level of confidence for both conditions.

enough in a majority of cases to let participants answering with relatively high confidence in both cases (laugh and non-laugh cases). Furthermore, the analysis showed that some laughs were always detected correctly, as well as non-laughs which were always miss-classified. This implies that the chosen laughter samples entail the prototypical body movements which lay-participants detect as such. Therefore, it will be valuable to investigate the body features of those laughter and non-laugh examples. Additional questions (e.g., demographic variables, personality: empathy scales, gelotophobia, i.e., the fear of being laughed at) and in-depth analysis may be necessary to get insight on the following issues: did participants focus on specific behavioral features to infer laughter? can we correlate these participants' features with the features derived from automatic analysis? are some laughter features more stereotypical than others?

Results also shown that some stimuli were easier to recognize than others: stimulus 4 obtained a recognition rate of 100%, i.e., all participants succeeded in recognizing this laugh (full convergence laugh and perceived laugh). We provide some hypothesis about this high recognition rate in Section VI.

## V. INTENSITY RATING STUDY

In the next steps, the inevitable body features of amusement laughter shall be systematized by manual annotation. To initiate the encoding of laughter body movements through manual annotation schemes [28], it is necessary to know how intense the different laughs are, as it is assumed that the body

movements will vary for different degrees of laughter intensity. Therefore, the laughs should be clustered according to their assigned intensity and then coded for their body features in a separate study (see above). In the following intensity rating study, two independent raters coded the segmented videos from the task of watching funny video clips in three groups of participants for their intensity. The watching funny clips task was chosen, as the participants were standing freely, not in direct interaction. The interaction could lead to confounding body movements which are not specifically linked to the laughter, but to the interaction of laughing people.

### A. Method

The previously segmented laughs from the video watching task were coded for their intensity. One trained rater coded all segments of laughter, the second rater coded 22 video segments, with 41 laughs rated. The coding was done on a 7 point Likert scale (intensity of the laugh 1 = "not intense at all (very weak)" 7 = "most intense (very strong)"), leading to one general score for each laugh.

After the intensity ratings were compiled, inter-rater agreement was obtained. The inter-rater reliability was 78% (intensity differences of +/- one scale point were not considered, every deviation above was considered). Overall, there were nine cases of disagreement (five times a disagreement of two scale points, four times a disagreement of three scale points). After the evaluation of inter-rater agreement, the examples of disagreement were discussed among the authors until agreement was obtained.

### B. Results

Frequencies show that 16 laughs were assigned of lowest intensity (= 1), another 26 were assigned the value of 2, 23 laughs each reached medium intensities (= 3, 4, or 5), 13 laughs reached a high intensity assignment (= 6) and 19 laughs were assigned the maximum intensity (see Figure 5).



Fig. 5. Distribution of laughs over the seven intensity steps.

Figure 5 shows that each stage of intensity had approximately the same amount of laughs over all groups of participants. We computed a repeated measures ANOVA with the frequency of laughs as dependent variable, the intensity stages as repeated measures. No significant main effect for the intensity stages was obtained i.e., there were no significant differences between the frequencies. Nevertheless, it needs to be noted that patterns look different for individuals.

Nevertheless, it needs to be noted that patterns look different for individuals. On the individual level, three subjects did not show lowest intensity laughs (their laughs were more skewed towards higher intensity) and six subjects did not display any maximum intensity laughs. For two individuals, no laugh was perceived higher than medium intensity (4 and 5). They also displayed fewest laughs over the whole video watching task.

### C. Discussion

The annotation of intensity levels showed that the different levels of intensity were equally distributed over the seven categories. This will allow for a separate analysis of laughter body movements at all different stages of intensity (between subjects). Furthermore, it was shown that inter-individual differences among subjects exist: as psychological literature suggests, individuals differ in how easily they laugh, and in their taste of humor. Both will influence the expression of amusement through laughter (frequency, intensity). It is evident that individuals that did not find the selected video clips funny would display less laughter, and that personality traits like extraversion or trait cheerfulness increase the likelihood of a person displaying laughter (see e.g., [29]; for an overview on trait cheerfulness, see [30]). For example, it was shown that extraverts already laugh at a less funny stimulus compared to introverts and do so at a higher intensity in equal perceived funniness [29]. It might be fruitful to investigate those inter-individual differences as well, especially in connection with personality traits. This is not only important for psychology, but also for creating believable agents: if one aims to create virtual agents with a personality (i.e., exhibiting a certain configuration of personality traits), one will need to consider habitual differences in the expression of laughter, and also the influence of the context (here the funny video) on the elicitation of amusement (the elicited intensity of the feeling).

## VI. ANNOTATION OVERVIEW

In Section IV we showed that stimulus number 4 was correctly recognized as a laugh event by all participants. To exemplify the manual annotation that will be carried out as the next step of our work, as stated in the previous sections, we annotated this event for two purposes: a) to show how the manual annotation will look, and more importantly, b) to develop some hypothesis on prototypical features of laughter, as it is assumed that a laughter stimulus which had a recognition rate of 100% must be entailing features which are perceived as defining for laughter body movements.

The original laugh stemmed from the “Tongue Twisters Task” (T6) and shows a male participant observing two further participants reading tongue twisters. With respect to the facial features, Figure 6 shows that the participant displays a Duchenne laughter, involving the action of the orbicularis oculi, pars orbitalis muscle, here labeled Action Unit (AU) 6 after the Facial Action Coding System; FACS [31]), and the zygomatic major muscle (Action Unit 12; AU12), with an open mouth and dropped jaw. In terms of vocal features, the participant utters a laughter related vocalization consisting of about 40 pulses. The participant is also displaying head movements at different times of the laughter event: the head turning left (AU51) and right (AU52), as well as up (AU53) and

down (AU54), and the head nodding up and down (AU82). In terms of body features (from top to bottom), rhythmic shoulder shrugging was observable (AU85), as well as movements of the trunk and the chest, in particular chest shaking backwards and forwards, the trunk throwing, as well as contracting and straightening of the trunk. For the arms, movements forward, claps, as well as the lifting of the arms to touch the face were observed. For the whole episode, the participant shifted the weight from one leg to the other (left to right and vice versa) several times, as well as stepping back; shifting the weight to the leg positioned further back. Although coded, the face was not visible to the participants, as the “puppet” did not have a face. We assume that the shaking of the shoulders is an essential indicator of laughter, especially in combination with weight shifting.

## VII. CONCLUSION AND OUTLOOK

In this paper, we presented a work methodology towards automated detection of laughter through body movements. Our main goal is to identify an adequate description of laughter in terms of its full body morphology. Firstly, a preliminary study showed how well naïve participants distinguish between laughter and non laughter when being presented with a virtual representation of a human body. Secondly, we assigned intensity levels to the laughs from the video watching task.

In the next step of our methodology we select the most intense laughs for fine-grained annotation. This annotation is conducted in the Noldus Observer annotation software. The laughs with the highest intensity ratings, 19 clips with one to two intense laughs in each clip (21 laughs) are coded. It is taken care that all the subjects of the three groups are represented at least once. All laughs scoring on the 7-point Likert scale for intensity are chosen, but in order to represent all subjects, 2 laughs beyond 6 (but the most intense for the respective individual) are chosen; both scoring 4 or 5 respectively on the given intensity scale. The manual annotation is basing on features of laughter body movements derived from the literature, combined with knowledge on laughter in terms of facial features (and there utilizing defined actions from the Facial Action Coding System [31]). We also aim to design a new perceptual experiment focusing on the behavioral features that make laughter appear the most “stereotypical”. This new experiment will draw upon previous work by de Gelder [32], that is, investigating congruent vs. non-congruent cross-modal stimuli of face/body to assess such stereotypicality (e.g., one smiling/neutral/sad face upon the same “typical” laughter body). Future results of our methodology will consist in software applications capable of detecting/analyzing laughter. We also aim to explore multimodal fusion, that is, improving laughter detection by combining audio, facial expression, and bodily features. Finally, these features will be taken into account in the implementation of virtual agents and social robots with laughter capabilities.

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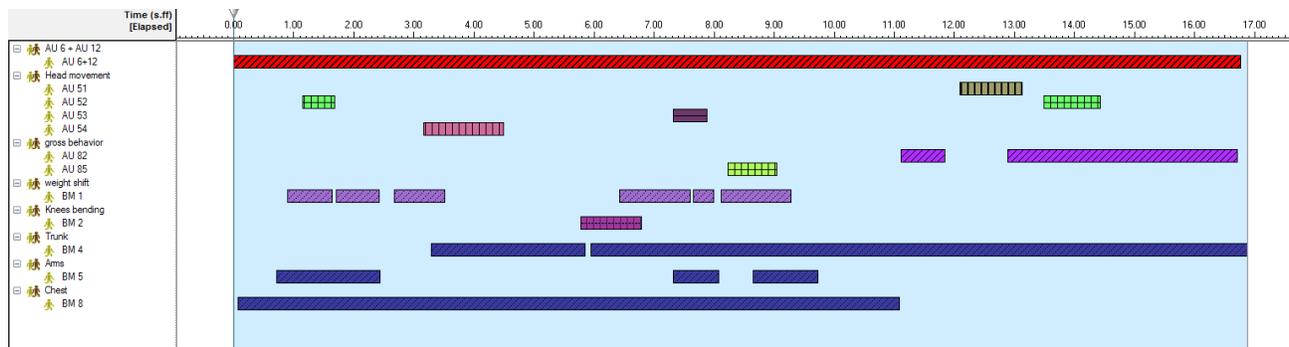


Fig. 6. Example of annotation: stimulus 4 was recognized as a laugh event by 100% of participants to the preliminary experiment described in Section IV.

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