Social and acoustic determinants of perceived laughter intensity

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Abstract

Existing research links subjective judgments of perceived laughter intensity with features such as duration, amplitude, fundamental frequency, and voicing. We examine these associations in a new database of social laughs produced in situations inducing amusement, embarrassment, and schadenfreude. We also test the extent to which listeners' judgments of laughter intensity vary as a function of the social situation in which laughs were produced.

1 Introduction

Humans seem to intuitively understand which laughs are intense and which are not. However, the exact characteristics of laughs used by listeners to make judgments of intensity remain elusive. The present research focuses on perceived intensity of laughter (as opposed to amplitude or sound pressure level). This dimension, also referred to as arousal, has been associated with spontaneous laughter production (Lavan et al., 2016) and with the extent to which a given laugh is perceived as a reaction to something humorous or funny (McKeown and Curran, 2015; Wood, 2019). It has also been described in terms of observable laughter characteristics including acoustic intensity or volume (Grammer and Eibl-Eibesfeldt, 1990), arousal (Urbain et al., 2014), or facial movements (Hess et al., 1995; Lynch, 2010; Ruch and Ekman, 2001). Despite its theoretical importance and implications for interpreting laughter, the construct of perceived intensity has received little attention in empirical research (Laukka et al., 2005).

McKeown and Curran (2015) conceptualize laughter intensity as a construct can be usefully assessed by subjective evaluations. Since laughter is ubiquitous in human social life (e.g., Scott et al., 2014), people are natural experts in recognizing its subtle nuances. In line with this reasoning, McKeown and Curran examined ratings of intensity of social laughs presented as audio-visual clips. The two corresponding studies showed that perceived laughter intensity is strongly and positively correlated with the extent to which a laugh is perceived as resulting from something humorous (McKeown and Curran, 2015) and that controlling for perceived intensity allows for flexible interchanging of laughs produced in different social situations (Curran et al., 2018). While these findings suggest that perceived laughter intensity is an important determinant in attributing meaning to laughter, it is also necessary to examine which characteristics of laughter best predict these judgments.

A subsequent study by Rychlowska and colleagues (2018) attempted to answer this question by analyzing a subset of data from McKeown and Curran (2015). Specifically, the researchers used ratings of perceived intensity of 266 laugh sequences produced by one man and one woman. These laugh recordings were also subjected to acoustic analysis. Several acoustic characteristics of laughter predicted perceived intensity of laughter such that, compared to less intense laughs, more intense laughs were longer, had higher amplitude or volume, higher mean fundamental frequency (pitch) and pitch range, and higher center of gravity. In addition, ratings of intensity were negatively associated with voicing. Thus, subjective intensity was predicted not only by volume but by a range of other characteristics of laughter.

Although the research of Rychlowska and colleagues (2018) provides insights into determinants of human intensity judgments, one important limitation of this study is the limited range of stimuli. The researchers analyzed a large number of laugh sequences but these laughs were produced by only two people. Moreover, it is highly likely that the laughs explored by Rychlowska and colleagues were conversational and social, rather than amused. The laughs were recorded as part of the Belfast Storytelling Database (McKeown et al., 2015) – a corpus of naturalistic interactions between groups of three or four participants talking about enjoyable experiences. Although these recordings document a rich

repertoire of nonverbal behaviors, they present only a limited range of laugh-inducing social situations.

The present research aims to provide a conceptual replication of the findings of Rychlowska and colleagues (2018). Specifically, we examine whether subjective judgments of laughter intensity can be predicted by measurable characteristics of laughter and by the social situation in which a given laugh was produced. We investigate these links using spontaneous laughs from 21 individuals (7 male) produced in social interactions engineered to elicit feelings of amusement, embarrassment, and schadenfreude (pleasure at another person's misfortune, Smith & van Dijk, 2018). These emotions were selected given their importance in previous research on laughter and smiles (Martin et al., 2017; Szameitat et al., 2009).

First, we test whether judgments of laughter intensity vary as a function of the context in which laughter occurs. Second, we examine the links between subjective evaluations of intensity and measurable characteristics of laughter.

2 Method

2.1 Stimuli

We analyzed 30 brief audio recordings of spontaneous social laughs (mean duration: 3.93 s, *SD* = 2.31). They were extracted from a database of audiovisual recordings of 58 English speakers (22 male, age *M* = 30.00) playing three competitive games in groups of three or four. Approximately half of the participants knew each other and recording sessions involved same-gender and mixed-gender groups. During the recording session, participants wore head-mounted microphones (Trantec HM22) and were asked to participate in several activities. Specifically, they played Bop It (a game that involves following quickly changing action commands), Pictionary (a game where one person makes a sketch depicting a word and other players try to guess the word), and they read a series of tongue twisters designed to make them unintentionally say swear words (McKeown et al., 2013).

The database involves more than 10,000 instances of laughter. Among these, we selected 30 laugh sequences based on predetermined criteria. Specifically, 10 laughs were produced in situations theorized to induce amusement. These laughs occurred when a person listened to a member of **their own team** reading tongue twisters and uttering a swear word against their will. Ten other laughs were produced during the Pictionary game when a person had to sketch the word "defecation" for other players. We expected this situation to produce feelings of embarrassment. Finally, 10 laughs occurred when a person watched a member of **the competing team** losing a round of Bop It.

2.2 Judgments of Laughter Intensity

Two hundred and three subjects (age *M* = 37.77, *SD* = 14.43) participated in an online study and rated perceived intensity of the 30 laugh sequences using slider scales ranging from 0 to 100.

2.3 Laughter characteristics

We used PRAAT (Boersma & Veenink, 2018) to extract the characteristics of each of the 30 laughs. When needed, laugh sequences were trimmed to remove the silence from the beginning and end of the samples (while keeping breath noises). We investigated eleven features covered in previous research (Rychlowska et al., 2018; Wood et al., 2017):

- *Duration* (log-transformed),
- Amplitude, or sound pressure level, in dB,
- Fundamental frequency (F0) variables (calculated using the PRAAT autocorrelation algorithm and expressed in semitone scales): *Mean F0*, *F0 range* (difference between the F0 minimum and the F0 maximum), *SD F0/duration*, or the standard deviation of F0 divided by the total duration (log-transformed), and *F0 slope*, or the mean absolute F0 slope (log-transformed).
- Spectral variables: *Center of gravity* (log-transformed), *harmonicity* or harmonics-to-noise-ratio, and *voicing,* or the proportion of voiced frames, versus frames lacking harmonic structure,
- Formant variables: *F1 mean* and *F2 mean*, or the first and second formant.

3 Results

3.1 Analytic Strategy

We analyzed participants' ratings of laughter intensity as a function of the social situation in which laughs originally occurred (amusement, embarrassment, schadenfreude) and the 11 laughter characteristics. Judgments of intensity were regressed on each of the predictor variables using linear mixed models. Since we analyzed multiple observations per participant and per laugh sequence, regression models included a by-subject and by-laugh random intercept. We also included random slopes for the social situation and each of the laughter characteristics. To minimize convergence problems and thus improve the statistical reliability of the regression models, tests of laughter

characteristics used the Nelder-Mead optimization routine.

3.2 Social Context

Although average intensity ratings tended to be higher for laughs produced in schadenfreude contexts (M = 43.60, SD = 25.66) than in amusement and embarrassment contexts (M = 39.89, SD = 22.82 and M = 38.38, SD = 24.18, respectively), the linear mixed model analysis revealed that this difference was not significant, B = 2.60, SE = 3.12, t(28.23) = 0.83, p = 0.41.

3.3 Laughter characteristics

Table 1 displays regression statistics for all predictor variables. Significant effects are highlighted in green and asterisks indicate log-transformed variables.

Variable	B	SE	t	p
Social context	2.60	3.12	0.83	0.41
Duration*	5.86	4.46	1.31	0.20
Amplitude in dB	1.17	0.17	6.68	<.001
F0 mean	1.29	1.07	1.21	0.24
F0 range	0.13	0.30	0.42	0.68
SD F0/Duration*	-12.05	9.55	-1.26	0.22
F0 slope*	2.84	6.34	0.56	0.66
Center of gravity*	7.60	5.00	1.52	0.14
Harmonicity	1.20	0.47	2.52	0.02
Voicing	0.18	0.10	1.78	0.08
F1 mean	0.01	0.02	0.83	0.41
F2 mean	-0.04	0.01	-2.87	<.001

Table 1: Main effects of social situation and laughter characteristics on perceived laughter intensity

Mean amplitude, harmonicity, and the second formant were the only significant predictors of laughter intensity judgments. Because we estimated 12 unique models with subjective intensity as a dependent variable, significant p-values were adjusted for the false discovery rate. These corrections yielded a $p < .001$ for amplitude, $p = .07$ for harmonicity, and $p = .04$ for the second formant.

4 Discussion

The present research tested whether judgments of laughter intensity vary as a function of social context and the features of laughter. We analyzed spontaneous social laughs produced in social situations designed to elicit amusement, embarrassment, and schadenfreude. Then, a group of naïve listeners rated the intensity of each laugh.

Regressing these intensity judgments on social context showed no significant effects of the situation in which laughs were produced. In other words, laughs associated with amusement, embarrassment, and schadenfreude were rated as similarly intense. Further studies examining laughs produced in different social situations will help explain whether these findings are due to a lack of systematic differences between laughs produced in varying contexts, to the substantial acoustic variability of laughter (Bachorowski and Owren, 2001), or to the limited sample of laugh sequences used in the present study.

Amplitude, harmonicity, and the second formant were the only variables predicting judgments of laughter intensity. Although our measurement of amplitude may be prone to errors (Svec and Granqvist, 2018), the observed positive association between amplitude and perceived intensity is expected in the light of extant research linking sound pressure levels with reduced inhibition (Bryant and Aktipis, 2014; Oveis et al., 2016). The negative correlation between F2 and intensity is less expected given the links between F2 and shortening of the vocal tract in smiled speech (Lasarcyk & Trouvain, 2008) and between F2 and judgments of emotion intensity (Laukka et al., 2005). Our findings also differ from the results of Rychlowska and colleagues (2018) in that only a few dimensions are statistically significant predictors of intensity judgments. Whereas the positive correlation between intensity and amplitude and the negative association between intensity and the second formant are consistent with this previous study, the present research shows a positive relation between harmonicity and perceived intensity, while the opposite was observed by Rychlowska and colleagues (2018). These inconsistencies may be explained by the methodological differences between the two studies. Specifically, the analyses conducted by Rychlowska and colleagues (2018) were restricted to laughs produced by two persons in conversational contexts. In the present research, we used laughs of 21 people produced in situations designed to induce playfulness and laughter. This higher diversity of laughter samples, combined with more stringent statistical testing (linear mixed models with random intercepts and slopes) may explain a smaller number of significant predictors of perceived laughter intensity. Together, our findings highlight the remarkable diversity of laughter, the importance of amplitude, and the complexity of human judgments of social signals.

References

Jo-Anne Bachorowski and Michael J. Owren. 2001. Not all laughs are alike: Voiced but not unvoiced laughter readily elicits positive affect. *Psychological Science*, 12(3): 252-257. doi: 10.1111/1467-9280.00346

Paul Boersma, and David Weenink. 2018. Praat: doing phonetics by computer [Computer program]. Version 6.1.09, retrieved 15 February 2020 from http://www.praat.org/.

Gregory A. Bryant, and C. Athena Aktipis. 2014. The animal nature of spontaneous human laughter. *Evolution and human behavior.* 35(4): 327-335. doi: 10.1016/j.evolhumbehav.2014.03.003

William Curran, Gary J. McKeown, Magdalena Rychlowska, Elisabeth André, Johannes Wagner, and Florian Lingenfelser. 2018. Social context disambiguates the interpretation of laughter. *Frontiers in Psychology*, 8: 2342. doi: 10.3389/fpsyg.2017.02342

Karl Grammer and Irenaus Eibl-Eibesfeldt. 1990. The ritualization of laughter. In *Natürlichkeit der Sprache und der Kultur: acta colloquii*, pages 192-214, Brockmeyer, Bochum, Germany.

Ursula Hess, Rainer Banse, and Arvid Kappas. 1995. The intensity of facial expression is determined by underlying affective state and social situation. *Journal of Personality and Social Psychology*, 69(2), 280-288. doi: 10. 1037/0022-3514.69.2.280

Lasarcyk, Eva, and Jürgen Trouvain. 2008. Spread lips + raised larynx + higher f0 = Smiled Speech? - An articulatory synthesis approach. *Proceedings of ISSP* (2008): 43-48.

Petri Laukka, Patrik Juslin, and Roberto Bresin. 2005. A dimensional approach to vocal expression of emotion. *Cognition and Emotion*, 19(5): 633-653. doi: 10.1080/02699930441000445

Nadine Lavan, Sophie Scott, and Carolyn McGettigan. 2016. Laugh like you mean it: Authenticity modulates acoustic, physiological and perceptual properties of laughter. *Journal of Nonverbal Behavior*, 40(2): 133-149. doi: 10.1007/s10919-015-0222-8

Robert Lynch. 2010. It's funny because we think it's true: Laughter is augmented by implicit preferences. *Evolution & Human Behavior,* 31(2): 141–148. doi: 10.1016/j.evolhumbehav.2009.07.003

Jared Martin, Magdalena Rychlowska, Adrienne Wood, and Paula Niedenthal. 2017. Smiles as multipurpose social signals. *Trends in Cognitive Sciences,* 21(11): 864-877. doi: 10.1016/j.tics.2017.08.007

Gary J. McKeown and William Curran. 2015. The relationship between laughter intensity and perceived humor. In *Proceedings of the 4th Interdisciplinary Workshop on Laughter and Other Non-Verbal Vocalisations in Speech*, pages 27-29.

Gary J. McKeown, William Curran, Ciaran McLoughlin, Harry J. Griffin, and Nadia Bianchi-Berthouze. 2013. Laughter induction techniques suitable for generating motion capture data of laughter associated body movements. *10th IEEE International Conference and Workshops on Automatic Face and Gesture Recognition (FG)*, Shanghai, 2013, pp. 1-5.

Gary McKeown, William Curran, Johannes Wagner, Florian Lingenfelser, and Elisabeth André. 2015. The Belfast Storytelling Database: A spontaneous social interaction database with laughter focused annotation. *6th International Conference on Affective Computing and Intelligent Interaction*, Xi'an, China. doi: 10.1109/acii.2015.7344567

Christopher Oveis, Alexandr Spectre, Pamela K. Smith, Mary Y. Liu, and Dacher Keltner. 2016. Laughter conveys status. *Journal of Experimental Social Psychology*, 65: 109-115. doi: 10.1016/j.jesp.2016.04.005

Willibald Ruch and Paul Ekman. 2001. The expressive pattern of laughter. In *Emotion, qualia, and consciousness*, pages 426-443. World Scientific, Tokyo, Japan.

Magdalena Rychlowska, Gary J. McKeown, Ian Sneddon, and William Curran. 2018. Not only decibels: Exploring human judgments of laughter intensity In *Proceedings of the 5th Interdisciplinary Workshop on Laughter*, 30-33.

Sophie Scott, Nadine Lavan, Sinead Chen, and Carolyn McGettigan. 2014. The social life of laughter. *Trends in Cognitive Sciences*, 18(12): 618-620. doi:10.1016/j.tics.2014.09.002

Richard Smith and Wilco van Dijk. 2018. Schadenfreude and Gluckschmerz. *Emotion Review*, 10(4), 293-305. doi: 10.1177/1754073918765657

Jan G. Svec and Svante Granqvist. 2018. Tutorial and guidelines on measurement of sound pressure level in voice and speech. *Journal of Speech, Language, and Hearing Research.* 61(3): 441-461. Doi: 10.1044/2017_JSLHR-S-17-0095

Diana P. Szameitat, Kai Alter, André J. Szameitat, Chris J. Darwin, Dirk Wildgruber, Susanne Dietrich, and Annette Sterr. 2009. Differentiation of emotions in laughter at the behavioral level. *Emotion*, 9(3): 397-405. doi: 10.1037/a0015692

Jérôme Urbain, Hüseyin Çakmak, Aurélie Charlier, Maxime Denti, Thierry Dutoit, and Stéphane Dupont. 2014. Arousal-driven synthesis of laughter. *IEEE Journal of Selected Topics in Signal Processing,* 8(2): 273-284. doi: 10.1109/JSTSP.2014.2309435

Adrienne Wood. 2019. Social context influences the acoustic properties of laughter. https://psyarxiv.com/npk8u/. doi: 10.31234/osf.io/npk8u

Adrienne Wood, Jared Martin, and Paula Niedenthal. 2017. Towards a social functional account of laughter. Acoustic features convey reward, affiliation, and dominance. *PLoS ONE,* 12(8): e0183811. doi: 10.1371/journal.pone.0183811.