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Not only decibels: Exploring human judgments of laughter intensity

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Abstract

While laughter intensity is an important characteristic immediately perceivable for the listeners, empirical investigations of this construct are still scarce. Here, we explore the relationship between human judgments of laughter intensity and laughter acoustics. Our results show that intensity is predicted by multiple dimensions, including duration, loudness, pitch variables, and center of gravity. Controlling for loudness confirmed the robustness of these effects and revealed significant relationships between intensity and other features, such as harmonicity and voicing. Together, the findings demonstrate that laughter intensity does not overlap with loudness. They also highlight the necessity of further research on this complex dimension.

1 Introduction

“Then it came – real laughter, total laughter – sweeping us off in unbounded effusion. Bursts of laughter, laughter rehashed, jostled laughter, laughter defleshed, magnificent laughter, sumptuous and wild... And we laughed to the infinity of the laughter of our laughs... O laughter! Laughter of delight, delight of laughter. Laughing deeply is living deeply.” – Milan Kundera

Representations of intense laughter abound in the literature and in cinema and, for most people, such laughs do not need to be defined. We intuitively understand what *unbounded*, *sumptuous*, *wild*, or *deep* laughter is, and we can recognize an intense laugh when we hear it. Research also shows that judgments of laughter intensity are associated with its spontaneous (versus volitional) production (Lavan et al., 2016) and with the extent to which laughs are perceived as humorous

(McKeown and Curran, 2015). But what exactly does it mean for laughter to be intense? Empirical investigations of this question have been relatively scarce and methods of measuring intensity are far from consistent. For example, this construct has been described as a function of loudness (e.g. Grammer and Eibl-Eibesfeldt, 1990), emotional arousal (e.g. Urbain et al., 2014), facial movements – measured with facial electromyography (e.g. Hess et al., 1995) or using the Facial Action Coding System (Ekman et al., 1982; Lynch, 2010). Laughter intensity has also been associated with specific patterns of facial expressions, postures, body movements, and physiological changes (Ruch, 1993; Ruch and Ekman, 2001).

In their recent research, McKeown and Curran (2015), adopted an alternative approach and focused on human judgments of laughter intensity. They theorized that, because people often laugh and observe – as well as interpret – laughs produced by others, they are natural “laughter experts”. Therefore, these researchers asked a large number of human participants to rate the intensity of laughs presented as audio-visual clips. Here, we build on this previous study and examine the acoustic correlates of human judgments of laughter intensity. Specifically, we analyze ratings of intensity as a function of eleven acoustic dimensions extracted using the PRAAT software (Boersma and Weenink, 2010). We also investigate the predictive power of these dimensions as a function of loudness.

2 Method

2.1 Intensity Ratings

The present research used a subset of data collected by McKeown and Curran (2015). In this study, participants recruited through Amazon’s

Mechanical Turk used a scale ranging from 1 to 10 to rate the intensity of laughter sequences, embedded in a website and derived from the Belfast Storytelling Database (McKeown et al., 2015) – a corpus of naturalistic interactions between groups of three or four participants, sitting around a table and telling each other stories. Recorded participants were unaware that laughter was the focus of the research. High-quality audio recordings were collected with head-mounted microphones. Segments of laughter were then extracted from the full recordings of the interaction, removing as much of the contextual information as possible. The present study used intensity ratings of 266 laugh clips of two English-speaking individuals, one male ($N = 125$) and one female ($N = 141$), recorded during two separate sessions. Audio sequences were evaluated by 540 Mechanical Turk participants who provided 1490 unique ratings. Each subject rated a variable number of sequences randomly drawn from the entire pool. The number of ratings per clip ranged from 1 to 13 ($M = 5.60$, $SD = 2.52$). Ratings of each sequence were then averaged across participants to obtain a single intensity score for each laugh.

2.2 Acoustic Dimensions

The acoustic analysis aimed to cover a broad range of dimensions previously associated with judgments of laughter (e.g. Lavan et al., 2015; Wood et al., 2017). After trimming the silence from the beginning and end of the samples, we used PRAAT (Boersma & Veenink, 2018) to extract eleven acoustic features:

- *Duration* (log-transformed to correct for positive skew),
- *Loudness*, or intensity, in dB,
- Pitch (F0) variables (calculated using the PRAAT autocorrelation algorithm and expressed in semitone scales): *Mean F0* or mean fundamental frequency, *F0 range* (expressed as F0 minimum/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). Pitch variables were available for 254 out of 266 laugh sequences.
- 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 Correlates of Intensity Judgments

A series of Spearman correlation analyses using raw scores revealed that ratings of laughter intensity were significantly and positively associated with duration, $\rho(264) = .42$, $p < .001$, 99% CI [.28, .56], loudness, $\rho(264) = .43$, $p < .001$, 99% CI [.30, .56], mean F0, $\rho(252) = .41$, $p < .001$, 99% CI [.27, .54], F0 range, $\rho(252) = .41$, $p < .001$, 99% CI [.26, .55], F0 slope, $\rho(251) = .27$, $p < .001$, 99% CI [.12, .42], and center of gravity, $\rho(264) = .21$, $p < .001$, 99% CI [.06, .39]. There was also a significant negative correlation between intensity and F2 mean, $\rho(264) = -.14$, $p = .02$, 99% CI [-.30, .03]. No other correlation was significant, $ps < .10$, $ps > .10$.

Additional analyses revealed a similar correlation pattern for the male and the female expresser, with two exceptions: Center of gravity was a significant predictor of intensity for the male, but not for the female expresser, $\rho(123) = .32$, $p < .001$, 99% CI [.08, .52] and $\rho(139) = .08$, $p = .35$, 99% CI [-.15, .30]. The opposite was true for the F2 mean, significantly predicting laughter intensity for the female, but not the male speaker, $\rho(139) = -.26$, $p < .01$, 99% CI [-.45, .04] and $\rho(123) = -.07$, $p = .47$, 99% CI [-.28, .16], respectively.

3.2 Beyond Loudness

The second set of analyses aimed to further explore the relationships described above and test their robustness while controlling for loudness. Our second goal was to test whether the importance of acoustic features as predictors of laughter intensity varies as a function of loudness. In other words, we explored determinants of perceived laughter intensity in soft, versus loud, laughs. For this, we conducted a series of linear regressions, in which participants' ratings of intensity were regressed on interactions between loudness and each of the following acoustic features: log-transformed duration, F0 mean, F0 range, log-transformed SD F0/duration, F0 slope, log-transformed center of gravity, harmonicity, voicing, F1 mean, and F2 mean. Each model used

mean-centered variables and included the two main effects along with the interaction.

Table 1 displays the regression statistics. Significant effects are in color: main effects are highlighted in green and interactions – in orange. Asterisks indicate log-transformed variables. Because we estimated 10 unique models, we report p-values adjusted for the false discovery rate.

Variable	B	SE	F	Adj. p
Duration*	1.49	.20	56.27	<.001
x Loudness	.09	.02	19.23	<.001
F0 mean	.06	.01	18.08	<.001
x Loudness	<.01	<.01	1.23	.34
F0 range	3.64	.62	33.84	<.001
x Loudness	.14	.06	4.78	.05
SD F0/Duration*	-.52	.27	3.70	.09
x Loudness	-.03	.03	1.28	.34
F0 slope	<.01	<.01	5.19	.04
x Loudness	<.01	<.01	4.11	.07
Center of gravity*	2.43	.38	40.76	<.001
x Loudness	.13	.03	16.60	<.001
Harmonicity	-.11	.02	26.88	<.001
x Loudness	<.01	<.01	0.24	.64
Voicing	-1.43	.39	13.46	<.001
x Loudness	-.02	.03	0.57	.53
F1 mean	<.01	<.01	8.64	<.01
x Loudness	<.01	<.01	0.22	.64
F2 mean	<.01	<.01	0.38	.60
x Loudness	<.01	<.01	2.16	.20

Table 1: Main effects of acoustic features on perceived laughter intensity and their interactions with loudness

The regression analyses revealed that human judgments of laughter intensity were significantly and positively associated with duration, F0 (pitch) mean, range, and slope, with center of gravity and F1 mean. Moreover, we observed a negative relationship of intensity with harmonicity and voicing, such that higher proportions of voiced frames predicted lower ratings of intensity. A closer inspection of the three significant interaction effects showed that the associations between intensity and duration, F0 range, and center of gravity were stronger for loud than for soft laughs. However, each of the three variables as well as F0 mean, F0 slope, harmonicity, voicing, and F1 mean predicted judgements of intensity while controlling for loudness and its interactions.

4 Discussion

The present research investigated acoustic features associated with human judgements of laughter intensity. Our findings reveal that laughs perceived as intense are longer, have higher fundamental frequency, or pitch, higher pitch ranges and steeper pitch slopes (or sharper pitch changes) than laughter rated as low in intensity. This result is consistent with previous research, linking pitch variables with enjoyment and intensity (e.g. Lavan et al., 2016; Niewiadomski et al., 2012; Wood et al., 2017). Intense laughs also have higher centers of gravity, sounding brighter, and are lower in harmonicity, having a less tonal sound than low-intensity laughs (Lavan et al., 2016). They also feature high F1, previously associated with arousal (Laukka et al., 2005). While at the first pass the negative relationship between laugh intensity and the proportion of voiced frames may seem surprising, given the previous evidence that voiced laughs elicit positive affect (Bachorowski and Owren, 2001), it also replicates other, more recent studies linking increased rates of unvoiced segments with spontaneity (Bryant and Aktipis, 2014; Lavan et al., 2015). The difference with the results of Bachorowski and Owren (2001) could also be explained by the fact that we analyzed laughs produced in social interactions, while the corpus used by Bachorowski and Owren features laughs of people watching funny video clips. The use of social laughter also distinguishes our research from the study of Niewiadomski et al. (2012), which investigated acoustic and visual predictors of intensity judgments using laughs produced by participants in reaction to comedy videos.

In sum, our findings reveal that human judgments of laughter intensity are a complex dimension that should not be conflated with loudness. Multiple acoustic features including duration, pitch variables, center of gravity, harmonicity, voicing, and F1 mean predict laughter intensity over and above loudness. These relationships provide insights into why and how relatively soft laughs can be perceived as high in intensity.

One important limitation of the present research is that we only analyzed laughs of two models, which does not allow to draw strong conclusions about the generalizability of the findings.

Describing a larger corpus and including the analysis of laughs produced in different social situations is a work in progress. We also hope to encourage further studies of laughter intensity and the links between this dimension and social motives and feeling states. In the light of recent findings suggesting that, after controlling for intensity, laughs produced in different situations become interchangeable (Curran et al., 2018), examining judgments of laughter intensity has the potential to improve our understanding of social and emotional messages conveyed by this expressive display.

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