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The perception of spontaneous and volitional laughter across 21 societies

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Abstract

Laughter is a nonverbal vocalization occurring in every known culture, ubiquitous across all forms of human social interaction. Here we examine whether listeners around the world, irrespective of their own native language and culture, can distinguish between spontaneous laughter and volitional laughter— laugh types likely produced by different vocal production systems. Using a set of 36 recorded laughs produced by female English speakers, in tests involving 884 participants from 21 societies across 6 regions of the world, when asked to determine whether each laugh was "real" or "fake," listeners differentiated between the two laugh types with an accuracy of 56 – 69%. Acoustic analysis revealed that sound features associated with arousal in vocal production predicted listeners' judgments fairly uniformly across societies. These results demonstrate high consistency across cultures in laughter judgments, underscoring the potential importance of nonverbal vocal communicative phenomena in human affiliation and cooperation.

Keywords: laughter, vocal communication, cross-cultural, emotion, speech

The perception of spontaneous and volitional laughter across 21 societies

Human social interaction relies on a complex suite of verbal and nonverbal communicative behaviors. Unlike language, across taxa, many nonverbal expressive behaviors have clear parallels in other species. Comparative analyses reveal homologies in play vocalizations across mammals; in humans, this manifests as spontaneous laughter (Davila-Ross, Owren, & Zimmermann, 2009; Gervais & Wilson, 2005; Provine, 2000; Vettin & Todt, 2005). Consistent with this characterization of human laughter as a biologically evolved species-typical feature, laughter appears in every culture, evincing remarkable consistency in form (Provine, 2000). The functions of laughter are also plausibly universal. However, this is more difficult to determine, as laughter occurs embedded within a variety of social contexts, resulting in many laugh types. A growing research corpus potentially addresses questions of function by examining contexts in which laughter is generated, and laughter's social consequences (e.g., Otten, Mann, van Berkum, & Jonas, 2017; Scott, Lavan, Chen, & McGettigan, 2014). In contrast, much less is known about how laughter is perceived. Research has explored distinctions between spontaneous and volitional laughter (Bryant & Aktipis, 2014; Lavan, Scott, & McGettigan, 2016; McGettigan, et al., 2013); judgments of affiliation in co-laughter (Bryant et al., 2016); and how perceivers ascribe social functions to laughter (Wood, Martin, & Neidenthal, 2017). The phylogeny of laughter suggests an avenue whereby, by investigating perceptions of laughter, one of the earliest functions of laughter can be explored. The human homologue of mammalian play vocalizations may have maintained the ancestral function of this trait, namely to uniquely signal affiliation. If so, then listeners should be able to distinguish this signal from other forms of laughter—and, critically, this ability should be a species-typical trait, independent of the many facets of communication that differ across cultures.

Laughter is a family of vocalizations linked by a particular pattern of rhythmic respiratory and laryngeal activity (Bachorowski, Smoski, & Owren, 2001; Luschei, Ramig, Finnegan, Bakker, & Smith, 2006), vocalizations that, with some notable exceptions (Provine, 2000), are often tied to feelings of mirth or joy. Laughs typically have a burst-like onset in which repeated oscillations of the glottis generate a series of bursts that decay over time in both energy and frequency (Provine & Yong, 1991). However, repetition is not essential, as a laugh can be comprised of only one burst as well. There is often, but not always, an associated perceived pitch in the bursts, resulting from the fundamental frequency (F_0) of vocal fold vibration regimes during glottal oscillatory cycles. Laughter production in normal conversation exhibits systematic features, including constrained vowel and loudness patterning, consistent affective properties, and a rule-governed relationship between laugh bursts and speech (Bryant, 2011; Provine, 2000; 1993; Ruch & Ekman, 2001; Szameitat, Alter, Szameitat, Wildgruber, Sterr, & Darwin, 2009; Vettin & Todt, 2004).

In other mammals, play vocalizations are derived from ritualized breathing during rough and tumble play (Gervais & Wilson, 2005; Knutsen, Burgdorf, & Panksepp, 1998; Provine, 2000). Although the rhythmic respiratory and laryngeal activity of human laughter constitute clear homologous aspects, human laughter differs from other primate play vocalizations in its higher proportion of voiced components; that is, more tonal, harmonically structured features attributable to vocal fold vibration (Davila-Ross, Owren, & Zimmermann, 2009). Intriguingly, voicing in laughter appears to be associated both with positive valence (Bachorowski & Owren, 2001) and with judgments of laughter as “fake” (Bryant & Aktipis, 2014). Such findings reveal the limited extent of knowledge regarding the relationships between physical properties of laughs and listeners’ percepts. Although laughter’s links to phylogenetically ancient play vocalizations indicate that some such perceptions should be independent of language, to date, only limited research has been conducted on laughter perception across cultures. Sauter and colleagues identified laughter as the most recognizable emotional vocalization across two disparate cultures (British and Himba) (Sauter, Eisner, Ekman, & Scott, 2010). Bryant et al. (2016) found that listeners across 24 societies could detect friendship status on the basis of brief decontextualized clips of co-laughter. These results reveal high perceptual sensitivity to this ubiquitous and ancient behavior.

Emotional vocal signals in humans are generated from a conserved production system shared by most social mammals (Jurgens, 2002). Humans also produce articulated speech using a largely distinct neural system (Ackermann, Hage, & Ziegler, 2014; Simonyan, 2014). Speech affords the imitation of a variety of sounds, including signals generated by the vocal emotion system such as laughter, crying, and pain shrieks. Nonverbal acted emotional vocalizations are acoustically distinct from their authentic counterparts, and the difference is perceptible (Anikin & Lima, 2017). However, cross-cultural findings are mixed, with some research reporting relatively low accuracy rates in discriminating play-acted vocal emotions from authentic expressions, as well as interactions between culture and emotion categories (Jürgens, Drolet, Pirow, Scheiner, & Fischer, 2013). Vocal emotion expressions are influenced by the vagal system that extends to the recurrent laryngeal nerve (Ludlow, 2013). Thus, arousal in speakers can have direct effects on the vocal apparatus, including increased vocal fold tension, sub-glottal air pressure, and glottal adduction rate, along with possible irregular vibration regimes of vocal fold tissue. Consequently, arousal in laughter is characterized by higher pitch, increased loudness, faster burst rate, and greater non-tonal noise. The evolutionary introduction of volitional forms of expression that emulate genuine emotional signals created an arms race pitting production dynamics against perceptual sensitivity—vocalizers attempt to manipulate listeners by emitting sounds that falsely appear to reveal emotional states, and, in turn, listeners benefit from the ability to discriminate between honest indicators of vocalizers' emotional states and facsimiles thereof. We should therefore expect perceptual systems to strive to track relevant features to enhance the accuracy of social judgments.

We test the above thesis by exploring cross-cultural recognition of dual vocal production pathways in human laughter. Paralleling work on so-called Duchenne smiles (Gervais & Wilson, 2005), many proposed taxonomies of laughter distinguish between genuine and deliberate forms; this maps onto the aforementioned emotion-speech production distinction. Colingual listeners can discriminate between these basic laughter types (Bryant & Aktipis, 2014, Lavan, Scott, & McGettigan, 2016; Lavan, Rankin, Lorking, Scott, & McGettigan, 2017; McGettigan, Walsh, Jessop, Agnew, Sauter, Warren, & Scott, 2013), and neuroimaging work shows these laugh types differentially activate brain regions during both production and perception (Lavan, et al., 2017; McGettigan et al., 2013; Szameitat, Kreifelts, Alter, Szameitat, Sterr, Grodd, & Wildgruber, 2010). Reflecting their respective production systems, spontaneous and volitional laughter have different acoustic features. Spontaneous laughs have higher values on acoustic correlates of physical arousal, such as F_0, and shorter burst duration, but also lower relative loudness, potentially due to the prolonged, regulated energy of volitional laughter produced by the speech system; they also often have fewer voiced elements, including a higher rate of intervoicing intervals (IVIs) (Bryant & Aktipis, 2014, Lavan, Scott, & McGettigan, 2016), which contributes to sound qualities that make them more similar to nonhuman animal vocalizations than volitional laughs (Bryant & Aktipis, 2014). Rate of IVI measures the proportion of the calls across a laugh not associated with voicing (i.e., nontonal), a ratio likely reflecting the extent of differential breath control deployment during production. The percentage of unvoiced components per call is positively associated with colingual listeners' judgments of the laughs being "real" (Bryant & Aktipis, 2014; Wood et al., 2017), as well as with listeners' inability to distinguish slowed versions of spontaneous human laughs from nonhuman animal calls (Bryant & Aktipis, 2014).

Research to date suggests that laughs produced by the two production systems are distinct. Because this reflects the activity of two different species-typical vocalization mechanisms, and selection will have consistently favored the ability to distinguish between the two types of laughter, we expect this distinction to be universally recognizable. The strongest test of this prediction examines listeners varying substantially in degree of linguistic and cultural similarity to the laughers. Because language and other aspects of culture shape many features of verbal performance (Henrich, Heine, & Norenzayan, 2010), if the ability to distinguish between the two types of laughs is evident across a broad spectrum of commonality or difference between producer and receiver, then this capacity for discrimination likely constitutes a biologically evolved, species-typical trait.

We explored whether listeners from around the world (See Figure 1) were able to distinguish between the two laugh types as produced by English speakers. We predicted that participants would reliably identify the laugh types, and, as found in earlier work (Bryant & Aktipis, 2014), that acoustic features associated with spontaneous production (i.e., arousal-linked features such as greater F0 and lower IVI) would predict their judgments.

Figure 1. Map of the 21 study site locations.

Methods

Participants

Based on previous work on listeners' discrimination of laughter types, we predicted a medium effect. An average sample size per study site of 40 participants at a level of $p < .05$ detects an effect size of .25 (Cohen's d) with 88% power (R package pwr, Champely et al., 2017). We recruited 884 participants (500 women; Mean age 26.6; SD = 7.0) from 21 different societies across six regions of the world (for full demographic information, see Supplemental Materials). Participant recruitment varied across study sites, but all were asked to volunteer, and no participants were paid.

Laughter stimuli

The stimulus set, used in a previous study (Bryant & Aktipis, 2014), included 36 laughs. Eighteen spontaneous laughs were taken from 13 natural conversations between pairs of young adult female American English speakers who, at the time of the conversation, were friends; recordings were made in a laboratory setting (16 bit amplitude resolution, 44.1kHz sampling rate, uncompressed wav files, Sony DTC recorder, Sony ECM-77B microphones) (Bryant, 2010). Complementing this set, eighteen volitional laughs, produced in response to the impromptu request “Now laugh” during the course of an unrelated project, were collected from a different set of 18 young adult female American English speakers; these too were recorded in a laboratory setting (16-bit amplitude resolution, 44.1 kHz sampling rate, uncompressed wav files, M-Audio Microtrack recorder). The laughs were duration matched and amplitude normalized. For a full description of the stimulus set, see Bryant and Aktipis (2014).

Procedure

The 36 laughter samples were presented in random order using SuperLab 4.0 experiment software. For those study sites in which a language other than English was used in conducting the experiment (16 out of 21), the instructions were translated beforehand by the respective investigators or by native-speaker translators recruited by them for this purpose. Customized versions of the experiment were then created for each of the study sites using the translated instructions and a run-only version of the software. For those study sites in which literacy was limited or absent, the experimenter read the instructions aloud to each participant in turn. Before each experiment, and after obtaining informed consent, participants were instructed that they would be listening to recordings of women laughing, and that, after each trial, they would be asked to determine whether the laugh was “real” or “fake.” Specifically, participants were told, “In some of the recordings, the women were asked to laugh, but were not given any other reason for laughing (we call these fake laughs). Other recordings are of women laughing naturally while talking to a friend (we call these real laughs).” Participants received one practice trial and then completed the full experiment consisting of 36 trials. The study was approved for all sites by the UCLA Institutional Review Board. For complete text of instructions and questions used in the experiment, see Supplemental Materials.

Results

Judgment task

To evaluate listener accuracy, we used a model comparison approach in which variables were entered into generalized linear mixed models (GLMMs) and effects on model fit were measured using Akaike Information Criterion (AIC). The data were modeled using the glmer procedure of the lme4 package (Bates et al., 2014) in the statistical platform R (R Core Team). The best-fitting model was a GLMM by the Laplace approximation, with fixed effects of laugh condition (spontaneous or volitional) and random effects of participants, laugh trial, and an interaction between societies sampled and laugh condition. Accuracy (% correct) was the dependent measure; see Table 1. Across all participants, the overall rate of correct judgments was 64% (SD = 0.48; Range = 0.56 - 0.69), a performance significantly better than chance (z = 3.50, $p < .001$) and spontaneous and volitional laughs were recognized overall at similar rates (z = 0.872, p = .38). There were no significant sex differences in listeners' judgments. Figure 2 shows the rates of correct judgments for each study site.

The best-fitting model included an interaction between societies sampled and laugh condition, with participants from some study sites showing a tendency to respond "fake" more often than "real" and other participant groups showing the reverse pattern. Signal detection analysis was used to separate sensitivity from response bias in the task. ROC curves for each society were drawn using the pROC package in R (Robin et al., 2011)(See Figure 3). See Table

S6 in the Supplemental Materials for all signal detection values, including area under the curve (AUC) values associated with the ROC figure.

Random effects			**Fixed effects**				
Factor	***Variance***	***STD***	***Factor***	***Estimate***	***SE***	***Z***	***Pr(>|z|)***
Subject	0.03005	0.1733					
Laugh Trial	1.53619	1.2394					
Society × Condition	0.08939	0.2990					
			(Intercept)	0.6252	0.2389	2.617	0.009 *
			Condition	0.1908	0.2188	0.872	0.383

Note: *: $p < .01$

Table 1. Best-fit model of judgment accuracy of spontaneous and volitional laughter.

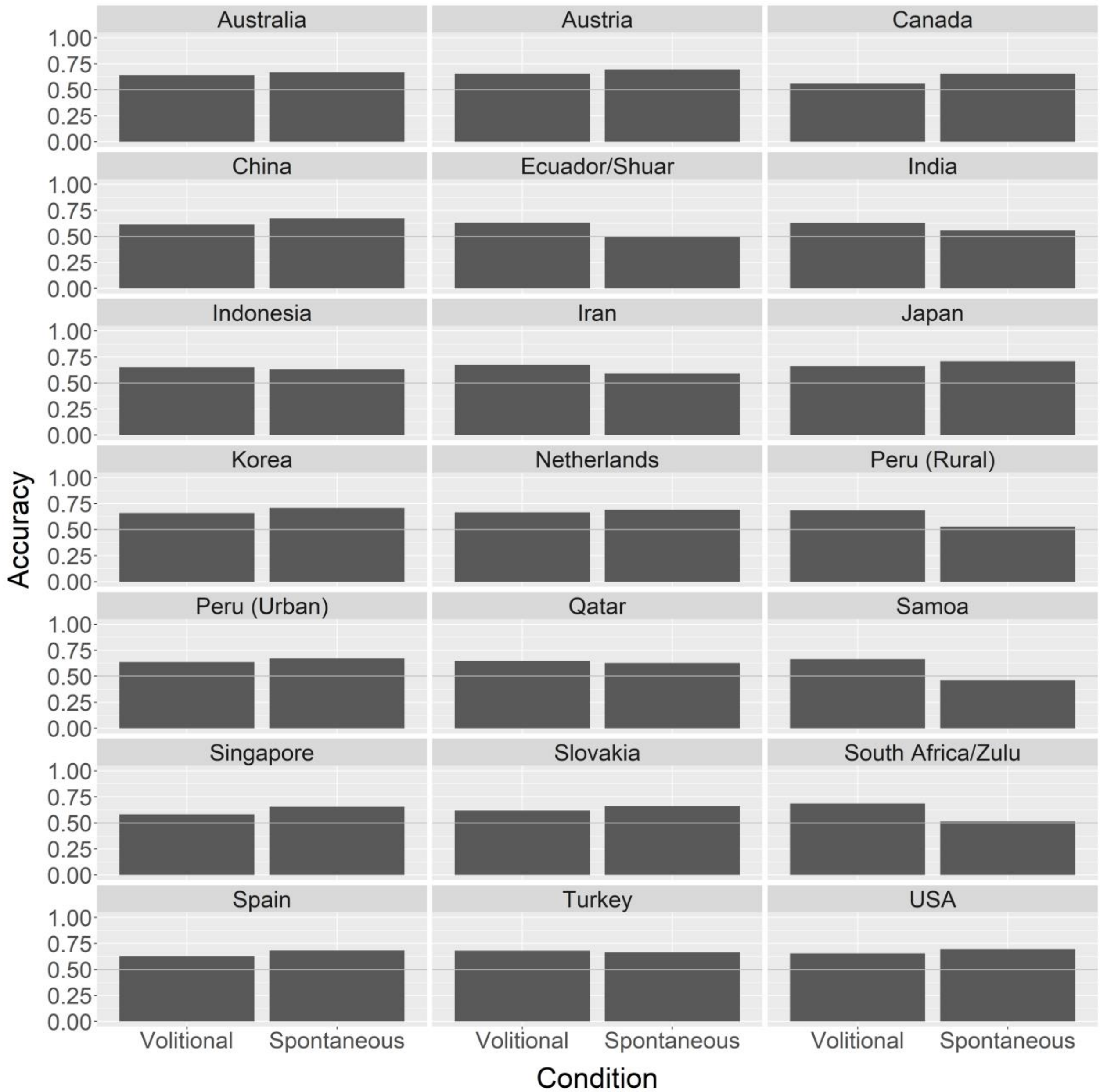

Figure 2. Accuracy (overall proportion of correct judgments) in each study site broken down by laugh condition (volitional and spontaneous). Chance performance represented by 0.50. In every society sampled, overall accuracy, collapsing across categories, was significantly better than chance.

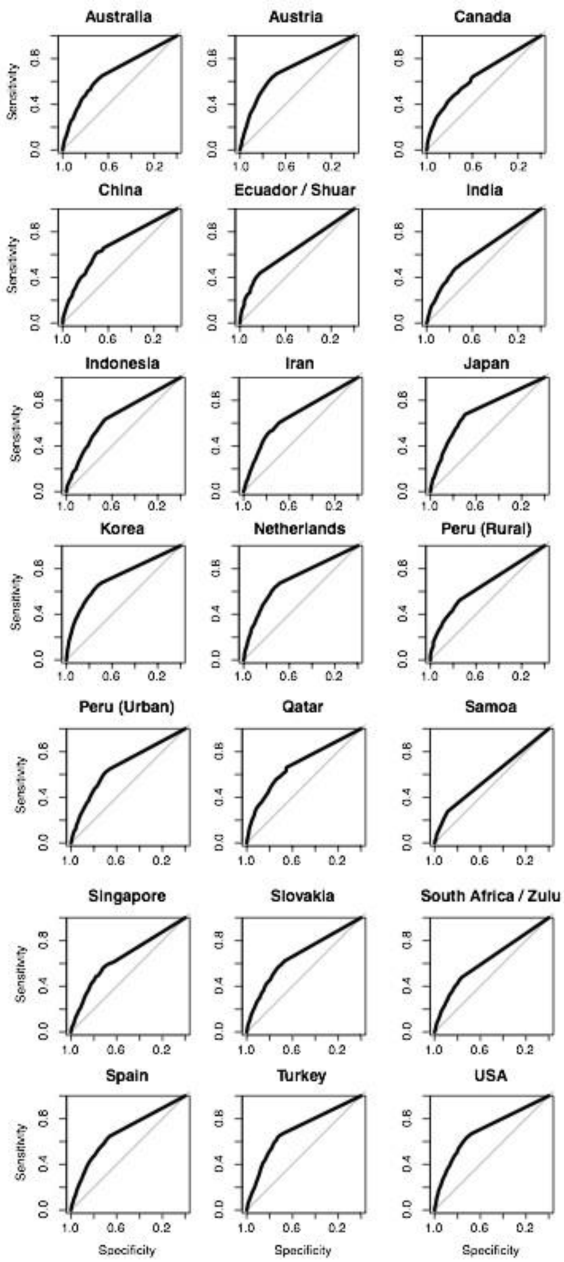

Figure 3. Sensitivity and specificity are measures of how well a binary classification test performs. Sensitivity is the ability of the test to correctly identify those exhibiting a given behavior (i.e., the true positive rate), while specificity is the ability of the test to correctly identify those not exhibiting the given behavior (i.e., the true negative rate). Arbitrarily setting spontaneous laughter as the condition of interest, here we define true positives as correctly identifying spontaneous laughs, and true negatives as correctly identifying volitional laughs. ROC curves represent the trade-off between sensitivity (delineated on the y-axis) and specificity (delineated on the x-axis) as the cut-off point is systematically varied. Thus, the area between the ROC curve and the main diagonal (termed the Area Under the Curve) represents overall performance of the decision making process independent of response bias (that is, independent of bias on the cut-off point). The bigger the area, the better performing the model.

An exploratory analysis of the possible impacts of six estimated demographic variables (English fluency, mass media exposure, mass media exposure in English, education, community size, and economic mode – see Supplemental Materials) on participants' response patterns revealed that societies' economic mode was most associated with a tendency to judge laughs as being "real." Economic mode refers to a rough categorization based on principal economic activities and market integration. For example, the Shuar in Ecuador live in small villages and have minimal dependence on market exchanges, while highly industrialized societies such as the US have maximal dependence on market exchanges. Figure S2 reveals an overall pattern of increased responses of "real" in societies with greater industrialization and more reliance on skilled professionals. For all model comparisons and complete demographic analysis, see Table S7 in Supplemental Materials.

Acoustic Analysis

Acoustic features, including the frequency and temporal dynamics of voiced and unvoiced segments, were automatically extracted from the individual laugh segments, following a procedure analogous to Bryant et al. (2016). The acoustic features were used to statistically reconstruct: i) the distinction between spontaneous and volitional laughs; and ii) the rate at which participants judged each laugh as real (i.e., spontaneous). We used a five-fold cross-validated process wherein a Lasso algorithm (Tibshirani, 1996) first individuated key features (Table S4 in the Supplemental Materials), then these were assessed in multiple logistic (for judgments of "real" versus "fake") and linear (for judgment rate) regressions. Because cross-validation is a stochastic process, we repeated the process 100 times to ensure stability of the results. We report cross-validated performance of the model (adjusted R^2 for linear regression, and ROC curve for logistic regression) including 95% CIs on the repetitions, and standardized beta coefficients for the same models fitted on the full dataset.

The acoustic-based model was able to reliably predict participants' judgments employing coefficient of variation of intensity (standardized β = 0.5, *SE* = .09, $p < .001$), mean pitch (standardized β = 0.41, *SE* = 0.09, $p < .001$), and the mean absolute deviation of harmonics-to-noise ratio (standardized β = -0.46, *SE* = 0.09, $p < .001$). The model could explain 63.9% of the variance (R^2, 95% CIs = 55.5 – 69.8). Figure 3 comparatively displays the cross-validated model predictions (x-axis) against the actual mean judgments reported by participants (y-axis).

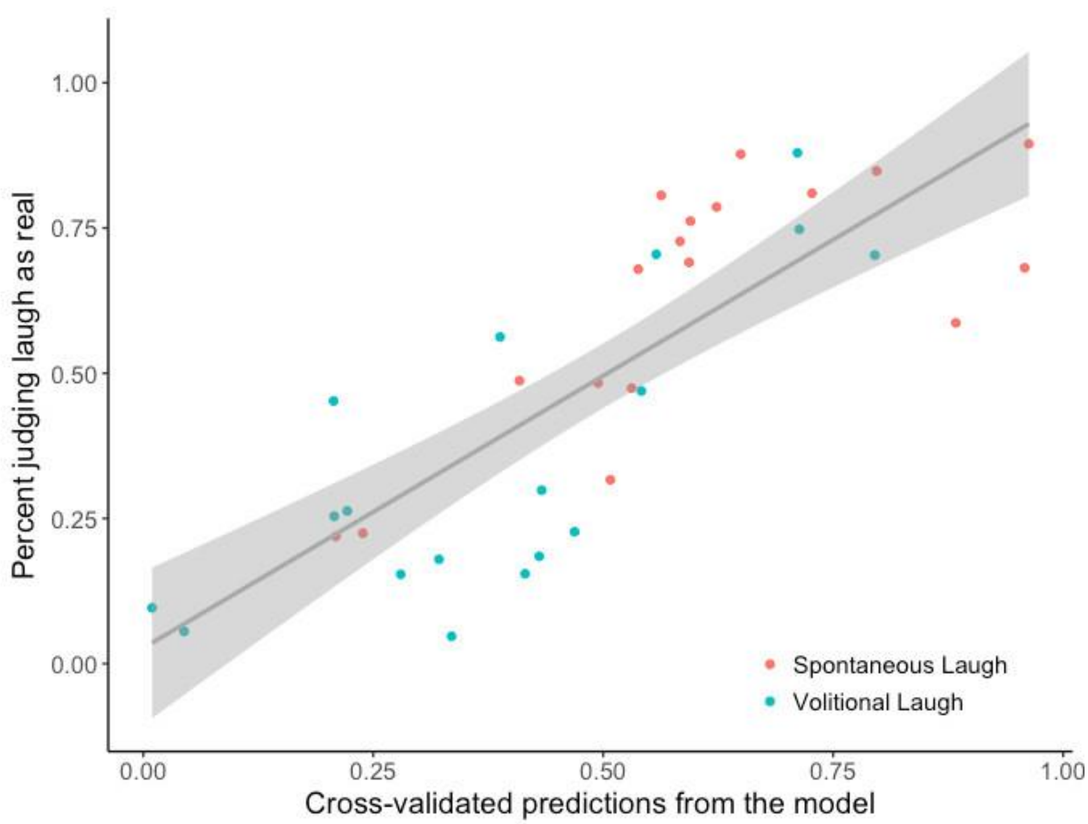

Figure 3. Scatterplot showing the correlation between participants' judgments (collapsed across all societies) of a laugh as being "real" and predicted values using the acoustic features selected by the statistical model.

Independent of participants' judgments, we were also able to reliably discriminate spontaneous from volitional laughs employing rate of intervoicing interval (IVI) (standardized β = 2.14, *SE* = 0.89, *p* = .016), harmonics-to-noise ratio interquartile range (standardized β = -0.97, *SE* = 0.68, *p* = .15), and median (standardized β = -1.14, *SE* = 0.66, *p* = .087). The model has an estimated area under the curve (AUC) of 83.32 % (95% CIs = 69.91 - 89.51), with an accuracy of 76.97% (95% CIs= 63.89 - 86.11), a sensitivity of 79.61% (95% CIs = 66.67 - 88.89), and a specificity of 74.33% (95% CIs = 61.11 - 83.33).

Across societies, laughs that had higher intensity variability, higher pitch, and lower harmonics-to-noise ratio variability were more likely to be judged as real. These features could also accurately discriminate spontaneous and volitional laughs (AUC: 64.79%, 95% CIs: 52.16 – 75; Accuracy: 64.44 %, 95% CIs: 55.56 – 75), although not as accurately as the optimal features identified by our analysis. For complete details of the acoustic analysis, see the Supplemental Materials.

Discussion

Our results show that, around the world, regardless of their culture, native language, or cultural or linguistic similarity to the vocalizers, people reliably distinguished spontaneous and volitional laughter. In every society, participants were above chance in correctly identifying laugh types, and judgments of spontaneity were associated with acoustic features likely tied to arousal in the vocalizers—specifically, greater intensity variability, higher pitch, and increased noisy features. These results are highly consistent with studies to date examining the perception of spontaneous and volitional laughter within cultures—acoustic correlates of arousal have been previously shown to be associated with judgments of laughter genuineness (e.g., Bryant & Aktipis, 2014, Lavan, et al., 2016; Lavan, et al., 2017; McGettigan, et al., 2013; Wood et al., 2017). But we also found some differences across cultures in judgment patterns of spontaneous and volitional forms, with small-scale societies in particular tending to judge tokens overall as more likely to be "fake" (see Supplemental Materials for details and discussion). Other recent work (Jürgens, et al., 2013) also found interesting interactions between encoding conditions (authentic emotional expression versus play-acted expressions) and culture, an issue that deserves more attention.

Our group has shown previously that, in 24 societies, listeners were able to determine whether dyads of native speakers of American English were friends or strangers on the basis of brief clips of co-laughter (Bryant et al., 2016). Consonant with the thesis that, reflecting genuine prosocial emotions, spontaneous laughter constitutes an honest signal of affiliation—one imperfectly emulated in volitional laughter—the acoustic features associated with identifying friends in that study were similar to the features of spontaneous laughs described here, namely features associated with speaker arousal. Taken together, these findings demonstrate that listeners are sensitive to acoustic features indicating emotional arousal in speakers, and suggest an adaptive laughter signaling system that inherently involves the triggering of emotional vocalizations with arousal-linked acoustic properties. Listeners everywhere can discriminate between two broad laughter categories; however, a fuller taxonomy of laughter types is needed. Moreover, it is possible that we inflated the distinctiveness of our general categories by using volitional laughs that did not originate in natural social contexts (i.e., they were produced on command). As Provine (2012) noted, voluntary productions of laughter differ in many ways from spontaneous laughs. Our stimulus set also included only female laughers. Future work should examine the dynamics of cross-sex laugh perception across disparate cultures, as well as potential affective properties of low-pitched, aggressive laughter afforded by male vocalizers.

The social ecology of nonverbal expression within a dual vocal systems framework requires a designation not only of which system produces a vocalization, but, moreover, of how it is deployed in social interaction (see also Wood et al., 2017). A laugh generated by the speech system is not necessarily a selfish manipulation; indeed, as suggested above, in many contexts such laughs indicate cooperative intent. A brief volitional laugh that signals, for instance, a conversational turn or the recognition of some encrypted (i.e., implicit) content is cooperative in both the Gricean/conversational and the biological sense (Flamson & Bryant, 2013). Future work should therefore examine the complexities of how laughter signals interact with language use. Much of what people laugh about in social interaction is tied to what people are saying—variations in the production and interactive timing of laughter can reveal rich information regarding the underlying cognitive processes in conversation. Finally, there is much to learn about how laughing fits into the multimodal contexts of ordinary interpersonal communication. The more closely we examine laughter, the more evident are its intricacies.

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Author Contributions

The first four authors are listed in order of the importance of their contributions. GB designed the hypothesis and methods, conducted the core analyses, and wrote and revised the manuscript. DF envisioned the cross-cultural component, organized the cross-cultural research, and assisted in writing and revising the manuscript. RF conducted the acoustic and signal detection analyses, and contributed corresponding draft text. EC managed the cross-cultural research. All remaining authors contributed data, and are listed in alphabetical order.

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Supplemental Material

Additional supporting material can be found at