Detecting affiliation in colaughter across 24 societies

Laughter is a nonverbal vocal expression that often communicates positive affect and cooperative intent in humans. Temporally coincident laughter occurring within groups is a potentially rich cue of affiliation to overhearers. We examined listeners’ judgments of affiliation based on brief, decontextualized instances of colaughter between either established friends or recently acquainted strangers. In a sample of 966 participants from 24 societies, people reliably distinguished friends from strangers with an accuracy of 53–67%. Acoustic analyses of the individual laughter segments revealed that, across cultures, listeners’ judgments were consistently predicted by voicing dynamics, suggesting perceptual sensitivity to emotionally triggered spontaneous production. Colaughter affords rapid and accurate appraisals of affiliation that transcend cultural and linguistic boundaries, and may constitute a universal means of signaling cooperative relationships.

H umans exhibit extensive cooperation between unrelated individuals, managed behaviorally by a suite of elaborate communication systems. Social coordination relies heavily on language, but nonverbal behaviors also play a crucial role in forming and maintaining cooperative relationships (1). Laughter is a common nonverbal vocalization that universally manifests across a broad range of contexts, and is often associated with prosocial intent and positive emotions (2–5). Laughter is inherently social is evident in the fact that people are up to 30 times more likely to laugh in social contexts than when alone (6). Despite the ubiquity and similarity of laughter across all cultures, its communicative functions remain largely unknown. Colaughter is simultaneous laughter between individuals in social interactions, and occurs with varying frequency as a function of the sex and relationship composition of the group: friends laugh together more than strangers, and groups of female friends tend to laugh more than groups of male friends or mixed-sex groups (7, 8). Colaughter can indicate interest in mating contexts (9), especially if it is synchronized (10), and is a potent stimulus for further laughter (i.e., it is contagious) (11). Researchers have focused on laughter within groups, but colaughter potentially provides rich social information to those outside of the group. Against this backdrop, we examined (i) whether listeners around the world can determine the degree of social closeness and familiarity between pairs of people solely on the basis of very brief decontextualized recordings of colaughter, and (ii) which acoustic features in the laughs might influence such judgments.

Significance

Human cooperation requires reliable communication about social intentions and alliances. Although laughter is a phylogenetically conserved vocalization linked to affiliative behavior in nonhuman primates, its functions in modern humans are not well understood. We show that judges all around the world, hearing only brief instances of colaughter produced by pairs of American English speakers in real conversations, are able to reliably identify friends and strangers. Participants’ judgments of friendship status were linked to acoustic features of laughs known to be associated with spontaneous production and high arousal. These findings strongly suggest that colaughter is universally perceivable as a reliable indicator of relationship quality, and contribute to our understanding of how nonverbal communicative behavior might have facilitated the evolution of cooperation.


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Data deposition: Experimental response data from all study sites and acoustic data from all laugh stimuli are available at https://escholarship.org/uc/item/99lbr9qz.

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features in laughs involving higher proportions of periodic components (i.e., increasingly voiced), and a predominantly egressive airflow. This pattern is different from laugh-like vocalizations of our closest nonhuman relative, *Pan troglodytes*, which incorporate alternating airflow and mostly noisy, aperiodic structure (2, 16). In humans, relatively greater voicing in laughs is judged to be more emotionally positive than unvoiced laughs (18), as is greater variability in pitch and loudness (19). People produce different perceivable laugh types (e.g., spontaneous (or Duchenne) versus volitional (or non-Duchenne)) that correspond to different communicative functions and underlying vocal production systems (3, 20–22), with spontaneous laughter produced by an emotional vocal system shared by many mammals (23, 24). Recent evidence suggests that spontaneous laughter is often associated with relatively greater arousal in production (e.g., increased pitch and loudness) than volitional laughter, and contains relatively more features in common with nonhuman animal vocalizations (20) (Audios S1–S6). These acoustic differences might be important for making social judgments if the presence of spontaneous (i.e., genuine) laughter predicts cooperative social affiliation, but the presence of volitional laughter does not.

All perceptual studies to date have examined individual laughs, but laughter typically occurs in social groups, often with multiple simultaneous laughers. Both because social dynamics can change rapidly and because newcomers will often need to quickly assess the membership and boundaries of coalitions, listeners frequently must make rapid judgments about the affiliative status obtaining within small groups of interacting individuals; laughter may provide an efficient and reliable cue of affiliation. If so, we should expect humans to exhibit perceptual adaptations sensitive to colaughter dynamics between speakers. However, to date no study has examined listeners’ judgments of the degree of affiliation between laughers engaged in spontaneous social interactions.

We conducted a cross-cultural study across 24 societies (Fig. 1) examining listeners’ judgments of colaughter produced by American English-speaking dyads composed either of friends or newly acquainted strangers, with listeners hearing only extremely brief decontextualized recordings of colaughter. This “thin slice” approach is useful because listeners receive no extraneous information that could inform their judgments, and success with such limited information indicates particular sensitivity to the stimulus (25). A broadly cross-cultural sample is important if we are to demonstrate the independence of this perceptual sensitivity from the influences of language and culture (26). Although cultural factors likely shape pragmatic considerations driving human laughter behavior, we expect that many aspects of this phylogenetically ancient behavior will transcend cultural differences between disparate societies.

**Results**

**Judgment Task.** We used a model comparison approach in which variables were entered into generalized linear mixed models and effects on model fit were measured using Akaike Information Criterion (for all model comparisons, see SI Appendix, Tables S1 and S2). This approach allows researchers to assess which combination of variables best fit the pattern of data without comparison with a null model. The data were modeled using the glmer procedure of the lme4 package (27) in the statistical platform R (v3.1.1) (28). Our dependent measures consisted of two questions: one forced-choice item and one rating scale. For question 1 (*Do you think these people laughing were friends or strangers?*) data were modeled using a binomial (logistic) link function, with judgment accuracy (hit rate) as a binary outcome (1 = correct; 0 = incorrect). For question 2 (*How much do you think these people liked each other?*), we used a Gaussian link function with rating response (1–7) as a continuous function.

Across all participants, the overall rate of correct judgments in the forced-choice measure (friends or strangers) was $61\%$ ($SD = 0.49$), a performance significantly better than chance ($z = 40.5$, $P < 0.0001$) (Fig. 2 and SI Appendix, Table S3). The best-fitting model was a generalized linear mixed model by the Laplace approximation, with participant sex as a fixed effect, familiarity and dyad type as interacting fixed effects, participant and study site as random effects, and hit rate (percent correct) as the dependent measure (Table 1). Participants ($VAR = 0.014$; $SD = 0.12$) and study site ($VAR = 0.028$; $SD = 0.17$) accounted for very little variance in accuracy in the forced-choice measure. Familiarity interacted with dyad type, with female friends being recognized at higher rates than male friends ($z = 42.96$, $P < 0.0001$), whereas male strangers were recognized at higher rates than female strangers ($z = -22.57$, $P < 0.0001$). A second significant
interaction indicates that mixed-sex friends were recognized at higher rates than male friends, and mixed-sex strangers were recognized at lower rates than male strangers ($z = 4.42$, $P < 0.001$). For the second question (i.e., “How much do you think these people liked each other?”) the same model structure was the best fit, with a similar pattern of results (SI Appendix, Fig. S1 and Table S4).

Overall, female friends were identified at the highest rate in every society without exception, but there was also a universal tendency to judge female colaughters as friends (SI Appendix, Fig. S2). Forced-choice responses for each colaughter trial were collapsed across societies and compared across dyad types, revealing that a response bias to answer “friends” existed in judgments of female dyads (70%), $F(2, 47) = 7.25, P = 0.002$, but not male (46%) or mixed-sex dyads (49%), which did not differ from one another (LSD test, $P = 0.73$). Additionally, female participants ($M = 0.62; SD = 0.49$) had slightly greater accuracy than male participants ($M = 0.60; SD = 0.49$) overall ($z = 2.31, P < 0.05$).

### Acoustic Analysis

Acoustic features, including the frequency and temporal dynamics of voiced and unvoiced segments, were automatically extracted from the individual laugh segments and used to statistically reconstruct the rate at which participants judged each colaughter segment as a friendship dyad. We used an ElasticNet process (29) to individuate key features to assess in a linear regression to estimate coefficients of the selected features, repeating the process 100 times to ensure stability of the results (Table 2). The resulting model was able to reliably predict participants’ judgments that colaughters were friends, adjusted $R^2 = 0.43$ [confidence interval (CI) 0.42–0.45]. $P = 0.0001$ (Fig. 3).

Across cultures, laughs that had shorter call duration, less regular pitch and intensity cycles, together with less variation in pitch cycle regularity were more likely to be judged to be between friends (for complete details of acoustic analysis, see SI Appendix).

### Discussion

Across all societies, listeners were able to distinguish pairs of colaughters who were friends from those who were strangers that had just met. Biases, presumably reflecting panhuman patterns in the occurrence of laughter in everyday life, existed in all societies sampled as well, such that participants were more likely to assume that female colaughters were friends than strangers. Male strangers were also recognized universally at significantly high rates, and participants worldwide rated the members of these dyads as liking each other the least among all pairs. Dynamic acoustic information in the laughter predicted the accuracy of judgments, strongly suggesting that participants attended closely to these sound features, likely outside of conscious awareness. The judgment pattern was remarkably similar across disparate societies, including those with essentially no familiarity with English, the language of the target individuals whose laughter was evaluated. These results constitute strong preliminary evidence that colaughter provides a reliable cue with which overhearers (and, presumably, colaughters themselves) can assess the degree of affiliation between interactants. Although embedded within discourse, laughter is nonverbal in nature and presents universally interpretable features, presumably reflecting phylogenetic antiquity predating the evolution of language.

Together with auxiliary experiments on the laugh stimuli (SI Appendix), acoustic data strongly suggest that individual laugh characteristics provided much of the information, allowing our participants to accurately differentiate between friends and strangers. Laugh features predicting listeners’ friend responses included shorter call duration, associated with judgments of friendliness (18) and spontaneity (20), as well as greater pitch and loudness irregularities, associated with speaker arousal (30). Acoustic analyses comparing laughs within a given copair did not indicate any contingent dynamic relationship that could plausibly correspond to percepts of entrainment or coordination one might expect from familiar interlocutors. Indeed, our colaughter audio clips may be too short to capture shared temporal dynamics that longer recordings might reveal. A second group of United States listeners evaluated artificial colaughter pairs constructed by shuffling the individual laugh clips within dyad categories (SI Appendix). Consonant with the conclusion that our main result was driven by features of the individual laughs rather than interactions between them, these artificial copairs were judged

### Table 1. Best-fit model for question 1 (Do you think these people laughing were friends or strangers?)

<table>
<thead>
<tr>
<th>Predictor</th>
<th>$\beta$ (SE) fold 1</th>
<th>$\beta$ (SE) fold 2</th>
<th>$\beta$ (SE) fold 3</th>
<th>$\beta$ (SE) fold 4</th>
<th>$\beta$ (SE) fold 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.611 (0.177)</td>
<td>0.578 (0.114)</td>
<td>0.547 (0.114)</td>
<td>0.566 (0.125)</td>
<td>0.594 (0.104)</td>
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<tr>
<td>Jitter mean</td>
<td>1.720 (0.345)</td>
<td>1.652 (0.306)</td>
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<tr>
<td>Jitter SD</td>
<td>−1.826 (0.325)</td>
<td>−1.797 (0.305)</td>
<td>−1.747 (0.302)</td>
<td>−1.697 (0.338)</td>
<td>−1.9 (0.297)</td>
</tr>
<tr>
<td>Fifth percentile shimmer</td>
<td>0.280 (0.199)</td>
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<tr>
<td>Mean call duration</td>
<td>−0.387 (0.075)</td>
<td>−0.358 (0.08)</td>
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<td>−0.412 (0.09)</td>
<td>−0.385 (0.07)</td>
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### Table 2. Sample coefficients from one run of the fivefold cross-validated model for friend ratio across 24 societies

<table>
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<th>$\beta$ (SE) fold 1</th>
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quite similarly to the original copairs in the main study. Finally, a third group of United States listeners rated the individual laughs on the affective dimensions of arousal and valence; these judgments were positively associated with the likelihood that, in its coloughter context, a given laugh was judged in the main study as having occurred in a friendship dyad.

Inclusion in cooperative groups of allied individuals is often a key determinant of social and material success; at the same time, social relationships are dynamic, and can change over short time spans. As a consequence, in our species’ ancestral past, individuals who could accurately assess the current degree of affiliation between others stood to gain substantial fitness benefits. Closely allied individuals often constitute formidable opponents; similarly, such groups may provide substantial benefits to newcomers who are able to gain entry. Many social primates exhibit these political dynamics, along with corresponding cognitive abilities (31); by virtue of the importance of cooperation in human social and economic activities, ours is arguably the political species par excellence. However, even as language and cultural evolution have provided avenues for evolutionarily unprecedented levels of cooperation and political complexity in humans, we continue to use vocal signals of affiliation that apparently predate these innovations. As noted earlier, human laughter likely evolved from labored breathing during play of the sort exhibited by our closest living relatives, a behavior that appears to provide a detectable cue of affiliation among extant nonhuman primates. The capability for speech affords vocal mimicry in humans, and as such, the ability to generate volitional emulations of cues that ordinarily require emotional triggers. In turn, because of the importance of distinguishing cues indicative of deeply motivated affiliation from vocalizations that are not contingent on such motives, producers’ vocal mimicry of laughter will have favored the evolution of listeners’ ability to discriminate between genuine and volitional tokens. However, the emergence of such discriminative ability will not have precluded the utility of the production of volitional tokens, as these could then become normative utterances prescribed in the service of lubricating minimally cooperative interactions; that is, “polite laughter” emerges.

Fig. 3. Acoustic-based model predictions of friend ratio (defined as the overall likelihood of each single laugh being part of a coloughter segment produced between individuals identified by participants as being friends) (on the x axis) with the actual values (on the y axis) (95% CI).

Fig. 4. Six sample waveforms and narrowband FFT spectrograms (35-ms Gaussian analysis window, 44.1-kHz sampling rate, 0- to 5-kHz frequency range, 100- to 600-Hz $F_0$ range) of coloughter from each experimental condition (friends and strangers), and dyad type (male–male, male–female, female–female). For each coloughter recording, the Top and Middle show the waveforms from each of the constituent laughs, and the spectrogram collapses across channels. Blue lines represent $F_0$ contours. The recordings depicted here exemplify stimuli that were accurately identified by participants. Averaging across all 24 societies, the accuracy (hit rate) for the depicted recordings were: female–female friendship, 85%; mixed-sex friendship, 75%; male–male friendship, 78%; female–female strangers, 67%; mixed-sex strangers, 82%; male–male strangers, 73%.
Laughter and speech have thus coevolved into a highly interactive and flexible vocal production ensemble involving strategic manipulation and mindreading among social agents. This finding opens up a host of evolutionary questions concerning laughter. Can affiliative laughter be simulated effectively, or is it an unfaithful signal? Hangers-on might do well to deceptively signal to overhearsers that they are allied with a powerful coalition, whereas others would benefit from detecting such deception. If the signal is indeed honest, what keeps it so? Does the signal derive from the relationship itself (i.e., can unfamiliar individuals allied because of experience signal their affiliation through laughter) or, consonant with the importance of coordination in cooperation, is intimate knowledge of the other party a prerequisite? Paralleling such issues, at the proximate level, numerous questions remain. For example, given universal biases that apparently reflect prior beliefs, future studies should both explore listeners' accuracy in judging the sex of coloughers and examine the sources of such biases. Our finding that colougher constitutes a panhuman cue of affiliation status is thus but the tip of the iceberg when it comes to understanding this ubiquitous yet understudied phenomenon.

Methods
All study protocols were approved by the University of California, Los Angeles Institutional Review Board. At all study sites, informed consent was obtained verbally before participation in the experiment. An informed consent form was signed by all participants providing voice recordings for laughter stimuli.

Stimuli. All colougher segments were extracted from conversation recordings, originally collected for a project unrelated to the current study, made in 2003 at the Fox Tree laboratory at the University of California, Santa Cruz. The recorded conversations were between pairs of American English-speaking undergraduate students who volunteered to participate in exchange for course credit for an introductory class in psychology. Two rounds of recruitment were held. In one, participants were asked to sign up with a friend whom they had known for any amount of time. In the other, participants were asked to sign up as individuals, where after they were paired with a stranger. The participants were instructed to talk about any topic of their choosing; “bad roommate experiences” was given as an example of a possible topic. The average length of the conversations from which the stimuli used in this study was extracted was 13.5 min (mean length ± SD = 809.2 ± 151.3 s). Interlocutors were recorded on separate audio channels using clip-on lapel microphones (Sony ECM-77B) placed ~15 cm from the mouth, and recorded to DAT (16-bit amplitude resolution, 44.1-kHz sampling rate, uncompressed wav files, Sony DTC series recorder). For more description of the conversations, see ref. 32.

Colougher Segments. Forty-eight colougher segments were extracted from 24 conversations (two from each), half from conversations between established friends (mean length of acquaintance = 20.5 mo; range = 4–54 mo; mean age ± SD = 18.6 ± 0.6) and half from conversations between strangers who had just met (mean age ± SD = 19.3 ± 1.8). Colougher was defined as the simultaneous vocal production (intensity onsets within 1 s), in two speakers, of a nonverbal, eggressive, burst series (or single burst), either