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Antiphonal laughter between friends and strangers

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Drawing from an affect-induction model of laughter (Bachorowski & Owren, 2001; Owren & Bachorowski, 2002), we propose that ''antiphonal'' laughter—that is, laughter that occurs during or immediately after a social partner's laugh—is a behavioural manifestation of a conditioned positive emotional response to another individual's laugh acoustics. To test hypotheses concerning the occurrence of antiphonal laughter, participants (n = 148) were tested as part of either same- or mixed-sex friend or stranger dyads, and were audiorecorded while they played brief games intended to facilitate laugh production. An index of antiphonal laughter for each dyad was derived using Yule's Q. Significantly more antiphonal laughter was produced in friend than in stranger dyads, and females in mixed-sex dyads produced more antiphonal laughter than did their male partners. Antiphonal laughter may therefore reflect a mutually positive stance between social partners, and function to reinforce shared positive affective experiences.

Laughter is a highly common form of human vocal production that occurs in a wide variety of social circumstances. Given everyday experiences with laughter, it is not surprising to find that this signal is often theoretically linked to pleasurable states and circumstances. Specific hypotheses in this vein variously consider laughter to be an expression of positive internal emotional states (e.g., Darwin, 1872/1998; van Hooff, 1972), a signal of playful intent (e.g., Glenn, 1991/1992; Grammer & Eibl-Eibesfeldt, 1990), or a response to humour (e.g., Apte, 1985; Deacon, 1989; Weisfield, 1993). In addition to indicating internal

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state, laughter is also considered to induce arousal and affect in listeners (Bachorowski & Owren, 2001). The ensuing hedonic tone is thought to vary as a function of the listener's sex, current affective state, and relationship to the laugher (Owren & Bachorowski, 2002). In the light of evidence that such induction effects do indeed occur (Bachorowski & Owren, 2001), we became interested in examining the temporal pattern of laughter between social partners. We more specifically wanted to determine whether the production of this affect-inducing signal is more closely time-locked between friends than between strangers.

Although we are just beginning to understand the associations among laugh production, laugh perception, and affective experience, we have little reason to doubt that laughter enhances the perceived pleasure of social interactions. Regardless of whether laughs are soft and gentle, like those produced by young infants and their caregivers, or the more boisterous versions often produced among friends, we presume that a key aspect of the pleasure experienced in these interactions is due to the impact of laugh acoustics on listener response systems. A corollary hypothesis is that social interactions are on average less pleasurable when unaccompanied by laughter. We think of pleasure as being a mild to perhaps moderately intense positive affective state. Our use of the term ''affect'' draws from Russell and Feldman Barrett's conceptualisation (1999; see also Watson & Tellegen, 1985), in which affect refers to consciously accessible feeling states that vary in degrees of both pleasure and activation. Our reliance on an ''arousal'' construct is similar to their activation dimension, although we are more specifically referring to the impact of laugh acoustics on auditory response circuitry, including those brainstem nuclei that contribute to overall levels of brain activation (see also Owren & Rendall, 2001).

In thinking about laughter's functional significance, one should bear in mind that laughter is decidedly a social signal, as it is far more likely to be produced in the presence of another individual than when alone. This basic effect has been observed in both naturalistic (Provine & Fischer, 1989) and laboratory settings (Bachorowski, Smoski, & Owren, 2002b; Brown, Dixon, & Hudson, 1982; Young & Frye, 1966). However, little is known about the ways in which social context influences the temporal sequence of laugh production. For example, whereas some investigators have indicated that the laughs produced by two social partners are associated (Grammer & Eibl-Eibesfeldt, 1990; Nwokah, Hsu, Dobrowolska, & Fogel, 1994), there have been few attempts to rigorously quantify such temporal associations. Provine (1992, 2000) likened these associations to a process of ''contagion'' and proposed that contagious laughter occurs due to the activation of a laugh-specific auditory feature detector and subsequent triggering of a ''laugh-generator''. Rather than relying on either the term ''contagion'', which suggests that some behaviour or agent has been unwittingly caught, or ''reciprocal'' (Nwokah et al., 1994), which can imply conscious intent, we prefer the term ''antiphonal''. Used in the animal literature to refer to co-occurring vocal signals (e.g., Biben, 1993; Snowdon & Cleveland, 1984), our application of the term to laughter refers to instances in which the laughter of one social partner co-occurs or is immediately followed by the laughter of another partner.

We conceptualise antiphonal laughter as being part of an affect-induction process that promotes affiliative, cooperative behaviour between social partners (Owren & Bachorowski, 2001, 2002; see also Dimberg & Öhman, 1996; Keltner & Kring, 1998; Owren & Rendall, 1997, 2001). From this perspective, laughter has a two-pronged impact on listener affect. First, the acoustic properties of laughter themselves can have a direct impact on listener arousal and affect. In support of direct-effect hypotheses, recent empirical evidence shows that particular kinds of laughs have acoustic properties that readily elicit positive affect in listeners (Bachorowski & Owren, 2001). The direct effects of laughter may in some ways be comparable to the effects of facial expressions, such as smiling and anger, which have been shown to elicit complementary responses in individuals viewing the expressions—even when perception is nonconscious (Dimberg, Thunberg, & Elmehed, 2000; see also Neumann & Strack, 2000).

The second way that laughter is hypothesised to impact listener response systems is through relatively indirect processes. We propose that antiphonal laughter can be understood as a conditioned positive affective response to the laughs produced by an individual with whom one shares an ongoing positive relationship. Individuals who routinely laugh together in positive circumstances, such as friends, have the opportunity to associate the idiosyncratic acoustic features of a given friend's laugh with a positive emotional state. As there is at least preliminary evidence that laugh acoustics are individually distinctive (Bachorowski, Smoski, & Owren, 2001), it is reasonable to suppose that individuals form conditioned positive affective responses to these acoustic features of a friend's laughter (see also Dimberg & Öhman, 1996).

The present study was designed to test several hypotheses concerning antiphonal laughter. The laughs we analysed were recorded during a game-playing paradigm that involved both affiliative and competitive tasks (Bachorowski, Hudenko, Blomquist, & Tomarken, 2002a). The high rates of laugh production that occurred during two of these tasks afforded us the opportunity to quantify the temporal pattern of laughter between two social partners, and then assess whether that pattern was differentially associated with social context. The dyads we tested were composed of either same- or mixed-sex friends or strangers. Using a quite different paradigm in which laughter was induced with film clips, we found that these two factors—sex and social-partner familiarity—influenced both the rate and acoustic features of laugh production (Bachorowski et al., 2002b). Specifically, individual male laughter was influenced by familiarity with one's social partner, whereas individual female laughter was more reliably associated with the sex of one's social partner.

Hypotheses concerning antiphonal laughter were driven both by these outcomes and the affect-induction framework. We specifically expected that more antiphonal laughter would occur between friends than between strangers. Laugher sex is a second factor that might moderate the occurrence of antiphonal laughter. As measured by self report (Doherty, Orimoto, Singelis, Hatfield, & Hebb, 1995; Eisenberg & Lennon, 1983), behavioural ratings (Doherty et al., 1995), and facial EMG (Dimberg & Lundquist, 1990), females have been shown to be more influenced than males by the emotional expressions of others. Females were therefore expected to produce more antiphonal laughter than males. Finally, we wanted to test whether the interaction between sex and social context found in our earlier study also occurred when antiphonal laughter was the behaviour of interest. The antiphonal laughter of mixed-sex pairs was thus of particular interest.

METHOD

Participants

A total of 204 Vanderbilt University undergraduates were recruited for participation. These individuals were tested as part of either a same- or mixed-sex friend or stranger dyad. Participants primarily came from sections of General Psychology and received research credit towards that course. Those tested as part of a stranger pair were matched with an unfamiliar student by the experimenter, and verification that the two were indeed unfamiliar to each other occurred when they were introduced in the laboratory. Those tested as part of a friend dyad were asked to bring a friend to the testing session. Friends participating at the request of another participant received $10, but had the option of receiving General Psychology credit if they were enrolled in that course.

Data from 42 of the 204 participants were excluded due to equipment problems ($n = 4$), experimenter error ($n = 12$), or because one or both members of the pair was an international student whose native language was not American English ($n = 26$). These last participants were excluded because they may have responded differently to the laugh-inducing stimuli we used than participant dyads in which both parties were native-born American English speakers. An additional exclusion criterion was based on the number of laughs available for analysis, with dyads excluded if either participant produced a total of three or fewer laughs during the two test items of interest. Seven pairs (i.e., 14 participants) failed to meet this criterion. Data from the remaining 148 participants were used in the present analysis, and included the laughs produced by 11 male-male friend, 8 male-male stranger, 12 female-female friend, 13 female-female stranger, 14 mixed-sex friend, and 16 mixed-sex stranger dyads. Participants had a mean age of 18.3 years (SD = 0.94) and primarily identified themselves as White ($n = 128$). The remaining participants identified themselves as Asian ($n =$ 10), Hispanic ($n = 3$), Black ($n = 2$), Middle Eastern ($n = 2$), subcontinent Indian

(n = 1), and of mixed descent (n = 1). One individual declined to provide ethnicity information. Informed consent was obtained prior to testing, and specific consent for the use of laughter data was obtained during debriefing.

Stimuli and apparatus

Instructions for the 17 items that comprised the ‘‘game-playing’’ paradigm were printed separately on laminated cards. Data from the two items that elicited the most laughter across individuals were included in these analyses. The first of these asked the pair to generate as many names as possible for an inflated plastic-doll version of Edvard Munch’s ‘‘The Scream’’, and the second asked the pair to draw pictures of each other’s faces using paper and crayons. Participants were instructed to work on each item for the full duration of a 90-s timer, although some dyads worked a bit longer than the designated interval. Details concerning the recording conditions can be found elsewhere (Bachorowski et al., 2001).

Design and procedure

Testing occurred in a comfortably furnished laboratory room. Participants first completed several personality inventories and were then audiotaped as they viewed and rated their emotional responses to each of three film clips (these data are not relevant here). Participants were then told that the remainder of the study concerned social problem-solving. For this game-like procedure, participants were seated in futon chairs positioned 0.9 m apart and separated by a low footstool; game materials were located in a cart next to the footstool. Participants were instructed to: ‘‘Take turns reading the card instructions out loud to your partner, and follow the cards’ instructions’’. The experimenter then left the room and monitored participants through the headphone output of the digital audiotape recorder. The experimenter did not communicate with participants during the game, and did not re-enter the testing room until the game had ended.

Laugh selection and behavioural coding

Laughter was broadly defined as being any sound that would be considered a laugh if heard under everyday circumstances (Bachorowski et al., 2001, 2002b). Laugh sounds thus included comparatively stereotypical, song-like laughs, as well as noisier grunt- and snort-like laughs. An instance of antiphonal laughter was defined as the production of a laugh by one member of a dyad that began either during or within 1 s following the offset of laugh production by the other member of the dyad. Any 1-s or greater interval in which neither participant laughed was coded as ‘‘No Laughter’’. Three behavioural codes were thus used: Participant 1 Laugh (P1), Participant 2 Laugh (P2), and No Laughter (N). These three categories therefore comprised a mutually exclusive and exhaustive set in which codes could not repeat. Codes were then concatenated into a behavioural sequence for each dyad. For example, a ‘‘P2-P1-P2-N-P1’’ sequence meant that Participant 2 laughed first, Participant 1 began laughing prior to or within 1 s of the offset of Participant 2’s laugh, Participant 2 began a second laugh prior to or within 1 s of the offset of Participant 1’s laugh, neither person laughed for a 1 s or longer interval, and the sequence concluded with a laugh produced by Participant 1. Both the ‘‘P2-P1’’ sequence and the ‘‘P1-P2’’ sequence in this example are instances of antiphonal laughter, with the first reflecting antiphonal laughter on the part of P1, and the second reflecting antiphonal laughter on the part of P2. Coding was performed using ESPS/waves + 5.3 digital signal processing software (Entropics, Washington, DC). Audio waveforms for both participants in a given dyad were viewed time-locked both to each other and to a labelling window. This procedure enabled visual representation of the time-locked vocal utterances to within 10^{-5} s accuracy.

An index of antiphonal laughter was determined for each dyad using sequential analysis techniques implemented in the General Sequencer (GSEQ) for Windows version 3.5.6 (Bakeman & Quera, 1999). Yule’s Q was then used as an index statistic to quantify the sequential association (Bakeman & Gottman, 1997; Bakeman, McArthur, & Quera, 1996; Yoder & Feurer, 2000). Unlike transitional probabilities (i.e., the probability of one partner laughing given the occurrence of the other partner’s laugh), Yule’s Q is not confounded with base rates of behaviour. Yule’s Q meets the assumptions underlying the general linear model, including an approximately normal distribution with a mean of zero (Bakeman et al., 1996). As such, it is appropriate for use in parametric inferential statistics. Possible values of Yule’s Q range from -1.0 to $+1.0$, with a value of 0.0 reflecting no sequential association. In the present application, significant positive Yule’s Q values indicate more antiphonal laughter than expected by chance, whereas significant negative values indicate less antiphonal laughter than expected by chance.

Results

Unless otherwise noted, analyses were conducted at the dyad level. Descriptive statistics for the number of laughs produced are shown in Table 1. For the purpose of comparison with Yule’s Q outcomes, transitional probabilities are also provided. A univariate ANOVA was conducted with sex composition of the dyad (i.e., male-male, female-female, or male-female) and social context (i.e., friend or stranger) as between-subjects factors. The results showed that the number of laughs produced by each dyad did not depend on dyad sex, $F(2, 68) = .838$, n.s. However, the number of laughs did depend on both social context, $F(1, 68) = 6.836$, $p = .01$, and, importantly, its interaction with sex, $F(2, 68) = 3.532$, $p < .05$. Overall, friend dyads produced more laughs than did stranger dyads. *Post-hoc* tests showed that the average amount of laughter produced by

TABLE 1
Number of laughs produced and conditional probabilities of antiphonal laughter

	Dyad sex			
Social context	*Male-Male*	*Female-Female*	*Male-Female*	*Total*
Friends				
Number of laughs	26.91 (14.16)	24.00 (7.37)	30.57 (17.98)	27.35 (14.03)
Transitional probabilities	0.34	0.34	0.35	0.34
Strangers				
Number of laughs	15.00 (4.57)	26.85 (10.88)	18.06 (6.84)	20.49 (9.32)
Transitional probabilities	0.27	0.34	0.25	0.29
Total				
Number of laughs	21.89 (12.49)	25.48 (9.29)	23.90 (14.47)	23.92 (12.33)
Transitional probabilities	0.32	0.33	0.31	0.32

Note: Values for number of laughs are means, with standard deviations in parentheses. Values for transitional probabilities represent the cumulative probability of a laugh given the occurrence of a partner laugh across participants.

stranger pairs involving males (i.e., male-male and male-female stranger pairs) was less than the average amount of laughter produced by all remaining pairs, $t(68) = 3.527$, $p = .001$.

Antiphonal laughter was examined by entering the same factors in a second univariate ANOVA, with the mean Yule's Q of each dyad used as the dependent measure. Although neither the main effect of sex nor its interaction with social context were significant, $F(2, 68) = 2.324$, n.s. and $F(2, 68) = .581$, n.s.,[1] the degree to which antiphonal laughter was produced did vary significantly with social context, $F(1, 68) = 9.171$, $p < .01$. Consistent with our earlier analysis, this social-context effect was due to the more frequent occurrence of antiphonal laughter in friend dyads than in stranger dyads (see Figure 1).

As the results of previous work (Bachorowski et al., 2001b; Grammer & Eibl-Eibesfeldt, 1990; Provine, 1993) showed that sex-based differences in laugh production occurred within mixed-sex dyads, analyses at the individual level within mixed-sex dyads were conducted. Here, rather than the dyad mean, the Yule's Q for each participant was used as the antiphonal index. Specifically, the antiphonal index for each female reflected the degree to which she laughed within 1 s of her male partner, whereas the antiphonal index for each male reflected the degree to which he laughed within 1 s of his female partner. So that

[1] There was a significant correlation between the total number of laughs produced and the antiphonal index, $r = .48$, $p < .001$. However, an ANCOVA using the total number of laughs by each individual as a covariate led to equivalent statistical outcomes.

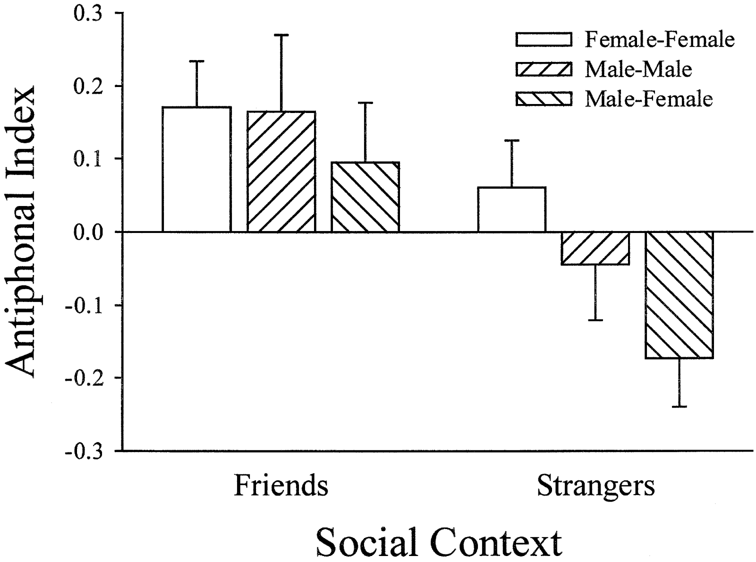

Figure 1. Mean Yule's Q and associated standard errors for all dyads as a function of sex and social context.

consideration was given to the variance shared between dyad members, a repeated-measures ANOVA was performed in which social context was the between-subjects factor, the sex of each dyad member served as a within-subjects factor, and the antiphonal index of each dyad member was the repeated-measures variable. The results of this test showed significant main effects of both sex, $F(1, 28) = 9.009$, $p < .01$, and social context, $F(1, 28) = 6.541$, $p < .05$. However, the interaction between sex and social context was not significant, $F(1, 28) = .043$, n.s. As can be seen in Figure 2, these outcomes indicate that in mixed-sex dyads, females were more likely to laugh antiphonally than were males, and friends produced more antiphonal laughter than did strangers.

DISCUSSION

The goal of this study was to test hypotheses concerning antiphonal laughter between two social partners. Both the total number of laughs produced and amount of antiphonal laughter were of interest. With respect to the latter, individuals tested with a friend were more likely than those tested with a stranger to laugh during or immediately following his or her partner's laugh. In addition, and despite the absence of overall sex differences in the occurrence of antiphonal laughter, females tested as part of a mixed-sex dyad were found to produce more antiphonal laughter than their male testing partners. Although the pattern of results was not fully identical to our previous work, important aspects

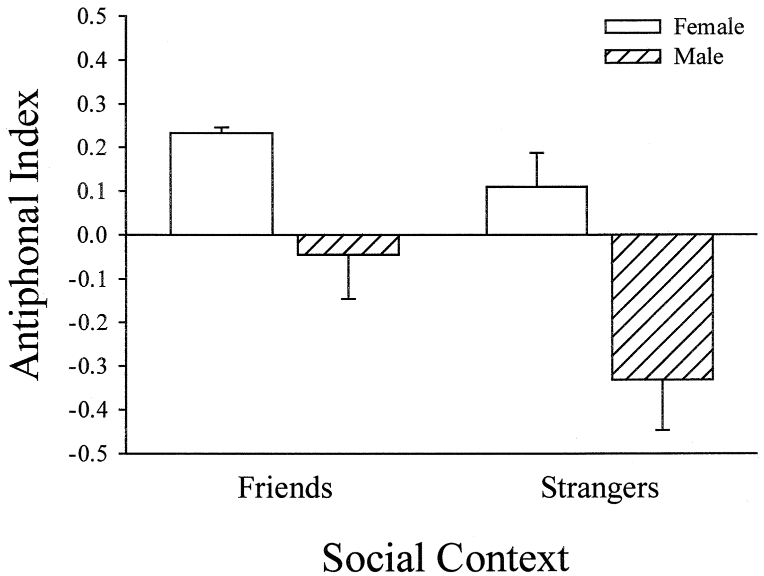

Figure 2. Mean Yule's Q and associated standard errors for mixed-sex pairs as a function of social context.

of the results were the same and again show that both the familiarity and sex of a social partner play a significant role in laugh production.

As noted earlier, an affect-induction framework shaped our thinking about antiphonal laughter. In particular, we hypothesise that repeated associations between individually distinctive laugh acoustics and shared, positive experiences promote the occurrence of antiphonal laughter. More broadly, we think that laughter generally signals willingness to engage in cooperative behaviour (Owren & Bachorowski, 2001) and that antiphonal laughter, in particular, may support or reinforce mutually pleasurable affective experiences. In contrast, the absence of such interaction histories should make it less likely that antiphonal responding would occur between strangers. In line with this reasoning, dyads composed of friends produced significantly more antiphonal laughter than those composed of strangers. These outcomes are consistent with the notion that conditioned positive emotional responses moderate the occurrence of antiphonal laughter between friends. Corollary support for this reasoning comes from the absence of or even inhibition of antiphonal laughter between strangers. It will be important in further work to specifically assess the associations between ongoing affective state and the use of antiphonal laughter.

Relative to their male partners, the high rate of female antiphonal laugh production in mixed-sex dyads is noteworthy. Contrary to our predictions, this pattern cannot be attributed to a general tendency on the part of females to produce more antiphonal laughter than males. However, it may be that females are specifically attuned to positive affective expressions by males. Others have noted that males are sociobiologically predisposed to be interested in females (Daly & Wilson, 1983; Geary, 1998), and producing affect-inducing sounds may thus help individual females to sway a male's affective stance towards her—independent of any actual interest she may have (Owren & Bachorowski, 2002). Although this kind of strategic behaviour may be entirely nonconscious, females have reported using related behaviours, such as flirting and playing on physical attractiveness and sexuality, to influence males (e.g., Dunn & Cowan, 1993; Johnson, 1976; Singer, 1964). In contrast to males' predilection to be interested in females, females may be more inclined to be wary or vigilant of males, especially male strangers. For individual male strangers, then, producing an acoustic signal that induces arousal in his female partner may serve to accentuate any negatively toned predispositions on her part. It may therefore be in a male's best interest to inhibit antiphonal responding when in the company of a female stranger (see also Owren & Bachorowski, 2002).

Although there have been few attempts to quantify antiphonal laughter, the present results can be reasonably compared to two earlier reports. In the first of these, Grammer and Eibl-Eibesfeldt (1990) had dyads wait for a 10 min interval while an experimenter returned a purported telephone call. These investigators subsequently examined the associations between several laugh-related measures and reported interest in one's social partner. Of particular relevance to the present study is the finding that co-occurring laughter was linked to individual's self-reported interest in going to the movies with their social partner. Thus, the degree of desire for further affiliation was statistically related to the amount of antiphonal laughter produced. The present findings extend this outcome by showing that the degree of actual affiliation (i.e., friend vs. stranger) is associated with antiphonal laughter. However, as the total number of laughs that dyads produced together was apparently used as the dependent measure in Grammer and Eibl-Eibesfeldt's study, overall laugh base rates were probably confounded with their index of co-occurring laughter. Using a much different paradigm, Nwokah and colleagues (1994) also found evidence of antiphonal laughter (''co-active'' in their terminology). In this study, mother and infant laughter was shown to become increasingly co-active over the course of the infant's first year of life. These results therefore indicate that antiphonal laughter occurs quite early in development, and suggest that its occurrence may be one marker of attachment.

With regard to total laugh production, we found that friends produced more laughter than did strangers, and that stranger pairs that include males (i.e., male-male and male-female stranger pairs) produced significantly less laughter than all other dyad compositions. As in our previous work, but in contrast to conclusions drawn by others (Adams & Kirkevold, 1978; Provine, 1993[2]), we found no overall evidence that females laugh more than males. Instead, the number of laughs produced by individuals of both sexes appears to be driven by the social context in which signal production occurs. Dyads in which males were paired with a stranger of either sex produced fewer laughs than the remaining pairs. These outcomes mirror findings from our previous study (Bachorowski et al., 2001b), in which males produced the least laughter with strangers of either sex. As males have been found to be more competitive than females in same-sex pairings (e.g., Aries, 1998; Keltner, Young, Heerey, Oemig, & Monarch, 1998; Maccoby, 1990; Miller, 1985; Sharkey, 1993), and are more likely to break cooperative coalitions (e.g., Bond & Vinacke, 1961; Garza & Borchert, 1990), they may be less likely to produce emotional cues—such as laughter—that encourage cooperation when paired with someone unknown to them. However, once cooperation has been established, the use of these cues may encourage the maintenance of the affiliative relationship.

Two statistical issues constrain our interpretations. First, not all dyads met the minimum number of behaviours recommended for calculation of Yule's Q (Bakeman & Gottman, 1997). As a potential consequence of insufficient codes is typically Type II error (Yoder & Feurer, 2000), the null findings of the present study should be interpreted with caution. Second, it is possible that excluding dyads based on insufficient laugh production biased the obtained outcomes. This seems unlikely, however, given that re-inclusion of the dyads in question did not change total-laugh outcomes. Ongoing work in our lab is explicitly addressing some of the theoretical and methodological shortcomings of the present study, such as the lack of self-reported affect and detailed information concerning the nature of the relationship between friend pairs. More broadly, further empirical work in this area will necessarily involve more exacting tests of conditioning-based explanations.

Experimental investigations of antiphonal laughter help clarify the ''hows'' and ''whys'' of laughter. In a general sense, we consider laughter to be both an index of positive affect and a signal that can induce affective states in social partners (see also Hess & Kirouac, 2000; Johnstone & Scherer, 2000). In this particular study, we show that antiphonal laughter is differentially associated with both sex and social context. These findings indicate that listener responsiveness to laughter is not solely attributable to signal acoustics, in which laughter is one behavioural outcome of comparatively direct links between signal perception and production systems. Instead, the occurrence of laughter in

[2] Although Provine (1993) concluded that females on average produce more laughter than males, he also noted that the amount of laughter produced by individuals of either sex is associated with both the sex composition of social groups and social role (i.e., speaker or audience) of the laughter.

general—and antiphonal laughter in particular—appears to be associated with a history of pleasurable interactions between social partners.

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