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Prosodic Contrasts in Ironic Speech

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Prosodic features in spontaneous speech help disambiguate implied meaning not explicit in linguistic surface structure, but little research has examined how these signals manifest themselves in real conversations. Spontaneously produced verbal irony utterances generated between familiar speakers in conversational dyads were acoustically analyzed for prosodic contrasts. A prosodic contrast was defined as a statistically reliable shift between adjacent phrasal units in at least 1 of 5 acoustic dimensions (mean fundamental frequency, fundamental frequency variability, mean amplitude, amplitude variability, and mean syllable duration). Overall, speakers contrasted prosodic features in ironic utterances with utterances immediately preceding them at a higher rate than between adjacent nonironic utterance pairs from the same interactions. Across multiple speakers, ironic utterances were spoken significantly slower than preceding speech, but no other acoustic dimensions changed consistently. This is the first acoustic analysis examining relative prosodic changes in spontaneous ironic speech. Prosodic contrasts are argued to be an important mechanism for communicating implicit emotional and intentional information in speech—and a means to understanding traditional notions of an ironic tone.

In natural conversation, people use a diverse range of communicative strategies to convey their meanings. Much of what people aim to communicate is not explicitly stated, and listeners must infer intentional meanings based on linguistic and paralinguistic evidence. However, the way interlocutors accomplish this is not well-understood—particularly how nonverbal features, such as prosody (i.e., rhythmic and tonal patterning in speech), interact with language. One relevant

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area of research is the study of vocal correlates of verbal irony. Specifically, researchers have examined acoustic properties of utterances where speakers imply meanings that are in particular opposition to sentence surface propositions. Many of these researchers have assumed the existence of an ironic tone of voice. Here, I demonstrate that although spontaneous speakers do in fact rely on prosodic signals particularly when producing ironic speech, it is not in a consistent manner across most instances of verbal irony.

Production and perception research on verbal irony has almost exclusively relied on actors. For example, in studies examining children's recognition of ironic intentions, researchers often use experimental conditions incorporating scripted speech stimuli produced with a purposeful ironic tone generally consisting of prolonged articulation, lowered pitch, and increased pitch variability (e.g., Ackerman, 1983; Capelli, Nakagawa, & Madden, 1990; de Groot, Kaplan, Rosenblatt, Dews, & Winner, 1995; Milosky & Ford, 1997). Clinical neuropsychological research also uses ironic speech stimuli with manipulations of intonation that are deemed to be more "sarcastic" (e.g., Channon, Pellijeff, & Rule, 2005; Channon et al., 2007; Dennis, Purvis, Wilkinson, Barnes, & Winner, 2001; Shamay-Tsoory, Tomer, & Aharon-Peretz, 2005; Wang, Lee, Sigman, & Dapretto, 2006). One distinct possibility is that these studies tap into people's stereotyped notions of what sarcasm sounds like, and actors subsequently produce internally valid, but exaggerated, tokens not resembling most occurrences in spontaneous interaction. Research has shown that spontaneous speakers do not produce verbal irony in such a systematic fashion (Attardo, Eisterhold, Hay, & Poggi, 2003; Bryant & Fox Tree, 2002, 2005; Nakassis & Snedeker, 2002). Perceptually, only the most dripping examples of spontaneous ironic speech can be recognized independent of the words. In these cases, listeners also rate the ironic tokens higher on other affective and intention dimensions (Bryant & Fox Tree, 2005). Because of the inextricable relations between intentions and emotional tones of voice, prosodic signals of irony will be necessarily confused with affective prosody embedded in the ironic utterances.

Gibbs (2000) suggested that many related, non-mutually exclusive tropes should be included in the category of verbal irony, including jocularity (playful ironic teasing), rhetorical questions (ostensive questions implying an assertion), hyperbole (heavy exaggeration), understatement (heavy downplaying or minimization), and sarcasm (ironic criticism). Although all of these subtypes are ironic, this carves the category of verbal irony according to different combinations of affect and intentions. Based on inherent form–function relations between sound and intention in animal signals (Cosmides, 1983; Morton, 1977), we should expect prosodic signals best suited for different types of ironic communication to predictably vary. For example, sarcasm is associated with harsh, negative valence and aggression, whereas jocularity is playful, humorous, and amicable. These types of utterances should be produced differently as part of

speakers' efforts to communicate effectively. Overall, the significant variation in affect and intentions in ironic language use should drive variable prosodic forms. This form–function approach does predict some consistency between particular combinations of affect and intentions and vocal signals, so different people using sarcasm (as a particular subtype of verbal irony) might produce such utterances in a similar manner. However, many researchers (e.g., Ackerman, 1983; Anolli, Ciceri, & Infantino, 2000; Channon et al., 2005; Rockwell, 2000) have extended this specific relation between intonation and sarcasm to the entire category of verbal irony, and the use of actors likely exacerbates this stereotyped assumption.

When using verbal irony, speakers are simultaneously communicating propositional information, an attitude toward the propositions, and their own disassociation from that attitude (Sperber & Wilson, 1986/1995). Vocal signals produced to guide listeners' understanding should function not only on surface linguistic features (e.g., local prosody for focus and accent), but also on multiple levels of attitudinal information conveyed by the utterance (e.g., global prosody for affective information *and* to signal an ironic intention). For example, an ironic display of anger might cause a speaker to superimpose an angry prosodic contour (e.g., high volume, ascending pitch, and fast speech rate; Murray & Arnott, 1993; Sobin & Alpert, 1999) on top of a positive expression (e.g., "That's just great!"), thus communicating an attitude (e.g., jocularity) toward an attributed emotion (anger) about a literal proposition (referent X is not great). This would be produced differently, for instance, than an ironic display of puzzlement in which a speaker might superimpose an exaggerated interrogative prosodic contour (Pell, 2001) on top of a rhetorical question. Thus, there are form–function relations between prosody and different types of ironic speech, for the same reason there are relations between emotion categories and their associated physical expressions (Bryant & Barrett, 2008; Cosmides, 1983; Ekman, Levenson, & Friesen, 1983). By describing speakers' nested intentional expressions in relation to emotion, researchers can make relatively specific predictions about how prosody will manifest itself in ironic speech.

Previous research has shown that vocal signals can inform listeners specifically about speakers' ironic intent. Bryant and Fox Tree (2002) found that listeners could correctly distinguish spontaneously produced ironic from nonironic utterances when auditorily presented in isolation, but contextual information also had a significant impact on their judgments. When the utterances were content-filtered to remove the lexical information but not the global prosody, they could no longer distinguish the utterance types (Bryant & Fox Tree, 2005). We concluded that, in those materials, listeners likely relied on local (i.e., linguistic) prosodic information that must interact with lexical items to be useful (e.g., pitch accents on key words). Using a different set of prosodically marked, spontaneous, ironic utterances, Bryant and Fox Tree (2005) performed acoustic analyses comparing these to nonironic utterances and found very little

evidence of prosodic consistency. The utterances were then content-filtered and presented to listeners in isolation, and rating data showed that many linguistic and affective dimensions played a role in verbal irony recognition. These results demonstrated that verbal irony involves many vocal features that overlap with multiple communicative behaviors. Taken together, these studies suggest that prosodic information is important in spontaneous ironic speech, and that both linguistic and affective prosody matters.

Rather than examining particular utterances in isolation from their contexts, an improved approach is to explore how speakers attempt to maximize relevance for their listeners by drawing attention to specific utterances (or constituents of utterances) through prosodic contrasts. A *prosodic contrast* is an acoustic change in the speech signal between adjacent phrasal units involving at least one prosodic dimension (e.g., pitch, amplitude, or duration; Bryant, 2004). This is not a disambiguation strategy special to verbal irony; but, instead, a more general principle of prosodic signaling that helps speakers communicate a wide array of affect and intentions. In this study, a prosodic contrast was operationalized as a statistically reliable change in any of five global acoustic dimensions between a target utterance and the speech immediately preceding it. The incredible variety of affect and intentions people express through ironic language should result in minimal consistency across instances—that is, we should not see systematic prosodic patterning across varying types of ironic speech (i.e., no ironic tone of voice); but, instead, see varied (i.e., bidirectional) changes in contrasting acoustic signals.

METHOD

Conversation Recordings

All spontaneous speech utterances analyzed in this study were taken from a corpus of conversations recorded at the University of California, Santa Cruz in the Fox Tree Research Laboratory between January 2002 and January 2003.

Recording procedure. Conversations were digitally recorded (16 bit, 44.1 kHz) to digital audiotape with clip-on unidirectional microphones (Sony ECM-77B) and then digitally transferred to a computer. Microphone levels were equalized before each conversation. Participants were seated in a room approximately 1.5 m apart and instructed how to place the microphones on their clothing. A research assistant verified that the microphones were approximately 15 cm to 20 cm from their mouths ($\pm$1.5 cm). Participants were instructed to start talking about "bad roommate experiences," but were told they could let the conversation go in any direction they desired. All conversations were recorded for approximately 15 min.

Verbal irony utterances were drawn from 11 conversations between familiar speakers (with all gender combinations). Familiar speakers were used for two reasons: (a) Preliminary observations strongly suggested that occurrences of verbal irony are considerably more frequent between familiar speakers, and previous research suggests this as well (e.g., Gibbs, 2000); and (b) incorporating non-familiar speakers would require additional analyses and recordings that are outside the scope of this project. Future analyses should include non-familiar conversational data.

Utterance Identification and Extraction

Twenty-five utterances of ironic speech were identified and extracted from the 11 conversations, and these ironic targets were paired with extracted baseline speech immediately preceding them. As a control, speech immediately preceding the baseline utterances (called *pre-baseline*) were also identified and extracted. These utterances were compared to the baseline utterances to estimate the frequency of prosodic contrasts in nonironic speech (see the Appendix for all conversational interactions). The initial determination of what constituted verbal irony was made by the author, and was confirmed by two experts on language use in conversation (J. Fox Tree & R. Gibbs). Types of verbal irony included understatement, rhetorical questions, sarcasm, hyperbole, and jocularity. The overall frequency of verbal irony in these conversations was lower than that found in other studies examining verbal irony in natural discourse (e.g., Eisterhold, Attardo, & Boxer, 2006; Gibbs, 2000), possibly due to the forced recording context. After this initial screening, an utterance had to satisfy two additional criteria: (a) The ironic content had to be obvious from the conversational context as judged informally by at least three semi-naive listeners (psychology graduate students with a basic understanding of indirect speech), and (b) the ironic targets and preceding utterances had to be relatively free from overlapping speech. Speakers were recorded on separate channels, allowing for the analysis of overlapping speech; however, occasional and severe instances of bleed-through (e.g., loud laughter) occurred.

Several identified targets were ambiguous in meaning enough to warrant exclusion, and two ironic exchanges (i.e., ironic targets with subsequent ironic responses) were excluded due to conflicts with the methodological approach (e.g., no baseline speech within 10 s). Ironic targets that were ultimately selected represented approximately 75% of all occurrences of verbal irony (including ambiguous cases) in the 11 conversations. Verbal irony occurred in some conversations more than others, and this is reflected in the overrepresentation of some conversations in the analyses. Rather than decide on additional criteria to eliminate tokens of verbal irony, all acceptable tokens were included.

The distances between ironic targets and baseline utterances varied across interactions ($M = 2.08$ s, $SD = 1.49$ s) and were similar to distances between pre-baseline and baseline utterances ($M = 1.13$ s, $SD = 2.02$ s), $t(24) = 1.75$, $p = ns$. Casual observation suggests that prosodic contrasts can be perceptually noticeable even when relatively distant from any preceding speech (e.g., >10 s); but, for this study, utterances were only compared when they were in reasonably close proximity (~2 s), with no irony targets over 5 s after baseline utterances, and no pre-baseline utterances over 8 s prior to baseline utterances. Paired baseline utterances were approximately matched with ironic targets for overall length, but phrasal units were left intact. Baseline utterances were always the last spoken words before the target utterances (i.e., no non-speech sounds or laughter), and pre-baseline utterances were always directly prior to baseline utterances, with one exception (see Conversation 9.2). All speech samples were isolated and prepared for analysis using Cool Edit Pro (Syntrillium Software, Scottsdale, AZ).

Acoustic Analyses

All 75 utterances (25 pre-baseline, 25 baseline, and 25 ironic targets) were re-sampled to 11.025 kHz to diminish aliasing (i.e., reduce unpredictable artifacts potentially introduced in the samples due to high-frequency components). Overall mean fundamental frequency (F0) and F0 standard deviation (F0 SD) (i.e., average pitch and pitch variability); overall mean amplitude measured in decibels (dB) and decibel standard deviation (dB SD) (i.e., average loudness and loudness variability); and speech rate measured by mean syllable duration (MSD). MSD was manually calculated by dividing the total time of all present acoustic energy corresponding to an utterance (identified through waveform and spectrograph displays) by the number of actual spoken syllables (as opposed to underlying syllable structure). Changes >30 ms were considered significant. Quene (2007) estimated the just noticeable difference in speech tempo to be 5%. In this study, across the speakers, 30 ms approximated an average change of ~15%, which is well above perceptual thresholds. Informal tests with these recordings suggested that changes across phrasal units of 30 ms to 40 ms in tempo were perceptible by most listeners. F0 and amplitude analyses were performed using Multi-Speech, the Windows-based version of Computerized Speech Lab (Kay Elemetrics Corp., Pine Brook, NJ). F0 was determined using an autocorrelation method. Octave errors and other extreme F0 calculation errors were manually corrected and accounted for less than 1% of all measurements.

Once all measurements were obtained, within-speaker comparisons between baseline and target utterances and between pre-baseline and baseline utterances were performed using *t* tests (separate utterances within speakers representing independent groups) with Bonferroni-corrected probability values (.05/25 tests =

.002). A between-speaker analysis was also performed using a multivariate analysis of variance (MANOVA), with utterance condition (i.e., pre-baseline, baseline, and ironic target) as the independent variable and the five acoustic dimensions as dependent variables. Any systematic prosodic production in conjunction with verbal irony should be revealed by measuring these global dimensions.

RESULTS

Table 1 displays the F0 and dB means and standard deviations, as well as MSD values for all utterances. Figure 1 shows the percentage of significant contrasts across the five dimensions between baseline and ironic target utterance pairs, and pre-baseline and baseline pairs. For pitch and loudness contrasts, significant changes were at or above known perceptual thresholds (Moore, 2008; Stevens, 1998).

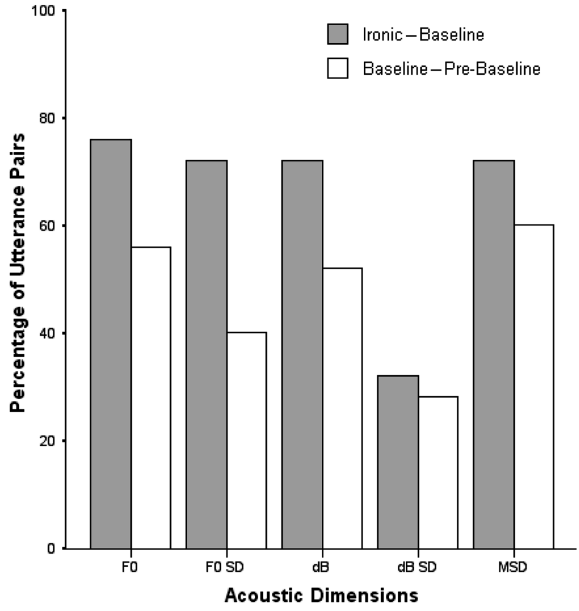

FIGURE 1 Percentage of utterance pairs with significant contrasts across five acoustic dimensions: ironic targets versus baseline and baseline versus pre-baseline. *Note.* F0 = fundamental frequency (pitch); F0 SD = fundamental frequency standard deviation (pitch variability); dB = decibels (amplitude); dB SD = decibel standard deviation (amplitude variability); MSD = mean syllable duration (speech rate).

TABLE 1
Means for Acoustic Measurements of Pre-Baseline, Baseline, and Ironic Target Utterances

Utterance Sets	*Type*	*F0*	*F0 SD*	*dB*	*dB SD*	*MSD*
Conversation 1.1	Pre-base	170	22.2	50.5	4.4	178
	Baseline	151*	7.3*	44.5*	4.2	205
	Ironic	159*	26.6*	43.7	4.6	187
Conversation 1.2	Pre-base	153	13.5	46.0	5.5	158
	Baseline	192*	29.3*	47.0	4.1	204+
	Ironic	178*	30.0	46.1	6.7*	235+
Conversation 2.1	Pre-base	233	27.4	47.2	4.7	212
	Baseline	225	21.9	48.7	7.2*	124+
	Ironic	232	32.7*	51.2*	5.2*	226+
Conversation 2.2	Pre-base	223	30.6	46.6	7.7	175
	Baseline	225	24.9	50.7*	4.7*	147
	Ironic	217	38.7*	47.7*	4.5	173
Conversation 2.3	Pre-base	235	48.6	51.4	7.0	174
	Baseline	231	31.0*	46.4*	6.7	149
	Ironic	171*	23.0*	57.4*	5.4	191+
Conversation 2.4	Pre-base	205	46.0	52.3	4.5	134
	Baseline	245*	43.0	44.2*	8.0*	171+
	Ironic	203*	40.9	43.0	9.1	222+
Conversation 2.5	Pre-base	204	30.1	49.6	4.0	254
	Baseline	208	28.6	44.2*	8.0*	155+
	Ironic	239*	35.9*	51.7*	5.8*	134
Conversation 2.6	Pre-base	213	17.2	49.2	8.3	169
	Baseline	217	27.8*	51.3	6.9	208+
	Ironic	225	30.9	47.1*	6.7	196
Conversation 2.7	Pre-base	217	30.6	46.9	7.5	152
	Baseline	203*	27.1	49.1	7.4	207+
	Ironic	222*	39.7*	56.1*	7.5	361+
Conversation 3	Pre-base	226	32.9	46.8	9.7	186
	Baseline	221	37.5	45.2	10.1	175
	Ironic	206*	23.4*	48.0*	5.6*	174
Conversation 4.1	Pre-base	195	30.6	44.2	5.3	144
	Baseline	214*	27.6	50.6*	7.7	364+
	Ironic	237*	43.0*	62.7*	7.1	293+
Conversation 4.2	Pre-base	240	29.0	48.8	7.9	207
	Baseline	222*	29.5	57.4*	7.2	220
	Ironic	205*	28.9	55.7	8.2	282+
Conversation 5	Pre-base	92	9.2	57.0	7.6	194
	Baseline	92	10.4	54.7	4.5*	186
	Ironic	88	4.5	50.0*	6.2	155+
Conversation 6	Pre-base	196	14.0	49.7	6.2	157
	Baseline	193	25.8*	36.5*	6.8	238+
	Ironic	197	18.2*	39.6*	7.0	275+
Conversation 7	Pre-base	201	22.9	38.3	3.4	226
	Baseline	205	26.1	38.3	4.2	246
	Ironic	211	7.8*	45.3*	6.1	516+

(*continued*)

TABLE 1
(*Continued*)

Utterance Sets	*Type*	*F0*	*F0 SD*	*dB*	*dB SD*	*MSD*
Conversation 8.1	Pre-base	110	12.4	49.2	7.4	207
	Baseline	93*	5.6*	46.8	7.3	192
	Ironic	108*	9.6*	45.2	9.8	385+
Conversation 8.2	Pre-base	188	10.7	45.7	6.7	159
	Baseline	201*	16.3*	43.7	7.0	301+
	Ironic	220*	27.4*	44.3	5.7*	239+
Conversation 8.3	Pre-base	189	27.9	43.0	7.7	278
	Baseline	258*	27.4	48.7	11.8	257
	Ironic	192*	6.7*	43.8*	6.8*	321+
Conversation 9.1	Pre-base	143	12.3	49.9	8.1	272
	Baseline	146	10.6	53.8*	6.1*	162+
	Ironic	138*	8.8*	56.1*	6.1	248+
Conversation 9.2	Pre-base	146	10.6	53.7	6.1	162
	Baseline	156*	12.1	56.0	6.2	121+
	Ironic	132*	13.9	55.5	5.8	185+
Conversation 9.3	Pre-base	147	17.1	56.2	5.3	173
	Baseline	164*	25.1*	56.4	8.8	135+
	Ironic	149*	8.2*	51.2*	12.3*	140
Conversation 9.4	Pre-base	232	20.0	57.0	6.8	145
	Baseline	212*	29.8*	52.0*	4.6*	213+
	Ironic	250*	30.0	58.6*	4.4	206
Conversation 9.5	Pre-base	139	8.0	49.4	6.2	266
	Baseline	210*	32.2*	57.4*	5.4	208+
	Ironic	137*	9.1*	54.8*	5.7	286+
Conversation 10	Pre-base	226	29.6	42.8	8.8	324
	Baseline	219	29.7	51.2*	9.5	196+
	Ironic	183*	47.5*	45.9*	4.2*	249+
Conversation 11	Pre-base	248	20.7	37.2	7.8	226
	Baseline	257*	24.3	43.7*	7.1	215
	Ironic	215*	18.1*	42.5*	5.8	174+

Note. Comparisons were between (a) pre-baseline–baseline and (b) baseline–ironic targets. + = MSD difference > 30 ms; F0 = fundamental frequency (pitch); F0 SD = fundamental frequency standard deviation (pitch variability); dB = decibels (amplitude); dB SD = decibel standard deviation (amplitude variability); MSD = mean syllable duration (speech rate).

*p < .002 (Bonferroni corrected alpha).

Overall, baseline speech contrasted from ironic targets (65%) significantly more than pre-baseline utterances contrasted from baseline speech (47%), $z = 2.58$, $\phi = 0.18$, $p < .01$. Figure 2 shows the co-occurrence of individual prosodic contrasts in the baseline versus ironic targets, and pre-baseline versus baseline utterances. On average, ironic target utterances had significantly more prosodic contrasts from baseline speech ($M = 3.24$, $SD = 1.09$) than the baseline speech

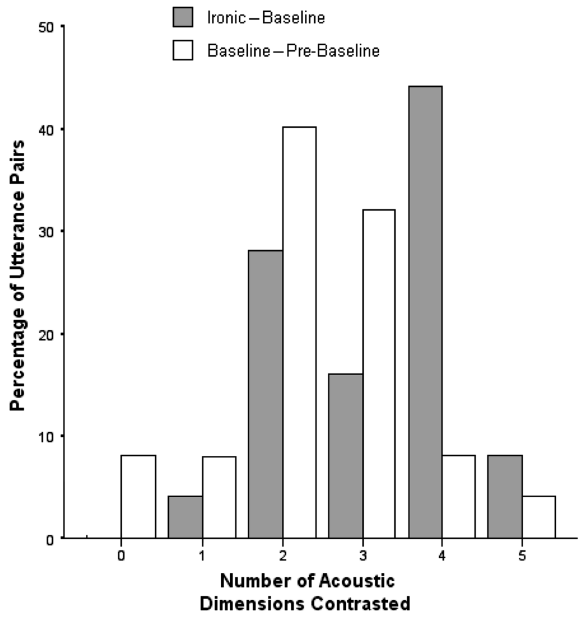

FIGURE 2 Co-occurrence of individual prosodic contrasts: ironic targets versus baseline and baseline versus pre-baseline.

had from pre-baseline speech immediately preceding it ($M = 2.36$, $SD = 1.15$), $t(24) = 2.60$, $p < .05$.

Absolute changes in all prosodic dimensions were measured in pre-baseline to baseline utterance pairs, and baseline to ironic target pairs; and these were compared. Absolute pitch changes (in semitones) were greater between baseline and ironic targets ($M = 2.14$, $SD = 1.73$) than between pre-baseline and baseline utterances ($M = 1.54$, $SD = 1.74$), $t(24) = 2.07$, $p < 05$. Pitch variability was also greater between baseline and ironic targets ($M = 1.01$, $SD = 0.84$) than between pre-baseline and baseline utterances ($M = 0.61$, $SD = 0.48$), $t(24) = 2.10$, $p < 05$. In the other dimensions (dB, dB SD, and duration), absolute changes did not differ between the pairings (all ps $> .05$). Changes were also not correlated, except in average pitch, $r = 0.66$, $p < .001$.

To check for systematic differences between utterance types on the prosodic measurements, means on the five acoustic dimensions across all 25 utterances in each category (pre-baseline, baseline, and targets) were calculated (see Table 2). To correct for between-speaker variability issues in F0 measurement, all F0 values were converted to semitones (relative to 50 Hz), but actual F0 values are reported in Table 2.

TABLE 2
Means and Standard Deviations for Five Acoustic Dimensions Across 25 Pre-Baseline, Baseline, and Ironic Target Utterances

Acoustic Dimension	*Pre-Baseline*		*Baseline*		*Ironic Targets*	
	M	*SD*	*M*	*SD*	*M*	*SD*
F0	191.0	42.5	198.0	43.1	189.0	43.2
F0 SD	23.0	10.9	24.4	9.2	24.1	13.0
dB	48.3	5.0	48.7	5.6	49.8	6.0
dB SD	6.6	1.6	6.9	1.9	6.5	1.8
MSD	197.0	49.5	200.0	54.7	242.0*	86.6

Note. F0 = fundamental frequency (pitch); F0 SD = F0 standard deviation (pitch variability); dB = decibels (amplitude); dB SD = decibel standard deviation (amplitude variability); MSD = mean syllable duration.

*$p < .05$.

A repeated-measures MANOVA was used, with utterance type as the within-subjects factor and the five acoustic dimensions as dependent variables, and the overall model was significant, $F(10, 88) = 2.09$, $p < .05$ ($\eta^2 = 0.19$). Univariate tests showed that only speech rate (i.e., MSD) was significantly different across all utterances pairs, $F(2, 24) = 4.58$, $p < .05$ ($\eta^2 = 0.16$). Planned comparisons revealed that the ironic target MSD was significantly longer than the baseline MSD, $t(48) = 2.06$, $p < .05$; but pre-baseline MSD and baseline MSD were not significantly different ($t < 1$).

When comparing baseline utterances to irony targets, in three of the dimensions, the direction of change was mixed (F0 = 7 higher, 12 lower; F0 SD = 9 higher, 9 lower; dB = 10 higher, 8 lower), but both dB SD and MSD contrasted significantly in one direction (dB SD = 2 higher, 6 lower; MSD = 3 faster, 15 slower). Amplitude variability was more often reduced in verbal irony targets than increased, although this was only marginally significant, $z = 1.54$, $\phi = 0.22$, $p = .06$; and duration was more often slowed down on verbal irony targets, $z = 3.54$, $\phi = 0.50$, $p < .001$. The direction of change was mixed for all dimensions in pre-baseline to baseline contrasts, although there was a trend of baseline utterances having F0 SD increases relative to pre-baseline utterances, $z = 1.41$, $\phi = 0.20$, $p = .08$.

DISCUSSION

Conversationalists using verbal irony were expected to contrast prosodic features in a variety of ways reflecting the diverse affective and intentional information

speakers communicate when using indirect language. This is the first acoustic analysis examining relative prosodic changes in spontaneous verbal irony, as most prior research has compared acoustic variables of scripted ironic and nonironic utterances produced by actors. Specifically, spontaneous speakers were expected to use these contrasts to a greater degree when speaking ironically than when using nonironic language. As predicted, speakers did contrast acoustic dimensions in their speech more often when using irony than other speech immediately preceding it, as evidenced by a higher percentage of contrasts overall and more simultaneous contrasts when speakers used verbal irony. There was little evidence of prosodic consistency across different speakers. When speakers contrasted pitch while speaking ironically, they did so with greater absolute changes than when not using irony, both in average values and variability. These greater absolute contrasts were not associated with more frequent use of changing pitch—they just produced the contrasts more dramatically when speaking ironically.

There was one prosodic regularity across verbal irony utterances: In the ironic targets examined here, speakers systematically spoke slower overall; and when speakers contrasted speech rate, they slowed down as opposed to sped up significantly more often. Slower speech in sarcasm has been reported before with actors, and has been described as one aspect of the presumed ironic tone of voice (e.g., Anolli et al., 2000; Cutler, 1974; Rockwell, 2000). There are at least two potential, and compatible, explanations for why slower speech would be regularly used in verbal irony. One reason could be that reducing speech rate in duration contrasts (rather than increasing it) optimizes articulatory effort relative to various physical constraints in speech production (Browman & Goldstein, 1992; Nelson, 1983). Second, slowing down speech gives the listener more time to process the relatively higher propositional load often contained in verbal irony, compared to literal interpretations of the same utterances. Individuals with closed-head injuries have difficulty understanding subtle ironic meanings of contextualized remarks, but have little trouble with literal meanings (Channon et al., 2005). This suggests additional processing might be needed for at least some types of verbal irony beyond what is required for understanding their literal counterparts. Moreover, research suggests that metarepresentation is needed to understand verbal irony; and that it takes longer, on average, to process verbal irony than other figurative language, such as metaphor (Colston & Gibbs, 2002).

There was a trend of amplitude variability being reduced in ironic targets relative to baseline utterances across speakers, which is similar to what Bryant and Fox Tree (2005) found in comparisons between matched ironic and nonironic speech. None of the other three measured acoustic dimensions systematically differed across speakers between verbal irony target sentences and the speech immediately preceding them. Speakers seemed to be using the vocal channel to disambiguate their intentions; but, if the traditional notion of an ironic tone of

voice was correct, we should expect much more consistent vocal behavior than what was found, especially with pitch. Studies using actors often find an effect of pitch, with some showing it systematically lowered (e.g., Rockwell, 2000) and others finding it increased (e.g., Anolli, Ciceri, & Infantino, 2002). In this study, actual occurrences of verbal irony in spontaneous speech were analyzed, and pitch was changed to a greater degree when speakers used ironic speech relative to baseline speech; but, the direction of change was mixed, both in average pitch and pitch variability. The prosodic contrast analyses suggest that when speaking ironically, speakers are inclined to alter (i.e., contrast) multiple acoustic dimensions simultaneously. The overall effect of multiple, simultaneous, prosodic contrasts likely provides a reliable indication of implied meaning, which is a topic for future research. Previous research has shown that listeners use multiple sources of information to recognize ironic speech (Attardo et al., 2003; Bryant & Fox Tree, 2002). These contextually embedded, multimodal signals can include visual information (face and body), linguistic information, and multiple acoustic dimensions.

Figure 3 displays an example of two prosodic contrasts in an occurrence of verbal irony (Conversation 2.2). In the ironic target ("I know, can you believe it?"), the speaker significantly increased her F0 variability and lowered her overall amplitude, compared to her preceding speech ("my side of the room would always be messy"). The type of verbal irony employed can affect what sorts of contrasts one might expect to find. For example, in the case of rhetorical question ironies (e.g., targets from Conversations 2.1 and 2.2: "You the messy?" and "I know, can you believe it?"), the speakers exaggerated features typically used to disambiguate questions from statements (Pell, 2001), so we might generally expect F0 variability and an altered stress pattern to be used more

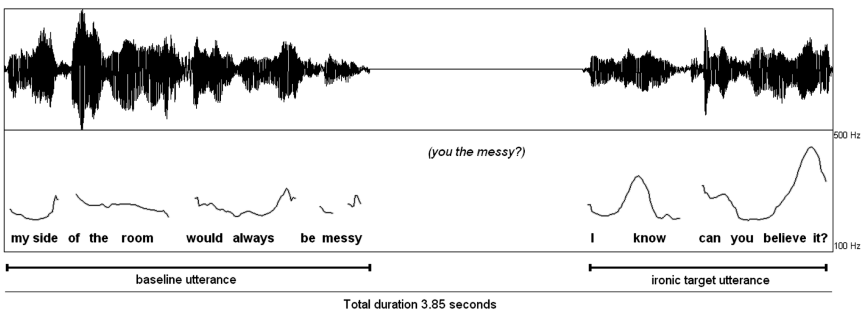

FIGURE 3 Prosodic contrasts in verbal irony. *Note*. Between the baseline and target utterances (in parentheses) is the text of an ironic utterance made by the other speaker. The upper section shows waveform amplitude, and the lower section shows F0 (fundamental frequency) contour. Relative to the baseline utterance, the ironic target has lowered overall amplitude and increased F0 variability.

often in cases like these. If the irony has a significant pretense component (Conversation 10.1: "Oh Annie, are you okay?"), then one might expect speakers to imitate the affect that one is pretending to communicate. In this example, the speaker was pretending to be compassionate and nurturing. This was enacted with a high register that contrasted in mean F0 and F0 variability (both higher) from her normal speaking voice, similar to the pitch patterns of infant-directed speech (Fernald, 1989). In this study, there were some predictable patterns associated with the types of tropes included (such as those just described), but the relatively small number of ironic tokens from each category makes this sort of analysis weak. Future research, however, should more systematically explore the association between trope types and specific vocal signals, as well as individual differences in delivery styles affected by factors such as audience design and common ground (Clark, 1996). The degree to which affect and context overlap across fuzzy trope categories will limit this sort of analysis, but some patterns are likely to exist in English speakers. We must distinguish between an ironic tone as a general phenomenon and a sarcastic tone as a specific one. Again, if particular intentions and emotions are regularly associated with sarcasm as a subtype of irony, there could be some justification for the term sarcastic intonation.

The importance of contrasts in the recognition of verbal irony does not stop with psychophysical information. Colston (2002) argued that contrast and assimilation effects are important for verbal irony understanding. People's judgments of various dimensions related to verbal irony (e.g., humor, expressiveness, etc.) are affected by the perceived incongruity between an ironic utterance and its referent situation. These contrasts can bias people's judgments of speakers' intentions. Wide discrepancies between utterances and situations cause greater contrast effects that make speakers seem funnier, more critical, more expressive, and so on. The degree of contrast or assimilation might affect how much speakers contrast other aspects of their communicative expression, such as speech features, and trade-off effects might occur. For example, if a speaker makes an ironic comment that evokes only a minor incongruity between it and a situation, the speaker might rely on more salient prosodic contrasts or other types of disambiguation. This is an empirical question that could address the larger matter regarding how speakers use speech and contextual information together in attempts to optimize relevance for their listeners (Gibbs & Bryant, 2008).

Spontaneous speakers employ prosodic contrasts when using verbal irony, but these prosodic phenomena are not special to verbal irony. Instead, prosodic contrasts represent one aspect of a multifunctional prosodic production system incorporated in all spoken language use. In most speaking contexts, speakers need to provide prosodic information for disambiguation at multiple levels, including a variety of local signals that help with clarifying explicit propositions (i.e., focus and accent functions) and global signals for communicating affective information. Evidence suggests that these functionally differentiated prosodic

signals are processed by separate brain regions (see Baum & Pell, 1999). Recent evidence suggests that speakers use prosody to communicate analogical referential information independent from affect and intentions (Shintel, Nusbaum, & Okrent, 2006) that could also appear as prosodic contrasts.

The comparison between pre-baseline and baseline utterances revealed that many prosodic contrasts occurred independent of verbal irony. In addition, many of the contrasts found between baseline and ironic target utterances were certainly related to factors other than signaling ironic intent. For example, the form of a preceding sentence can influence the way contrasted speech manifests itself. If a sentence preceding an ironic utterance is an interrogative in American English, the terminal high-rise will dictate which types of pitch movements the speaker can use to contrast the next utterance (e.g., lowered F0 with descending contour). This may have little to do with the attitudinal information being conveyed, and instead be a result of contrast constraints. Because prosody functions at multiple levels simultaneously, speakers face a prosodic load problem (Pell, 2001). For instance, speakers might need to optimize the mutual communicative effectiveness of segmental (e.g., local or linguistic) and suprasegmental (e.g., global or affective) prosodic features that are in organizational conflict. Research examining the interaction of local and global prosodic signals suggests that, although multiple production subsystems might be acting simultaneously, trading relations do exist between, for example, linguistic and affective pitch production (McRoberts, Studdert-Kennedy, & Shankweiler, 1995).

Particular contrasts could also be made more salient due to converging functional needs. For example, if a speaker needed to produce contrastive stress on one particular lexical item for semantic focus, in addition to contrasting global features of the utterance containing that item for the purposes of signaling ironic meaning, the number of changing dimensions (and degree of change) would likely increase. Again, when prosodic production needs arise at multiple levels (e.g., contrastive stress in the surface structure of an utterance could conflict with a contrastive stress necessity that helps with indirect communication), the possibility of conflicts is increased. This trade-off process is likely to be at least partially constrained by context-specific factors related to the interlocutors. Sacrifices in clarity can depend on what information particular listeners might need given the relevance demands of the communicative situation (Gibbs & Bryant, 2008). Thus, we can make testable predictions concerning how trading relations might manifest themselves depending on particular communicative contexts. For example, if an accent on a multisyllabic word had mutual effects on judgments of syntactic structure and sarcastic intent, we might expect a strategy that leads toward the least costly (and, perhaps, least likely) misunderstanding. In such a case, context might facilitate syntactic processing to a greater degree than irony understanding, so speakers should systematically opt for the syntactically "incorrect" pitch accent over the ironically "correct" accent on that particular word.

Recent work has found that different contexts can affect not only how irony is disambiguated, but how much people produce it at all. For example, people using computer-mediated communication (CMC) were more likely to produce sarcasm and ironic rhetorical questions than matched speakers in a face-to-face (FtF) setting (Hancock, 2004). Moreover, the FtF interlocutors used more signals of ironic intent. As suggested by the author, this counter-intuitive result likely reflects different discourse goals and risks associated with the different communication channels, illustrating how irony is used as a means to communicate particular intentions that are differentially assisted by disambiguating devices, such as prosody in FtF communication or emoticons or ellipsis in CMC contexts. Moreover, some circumstances might increase speakers' egocentric biases that they will be understood, and varying contexts and communication medium differences can affect judgments in how we formulate our communicative acts (Keysar & Henly, 2002; Kruger, Epley, Parker, & Ng, 2005).

Along with examining how contextual factors might affect different simple prosodic changes speakers make, future research should examine changes in voice quality used in mocking, imitation, and pretense. Spectral contrasts likely help speakers fulfill a variety of discourse goals. Future research should also explore the perception of contrasts and how they influence judgments of speakers' intentions. The reliable acoustic differences documented in this study provide a guideline as to what prosodic patterns we might expect in ironic speech generally. The contrasts are described here statistically, but most of the changes were well-beyond known perceptual thresholds. Nevertheless, many factors affect judgments of different acoustic dimensions—speech is dynamic, and rather dramatic acoustic changes can go unnoticed in some contexts. More work is needed to uncover the many constraints on prosodic processing and actual thresholds of spontaneous speech perception. Overall, researchers must address the general problem of understanding how multiple prosodic signals get appropriately mapped onto their respective communicative functions. By exploring speech production and perception processes in relation to intentional communicative behaviors, we can begin to identify design features of the vocal communication system.

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APPENDIX

The following transcriptions contain all 25 utterance sets (pre-baseline, baseline, and ironic targets) from the prosodic contrast analyses. Italicized text represents the pre-baseline speech, underlined text represents the baseline speech, and bold text represents the ironic targets. Asterisks indicate overlapping speech. Some exchanges with multiple instances of verbal irony are represented twice

to provide information about which utterances were analyzed relative to one another. Speaker A is always the speaker producing the verbal irony.

Conversation 1

1.1 a. I think Elise wouldn't be a really bad roommate because like like *Lia will be like sleeping and quiet or sitting or something* and then like Elise will come in **with like 15 billion people**

1.2 a. um they did it with a . . . *screwdriver slash pliers that Maya got for Christmas*.

b. [unvoiced laugh] why would someone give her that for Christmas? Cus *she's butch.*

a. *I don't* know [vocal noise]

b. she's not going to give me my guitar back I know it.

a. **she's going to keep it forever.**

Conversation 2

2.1 a. *I know, sarcasm*

b. [laughter]

a. um, what else, lets see, how about you?

b. Well, um, when I was like-for the first-probably about like . . . six or seven years of my life I had to share a room with my sister . . . and, it wasn't good cuz we did not get along at all we, like hated each other's guts for some reason, I don't even know why, but we did, and like, so of course I was the more, I was the messier one so my side of the room would always be messy

a. **you the messy?**

2.2 a. *so of course I was the more, I was the messier one* so my side of the room would always be messy

b. you the messy?

a. **I know can you believe it?** *[laughing]*

b. *[laughing]*

2.3 a. yeah, I thought you were talking about that little portable one

b. no that one's fine . . . it's just, you know, I like sometimes to have music out loud instead of just in *my earphones*

a. **yeah I hate* having to turn on my computer*, open, turn on my computer to like listen to music

b. yeah, I'm sorry

a. well yeah . . . **whatever Kristen**

2.4 a. *no, we're allowed to get into tangents remember*

b. oh we are, okay

a. we're just supposed to get into deep conversations, okay, whatever

b. okay, so

a. [laugh] **deep conversation, lets think think** [laughing]

2.5 a. *oh yeah*
b. cus my little brother like. . .
a. how old is he seven did you say?
b. he's ten
a. ten *[laughing]*
b. *[laughing]*
a. **I'm a good listener** [laugh]

2.6 b. I think that if like if it were for like three months I was stuck in like a cabin with the same people I'd be like get away from me I don't want to see you. You know cuz you can't necessarily go like away you know *like when I get annoyed like with you* or just plain annoyed in general
a. it happens? [laughing]
b. [laughing] **no it never happens**

2.7 b. *you seem to be more sure of yourself than I am* but you have no idea how, like, not confident I am
a. well you should change [laughter] I know it's easier said than done
b. **yeah you should change** [laughter]

Conversation 3

a. my shampoo is like half gone, *I've had it for like two weeks.* I was like what shampoo is Mike using? What shampoo is Laura using? **Like I'm sorry I'm not providing shampoo for you and your entire family and friends** [laughing]

Conversation 4

4.1 a. *yeah, when I called up and stuff*
b. dude, my mom called me yesterday, right, and I was talking to her and she asked me some crazy ass questions, like, yeah, so what do your roommates eat, do your roommates eat all that often
a. uh huh
b. I don't know, why the hell are you asking me, don't you ask them that, don't you ask them that? No, why do I care if they ate or not? It's none of my business.
a. I know, . . . that's kinda weird
b. it's like they're old
a. **thanks for asking about me mom!**

4.2 a. *they cleaned it inside the bowl?*
b. yeah, but it's like *still on the wall*
a. *But not the cover right?*
b. How the hell do you shit so that it's on the wall?
a. [laughter] **he has really bad aim?**

Conversation 5

a. *Cause I never did, like*, I just never had
b. no one's asked me *laughs*
a. *ahh-fsss* **wonder why**

Conversation 6

a. *The girl that was walking with us in core*, she's really like clean freak **like she brought like eight thousand cleaning materials**

Conversation 7

a. *maybe*
b. [laughter] hmmmmm, watch, they're like out the door [fake crazy laughing noise]
a. they're all listening
b. *laughter*
a. *laughter*
b. ahww . . . they're gonna listen to it anyway
a. **gee, great!**

Conversation 8

8.1 a. uh, maybe I'm five eight, *I don't think so though*, I'd like to think that I was
b. are you gonna grow any more?
a. **yeah** *[laughter]*
b. *[laughter]* please?!

8.2 a. uh huh
b. my roommate had a nightlight at the beginning of the year
a. ohhh, that's *cute*
b. *I* know, I didn't mind at all, but
a. *did he finally let go?*
b. yeah
a. that's good, that's growth right there, **you helped him grow**

8.3 a. you don't really exercise at all, do you?
b. I had to build a desk and I had to lift my computer on top of it
a. [breathy laugh] *wow*, that's like . . . **intense**

Conversation 9

9.1 a. *microwave, fridge* . . . do you even have that in all your tiny room?
b. my tiny room?
a. **your miniscule, almost non-existent room**

9.2 a. microwave, fridge . . . *do you even have that in all your tiny room*
b. my tiny room?
a. your miniscule, almost non-existent room
b. [laughter] it's uh, I have a refrigerator, and I brought a microwave too, she brought a TV

a. so you guys just share everything?
b. yeah
a. ah, *k*
b. *is* that was you guys do too?
a. [chuckle] it's not like **I have the refrigerator, it is mine!**

9.3 a. *and then it will be yours when you leave*
b. If that's the way you wanna put it
a. have you even used your microwave?
b. [laugh] no
a. no
b. only because we, um, Amy made popcorn the other day but she went in the other room to make it
a. [laugh] **well it's a good thing you guys got it**

9.4 a. *So it's a win-win situation*
b. okay, you're right, you're not scamming them
a. I know
b. . . . totally
a. **I'm a genius**

9.5 a. *yeah, that's true*
b. So it's a win-win situation
a. okay, you're right, you're not scamming them
b. I know
a. . . . totally
b. I'm a genius
a. uh . . . **quite genius truly**

Conversation 10

a. *like she looked like so alone, you know*
b. I know
a. and it was like I'm not gonna like be all over like **oh Annie are you okay?** you know like, I'm not gonna do that cuz I don't want to.

Conversation 11

a. *If it's not real . . . fake*, I wanna see his fake ID, I wanna know if it looks like him
b. ohh, oh his ID ID, I thought you meant like student ID, I'm like why *does* . . .
a. *ohh* **yeah, I wanna see his student ID cuz, you know I care that much about it**