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## RESEARCH ARTICLES

# Parent and Nonparent Perception of the Multimodal Infant Cry

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This study examined whether perceivers can detect infant distress in the visual and acoustic signals within the cry. Parent and nonparent perceivers rated distress in 3-, 6-, 8-, and 12-month-old infants' cries that were manipulated to separate facial, vocal, and bodily action. Mean perceiver ratings differed for high- and low-distress cries at each infant age on the basis of facial and vocal action, but not bodily movement. Perceivers rated the cry sound as more distressed and the cry face as less distressed with increasing infant age. Parents rated the cries as less distressed overall than did nonparents. The results suggest that information about distress is available for perceivers in the crying infant's face and voice.

Crying is the infant's central means of signaling distress. Acoustics have been the primary focus in the literature on infant crying (Adamson, 1995). The cry sound has been examined for clues to the cry's eliciting condition (Wasz-Höckert, Lind, Vuorenkoski, Partanen, & Valanne, 1968), as an indicator of illness (Karelitz & Fisichelli, 1962; Michelsson, 1980; Zeskind, Marshall, & Goff, 1996), for utility in individual recognition of infants (Green & Gustafson, 1983; Gustafson, Green, & Cleland, 1994), and for specific features that may affect perception and resulting caregiving behaviors (for a review, see Murray, 1985).

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Supplementary materials to this article are available on the World Wide Web at http://www.infancyarchives.com.

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However, the act of crying involves more than the production of sound. Cry behavior consists of facial and body movement repertoires as well as vocalizations (Wolff, 1987). The results of a study by Green and colleagues (Green, Gustafson, Irwin, Kalinowski, & Wood, 1995) demonstrate that visual signals affect perception of infant sounds. When presented with conflicting visual and vocal stimuli (e.g., a cry sound dubbed over a video of a laughing infant), visual signaling influenced ratings even when perceivers were explicitly instructed to report only about the sound the infant produced. Although these findings suggest that visual information influences perception of cry sounds, the Green et al. study did not examine the visual and vocal signals within a cry bout. No study has investigated perception of the facial, vocal, and bodily repertoires in the cry, to my knowledge.

This study was designed to explore whether perceivers detect distress in the crying infant's face, voice, and body. To do this, facial, vocal, and bodily action was experimentally isolated. Because this is the first study to examine the visual and acoustic signals within the cry, these findings provide important new information about cry perception.

The infant cry has been proposed to be a coordinative structure (Goldfield, 1995; Golub, 1980), "a group of muscles often spanning several joints that is constrained to act as a unit" (Kugler & Turvey, 1987, p. 253). One function of this coordinative structure is to communicate distress (for others, see Goldfield, 1995). The first hypothesis of this study was that the facial, vocal, and bodily movements that coordinate to create the action of crying provide redundant information about distress for perceivers. Therefore, perceiver ratings from the facial, vocal, and bodily signals within the cry were each expected to reflect the infant's level of distress.

Thelen (1991) conceptualized infant vocal productions to be phonological attractors, or extremely stable behavioral configurations. New, stable configurations in infant behavior are proposed to emerge as a function of developing motor and social skills (Thelen, 1991). The second hypothesis was that redundancy in the cry would change with infant age. With increasing motor skill and social experience, ratings of the older infants' cries were expected to be less redundant than those of the young infants.

Parent and nonparent perceivers have previously been reported to rate infant cry acoustics similarly (Green, Jones, & Gustafson, 1987). However, there is no available evidence about whether experienced caregivers identify distress differently than their less experienced counterparts from the visual signals within the cry. The third hypothesis was that parent perceivers would be better able to detect infant distress from facial or bodily action than the nonparents.

To test these hypotheses, parent and nonparent perceivers rated isolated facial, vocal, and bodily action from 3-, 6-, 8-, and 12-month-olds' high- and low-distress cry bouts. A mask was placed over videos of the crying infant's face and body to isolate the visual signals within the cry. An auditory-only condition presented the cry sound to perceivers. The perceivers' ability to differentiate high- from low-distress cries based on facial, vocal, and bodily action was examined to determine whether information about distress was available in each of these signals.

## METHOD

The stimuli consisted of video of the original cry bout, silent video of the isolated face and isolated body, and audio of the cry sound. Parent and nonparent perceivers rated the distress level of each of these signal types in 3-, 6-, 8-, and 12-month-old infants' cries.

### Participants

Parent participants were 31 primiparous adults (15 men and 16 women, *M* age = 30.9 years, age range = 26–38 years) recruited from birth announcements. The parent perceivers were 15 married couples and 1 mother with an infant in the home. Their infants were 8 boys and 8 girls, with a mean age of 9.7 months (age range = 2–17 months). Parents received a t-shirt and a small toy for their participation.

Nonparent participants were 59 undergraduate students (30 men and 29 women, *M* age = 19.2 years, age range = 18–25 years) at the University of Connecticut. All received credit in partial fulfillment of the requirements for an introductory psychology course. All participants reported normal hearing and normal or corrected vision.

### Procedure

*Perceiver ratings.* Each participant rated distress from 64 video and/or audio segments of infants' crying. Presentation of video was done at full screen on a Panasonic CT 2010Y 20-in. color television. Sound was played through the television speakers.

Perceivers were instructed to attend to each experimental trial and to rate the infant's behavior on each of five distress rating scales. Each trial began with an alert signal consisting of two short tones, followed by two presentations of the video and/or audio segment separated by a 3-sec blue screen. After the second presentation of each segment, a screen appeared for 10 sec, directing participants to "Mark your answer now." Presentation of stimuli was blocked by signal type (e.g., face-only segments). Each stimulus set was followed by a 1-min break. Completion of the distress ratings took 25 min. After rating the videotape, participants completed the Assessment of Caregiving Experience Questionnaire (ACE; Gustafson, Brady, Hinse, & Green, 1998), which measures caregiving experience.

*Acoustic analyses.* To ensure that the cries in this study were representative of the typical range of cry sounds, the cry sounds were digitized and analyzed using the Praat acoustic analysis software (Version 4.0.4; Boersma & Weenink, 2001). The cries were sampled at 44,100 Hz and subjected to a Fast Fourier Transform (FFT). An FFT creates a Frequency × Amplitude display, allowing for measurement of the frequency components of the acoustic signal. Among these frequency components is the lowest frequency in the sound spectrum, the fundamental frequency ($F_0$). $F_0$ is the rate of opening and closing of the vocal folds, and has previously been associated with perceptual ratings of the cry (Zeskind, Klein, & Marshall, 1992). Because cries can show great variability in $F_0$ within a bout (Green, Irwin, & Gustafson, 2000), each sound was divided into 10 equidistant segments for measurement. In each of these segments, $F_0$ was measured from the phonated portions within the cry (when the sound structure includes harmonics, or multiples of the $F_0$; Wood & Gustafson, 2001). Phonation was identified by visual inspection of the formant structure in the spectrogram. In addition to $F_0$, the total duration and mean pause duration (breaks in audible vocalization; Wood & Gustafson, 2001) was measured to describe the cry bouts.

## Materials

*Cry stimuli.* The cry stimuli were created from a corpus of videotapes of infants in their homes. Segments of spontaneous crying were chosen. The segments selected for stimulus creation were recorded from immediately before the onset of sound production and continued to cessation of vocalization. Cry length was variable, ranging from 1.32 to 8.74 sec, with a mean length of 3.6 sec. The infants were in various postures, including being supported in a seat or walker. Although infant posture varied, the infants' arms and legs were free to move. Caregivers were not present in the video segments to avoid possible influence of their facial expressions or vocalizations.

The distress level of the cry bouts was determined from a pilot study designed to create materials for the current work (Irwin, 1998).[1] Sixteen cries—two high- and two low-distress cries at each infant age—were experimentally manipulated to create the four signal types (face only, body only, voice only, and unedited) for a total of 64 trials.

The cry segments were digitized and edited using video editing software (video captured with miroMotion DC20 version 1.0, 1996, edited with Adobe Premiere version 4.0.1, 1995). All segments were digitized at 30 frames per second, at highest quality JPEG compression. The body-only and face-only stimuli were con-

[1]In this study, 40 adult nonparent participants (an equal number of men and women, mean age = 19 years, age range = 18–23 years; Irwin, 1998) rated 40 video segments of 3-, 6-, 8-, and 12-month-old infants' crying. For each infant age, the two highest and lowest rated distress segments were chosen for experimental manipulation.

structed by placing an opaque gray mask over the face or body, respectively. To make the voice-only stimuli, cry sounds were paired with a blue video screen. Order of trials within each signal type (e.g., voice only) was random. The completed stimuli were transferred to videotape for presentation to perceivers. A still image depicting the face-only, body-only, and unedited signal types from a 3- and an 8-month-old infant cry bout can be seen in Figure 1.[2]

*Distress rating scales.* Participants rated infant distress with a set of Likert-type distress rating scales, one for each of the following descriptors: unhappy, upset, sad, agitated, and uncomfortable. Each distress rating scale ranged from 1 (*the infant did not exhibit the behavior at all*; e.g., *not at all unhappy*) to 4 (*the infant exhibited the behavior to a moderate extent*), to 7 (*the infant exhibited the behavior very much*).

*Measuring caregiving experience.* As a metric of caregiving experience, the ACE (Gustafson et al., 1998) was given to each participant. The ACE includes questions about general (e.g., amount of time spent caring for, or in the presence of, infants) and specific experience with infants (e.g., whether an individual has ever diapered, bathed, or fed an infant). Caregiving experience was measured with the total experience score, a cumulative score that includes amount of time spent in the presence of an infant, caring for an infant, and a sum of specific caregiving experiences, including bathing, feeding, and changing.

## RESULTS

### Perceiver Ratings

A mean rating of the five distress descriptors was derived for each trial. These mean ratings were analyzed with a mixed factor analysis of variance (ANOVA) with one between-subject variable, parental status[3] (parent or nonparent), and three within-subjects variables: age of infant presented (3, 6, 8, and 12 months old), distress level (high or low), and signal type (face only, body only, voice only, unedited). All main effects and most interactions, including the four-way interaction, were significant.[4] Therefore, follow-up analyses were performed. The fol-

[2]Sample stimuli can be downloaded from http://www.infancyarchives.com.

[3]Parents (with the exception of 1 mother) were recruited together. However, parent perceivers were treated as independent participants in all analyses, because they rated the cries separately.

[4]All main effects and interactions were significant in the omnibus analysis with the exception of the Signal Type × Parental Status interaction. In addition, a single significant effect of perceiver gender on distress ratings was found of all potential main effects and interactions including the gender variable. The effect was a Signal Type × Infant Age × Gender interaction, $F(9, 774) = 2.5$, $p < .001$. As this interaction did not include the critical distress level variable, it was not theoretically relevant. Therefore, all reported analyses were collapsed over perceiver gender.

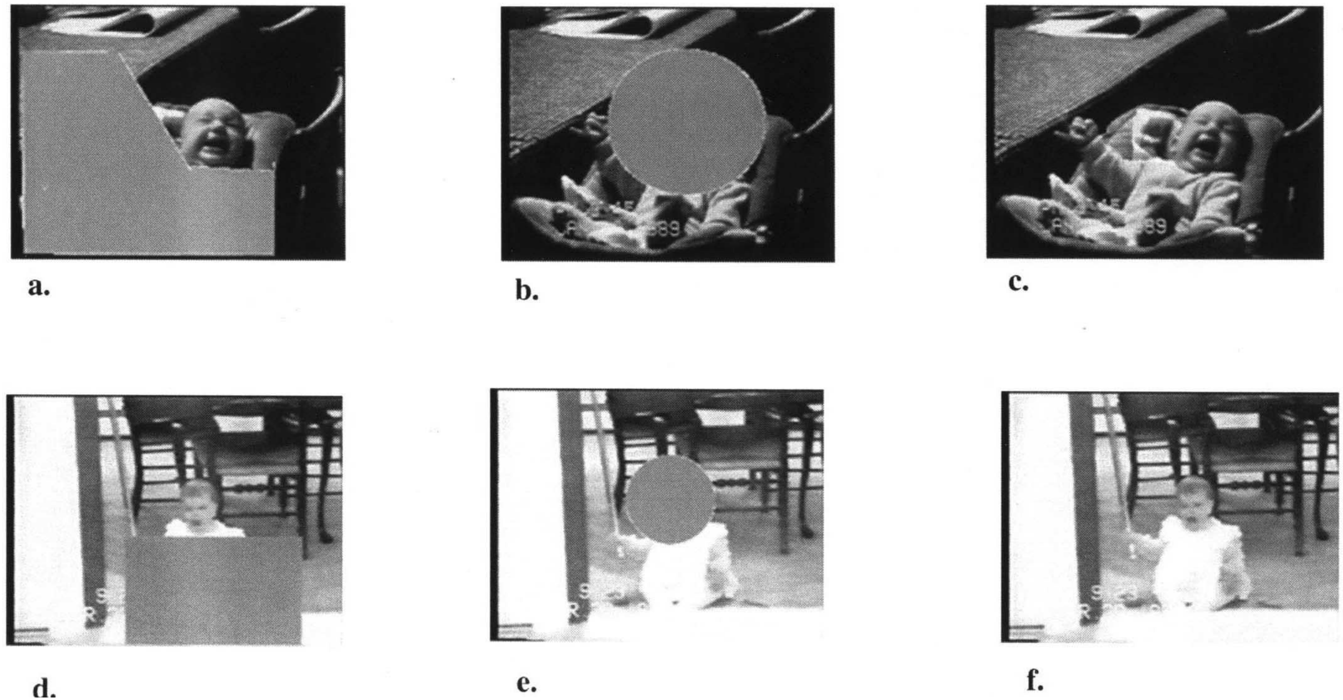

FIGURE 1 Still image of face-only, body-only, and unedited conditions from a 3- and 8-month-old infant cry bout. Top image (a) face-only, (b) body-only, and (c) unedited condition for a 3-month-old's cry bout. Bottom image (d) face-only, (e) body-only, and (f) unedited condition for an 8-month-old's cry bout.

low-up analyses were four-mixed factor ANOVAs, one for each signal type. Each analysis included the parental status, distress level, and infant age variables. Table 1 presents the sources of variance, degrees of freedom, and estimates of effect size for these analyses. Figures 2 through 5 present the parents' and nonparents' mean ratings of high- and low-distress cries at each infant age for the face-only, voice-only, body-only, and unedited signal types, respectively.

*Distress ratings of the face, voice, and body during crying.* The first hypothesis was that each of the signals within the cry would yield information about level of distress for perceivers. To assess this hypothesis, ratings of the face only, body only, voice only, and unedited signals were examined at each infant age. A signal type was considered to be informative if perceivers could identify low- from high-distress cries. The mean ratings for high- and low-distress cry bouts by infant age, signal type, and parental status can be seen in Table 2.

At each infant age, perceivers rated high-distress cries as significantly higher in distress than low-distress cries from the face-only, voice-only, and unedited segments. These findings indicate that perceivers were able to detect level of infant distress from the isolated face and voice as well as the original, unedited cry. Mean distress ratings for the body-only signal type was low for both low- and high-distress cries. In addition, no clear pattern of ratings was found for the body-only segments, with higher rated distress for the high-distress cries in the 6- and 12-month-olds' bouts, and the opposite pattern for the 3- and 8-month-olds' bouts. These results suggest that perceivers were not able to detect level of distress from the isolated body.

*Distress ratings of cries at different infant ages.* The second hypothesis was that ratings of the face, voice, and body would be less redundant in the cries

TABLE 1
Sources of Variance, Degrees of Freedom, and Effect Size ($\eta^2$) for the Cry Distress Ratings for Each Signal Type

| | | $\eta^2$ | | | |
|---|---|---|---|---|---|
| *Sources of Variance* | *df* | *Face* | *Voice* | *Body* | *Unedited* |
| Parental status | 1, 88 | .95*** | .95*** | .92*** | .95*** |
| Distress level | 1, 88 | .86*** | .87*** | .05* | .89*** |
| Parental Status × Distress Level | 1, 88 | *ns* | .15*** | *ns* | .07*** |
| Infant age | 3, 264 | .39*** | .51*** | .10*** | .42*** |
| Infant Age × Parental Status | 3, 264 | .03** | .08*** | *ns* | .04** |
| Infant Age × Distress Level | 3, 264 | .45*** | .32*** | .45*** | .16*** |
| Infant Age × Distress Level × Parental Status | 3, 264 | *ns* | .08*** | .11*** | *ns* |

*$p < .05$. **$p < .01$. ***$p < .001$.

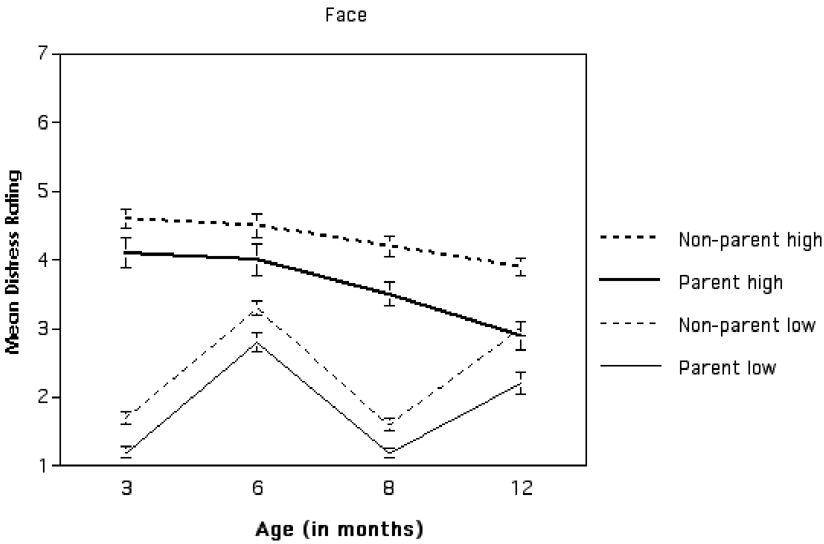


**FIGURE 2** Parent and nonparent mean ratings of low- and high-distress face-only cries. Error bars depict standard errors of the mean.

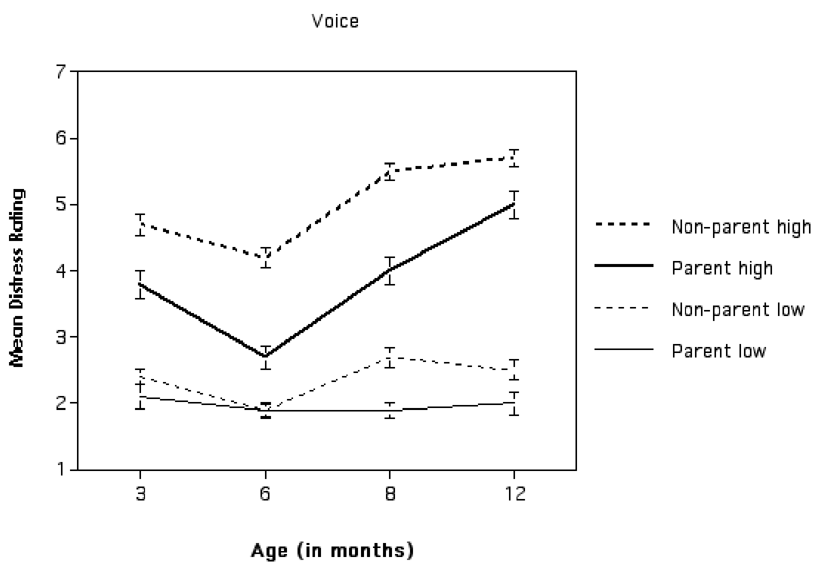


**FIGURE 3** Parent and nonparent mean ratings of low- and high-distress voice-only cries. Error bars depict standard errors of the mean.

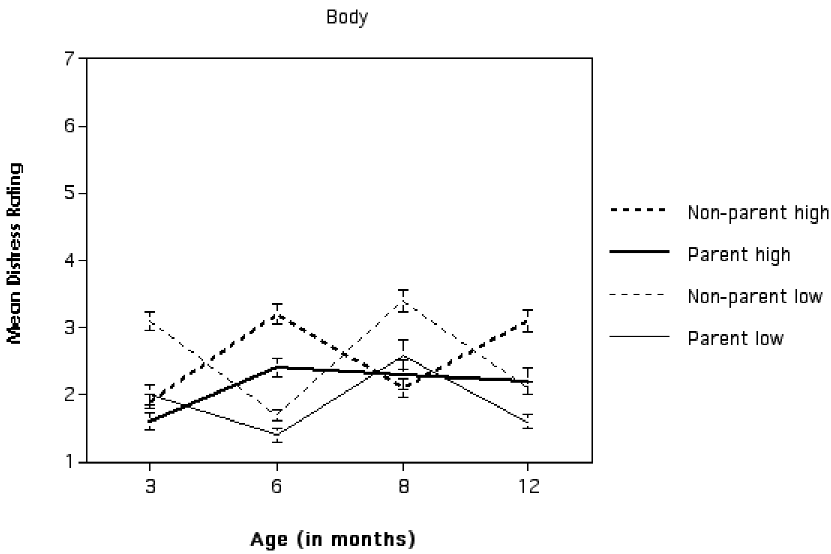


**FIGURE 4** Parent and nonparent mean ratings of low- and high-distress body-only cries. Error bars depict standard errors of the mean.

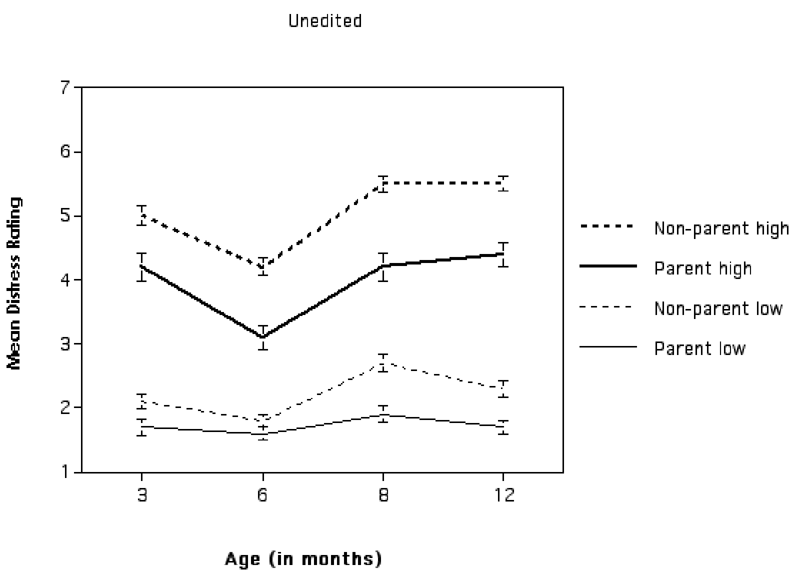


**FIGURE 5** Parent and nonparent mean ratings of low- and high-distress unedited cries. Error bars depict standard errors of the mean.

TABLE 2
Parent and Nonparent Ratings of Low- and High-Distress Cry Bouts by Signal Type and Infant Age

| | | *Infant Age* | | | |
|---|---|---|---|---|---|
| *Parental Status* | *Signal Type* | *3 Months* | *6 Months* | *8 Months* | *12 Months* |
| Parents[a] | Face only | 1.2 < 4.1 | 2.8 < 4.0 | 1.2 < 3.5 | 2.2 < 2.9 |
| | Voice only | 2.1 < 3.8 | 1.9 < 2.7 | 1.9 < 4.0 | 2.0 < 5.0 |
| | Body only | 2.0 > 1.6 | 1.4 < 2.4 | 2.6 = 2.3 | 1.6 < 2.2 |
| | Unedited | 1.7 < 4.2 | 1.6 < 3.1 | 1.9 < 4.2 | 1.7 < 4.4 |
| Nonparents[b] | Face only | 1.7 < 4.6 | 3.3 < 4.5 | 1.6 < 4.2 | 3.0 < 3.9 |
| | Voice only | 2.4 < 4.7 | 1.9 < 4.2 | 2.7 < 5.5 | 2.5 < 5.7 |
| | Body only | 3.1 > 1.9 | 1.7 < 3.2 | 3.4 > 2.1 | 2.1 < 3.1 |
| | Unedited | 2.1 < 5.0 | 1.8 < 4.2 | 2.7 < 5.5 | 2.3 < 5.5 |

*Note.* Means for low-distress cries are on the left; means for high-distress cries are on the right. Means separated by a less than or greater than symbol differ at $p < .05$ in the Tukey honestly significant difference comparison; those means separated by an equals sign did not differ. Standard deviations for these means varied between 0.63 and 1.

[a]$n = 31$. [b]$n = 59$.

of older infants. There did not appear to be differences in ratings of the body-only segments or in the voice- or face-only low-distress segments. However, there was some evidence of divergence in perceiver ratings of high-distress voice and face segments with increasing infant age. Perceiver ratings of the cry voices showed a positive linear trend, indicating an increase in perceived distress with age: parents, $t(30) = 8.28$, $p < .001$; nonparents, $t(58) = 9.53$, $p < .001$. Conversely, perceiver ratings of the high-distress face-only cries showed a negative linear trend, suggesting a decrease in perceived distress: parents, $t(30) = –8.10$, $p < .001$; nonparents, $t(58) = –4.71$, $p < .001$. The body-only signal type was not assessed for trends, as perceivers could not identify level of distress solely from the infant's bodily movement.

*Parent and nonparent ratings of the cry.* The third hypothesis was that parent perceivers would be better able to identify infant distress from the isolated face and body. Contrary to this hypothesis, no significant differences were found in parents' and nonparents' ratings of distress for the face-only cry segments. A significant three-way interaction was found for the body-only signal type; however, this effect is not theoretically relevant, as perceivers were unable to differentiate high- from low-distress cries from the body-only segments.

A significant main effect of parental status for each signal type reflected parent perceivers' lower mean ratings of distress than nonparents. This discrepancy in ratings was larger for the high-distress cries in the voice and unedited signal types, resulting in a significant Distress Level × Parental Status interaction. Therefore, the primary difference between parents' and nonparents' ratings appeared to be in amount of rated distress, with parents perceiving the cries as less distressed than nonparents.

### Caregiving Experience

Parent perceivers had significantly more experience caring for infants than did nonparents: *M* parent total experience score = 26, *SD* = 2.1; *M* nonparent total experience score = 17, *SD* = 6.9; $F(1, 86) = 48.11$, $p < .0001$, $\eta^2 = .36$, as derived from responses on the total experience portion on the ACE (Gustafson et al., 1998). However, in addition to differences in caregiving experience, parents and nonparents also differed significantly in age: *M* parent age = 30.9 years, *SD* = 2.7; *M* nonparent age = 19.2 years, *SD* = 1.7; $F(1, 88) = 618.0$, $p < .001$, $\eta^2 = .87$.

### Acoustic Analyses

The mean $F_0$ of the cries ranged from 345.8 to 529.8 Hz. The range of mean pause duration was 160 to 700 msec. These acoustic parameters indicate that the current cry stimuli are within the range of cry sounds reported in the literature (Gustafson & Green, 1989; Wood & Gustafson, 2001).

An ANOVA was conducted on cry tokens with distress level (low, high) as the independent variable and duration, mean pause duration, and mean $F_0$ as dependent variables. The cries perceived as high distress were longer in duration than the low-distress cries: *M* high-distress cries = 4.2, *SD* = 1.8; *M* low-distress cries = 3.1, *SD* = 1.2; $F(1, 130) = 11.3$, $p < .001$, $\eta^2 = .08$. No differences were found in mean $F_0$ or mean pause duration between the low- and high-distress cries.

## DISCUSSION

This exploratory study was designed to examine whether perceivers could detect distress from the crying infant's isolated face, voice, and body. Parents and nonparents rated infant distress from facial, vocal, and bodily action within low- and high-distress cries. Consistent with the large body of work on cry acoustics, perceivers were able to identify the infant's level of distress from the cry sound at each infant age. Importantly, these results also show that perceivers were able to detect distress from the infant's face. Isolated body movement was not a useful signal for perceivers in identification of infant distress. Facial and vocal action was redundant, each signaling the infant's level of distress for perceivers.

Increases in motor control and social skill were expected to create a less redundant signal in older than younger infant's cries. Although this was not observed in the ratings of the body or low-distress cry faces and voices, there was some evidence of differentiation in the high-distress cry faces and voices. With increasing infant age, the isolated voice was rated as more distressed, and the face less distressed. The current cross-sectional design precludes any conclusions about change in cry perception with development. Longitudinal study of infant crying is needed to better assess whether cry faces and voices are less redundant over time.

Greater motor control of the vocal apparatus over time (Lieberman, 1984; Lieberman, Harris, Wolff, & Russell, 1971; Thelen, 1991) provides an account for the higher ratings of distress in older infants' vocal productions. However, perceivers also rated the older infants' cry faces as lower in distress with age. As caregivers were not immediately present during the cry bouts, it is possible that the face and voice serve different functions in older infants' cries, with the voice signaling distress and the face used to search for the caregiver. An examination of distress ratings from faces and voices of infants in social and nonsocial contexts would test this hypothesis.

Parent perceivers rated the cries lower in distress than did nonparents. The cries in this work might not represent the entire spectrum of distress. For example, none of the cries in this work probably approached the level of distress in a pain cry (e.g., that of a circumcision cry; Porter, Miller, & Marshall, 1986). Therefore, experience caring for an infant might expose parents to a greater range of infant distress than nonparents, which could have led to lower ratings. However, the difference in age between parent and nonparent perceivers is a confounding variable, making an interpretation of this effect difficult.

An examination of the acoustic properties of the cries in this study showed that the high-distress cries were significantly longer than the low-distress cries. The high- and low-distress cries did not differ in mean $F_0$ or mean pause duration. Previous research has failed to find a difference in mean $F_0$ between cries perceived to be low and high distress (Wood & Gustafson, 2001). Clearly, information about distress was available in the cry sounds in this study. However, a number of factors make a comparison of their acoustic parameters to those in the literature problematic. First, the distress level of the cries in this study was identified based on audiovisual presentation. Second, although acoustic analysis of the cry sounds demonstrated that the mean $F_0$ and mean pause duration were within the range for typical infant productions, the cries available for comparison were from younger infants (1-month-olds).

According to Adamson (1995), an encounter with a distressed infant typically includes visual as well as acoustic information. The results reported here reveal that perceivers were able to use both the face and voice to identify the crying infant's level of distress. Therefore, by studying only the sound portion of the cry, we ignore the role of visual signaling in infant cry perception.

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