Research Article

Recognizing Intentions in Infant-Directed Speech

Evidence for Universals

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ABSTRACT—*In all languages studied to date, distinct prosodic contours characterize different intention categories of infant-directed (ID) speech. This vocal behavior likely exists universally as a species-typical trait, but little research has examined whether listeners can accurately recognize intentions in ID speech using only vocal cues, without access to semantic information. We recorded native-English-speaking mothers producing four intention categories of utterances (prohibition, approval, comfort, and attention) as both ID and adult-directed (AD) speech, and we then presented the utterances to Shuar adults (South American hunter-horticulturalists). Shuar subjects were able to reliably distinguish ID from AD speech and were able to reliably recognize the intention categories in both types of speech, although performance was significantly better with ID speech. This is the first demonstration that adult listeners in an indigenous, nonindustrialized, and nonliterate culture can accurately infer intentions from both ID speech and AD speech in a language they do not speak.*

A major function of speech is the communication of intentions. When people speak, they form their utterances so that others will grasp their meaning. In everyday conversation between adult native language users, intentions can be conveyed through multiple channels, including the syntax and semantics of their language, but also through other means, such as prosody. Accurately communicating intentions to infants, however, presents a particular challenge. Because infants are not yet linguistically competent, speakers cannot make use of the full range of language systems normally available for communicating intentions between adult language speakers, including grammar and even the meanings of words themselves.

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The fact that adults often speak differently to infants than they do to adults is consistent with this view. In particular, when adults talk to infants, they frequently exaggerate prosodic cues normally used for conveying intentions in adult-directed (AD) speech. This pattern of exaggerated prosody is called infant-directed (ID) speech. A variety of reasons why adults use ID speech have been proposed. Likely functions include eliciting infants' attention (Fernald & Simon, 1984; Werker & McLeod, 1989) and communicating affective intentions (Fernald, 1989, 1992). More controversial proposals include the idea that ID speech helps children learn aspects of language, such as vowel categories (Kuhl et al., 1997; Trainor & Desjardins, 2002) and grammar (Christophe, Nespor, Guasti, & Van Ooyen, 2003; Morgan & Demuth, 1996). Fernald (1992) suggested that the function of ID speech changes over development. Initially, the speech signal might serve to direct infants' attention and modulate arousal and affect, but by the 2nd year, ID speech can fulfill more specific linguistic purposes.

Distinctive ID speech has been found in all languages studied to date, and it manifests itself similarly, with only subtle variation (Falk, 2004; Fernald, 1992). For instance, relative to AD speech, ID speech often has overall higher mean fundamental frequency (F0), wider F0 range, more exaggerated F0 and intensity contours, and more musical rhythmic properties than AD speech (Fernald, 1989). Fernald (1992) described similarities in how pitch contours (i.e., F0 values represented over time) relate to communicative intentions across several languages. For example, prohibition utterances are often characterized by low F0, narrow F0 range, and staccato-like bursts. In contrast, approval vocalizations generally have high average F0, wide F0 range, and a prominent F0 rise-fall contour. These acoustic configurations modulate infants' attention and subsequent behavior in expected ways without relying on verbal commands that are not readily understood.

Not only are there apparent universals in production, but there is strong evidence that infants everywhere have a complementary response bias. Infants generally prefer to listen to ID speech over AD speech regardless of the gender of the voice (e.g., Werker & McLeod, 1989), and even prefer ID speech in a foreign language to AD speech in the language they are accustomed to hearing (Fernald & Morikawa, 1993). There is limited evidence that infants respond differentially to distinct types of ID speech. Fernald (1993) found that observers coded infants' faces as exhibiting more negative affect while the infants listened to ID prohibitions and more positive affect when they listened to ID approvals, even when the ID speech was in an unfamiliar language. Papousek, Bornstein, Nuzzo, Papousek, and Symmes (1990) found that infants looked longer at a face while hearing approvals rather than disapprovals. These findings suggest that the differential acoustic structure in these ID speech types modulates infants' affect and arousal in predictable ways. Some research has examined adults' ability to infer intentions of ID and AD speakers. Fernald (1989) found that adults were able to correctly identify the communicative intent in content-filtered ID speech and AD speech; moreover, they were better at this task in the ID-speech condition. These results support the hypothesis that there is a form-function relationship in ID speech that is well suited to facilitate the communication of intentions between ID speakers and preverbal infants.

Cross-cultural work done thus far has examined ID speech only in speakers from industrialized cultures with common exposure to similar emotion stimuli through mass media, and no cross-cultural research, to our knowledge, has examined adults' ability to infer intentions in a language they do not speak. If ID speech is the product of a species-typical behavioral program designed to facilitate communication with infants, one would expect it to be not only manifest in all cultures regardless of language or media influence, but also recognizable across disparate cultures regardless of the language typically spoken. When speaking to infants, adults cannot make use of their full language capacity, so they often rely heavily on prosodic cues. Adults who do not speak a particular language are in a position similar to infants' when listening to ID speech in that language: Like infants, they have access to prosodic cues, but not syntactic or semantic information. This observation suggests an experimental test of the hypothesis that ID speech contains prosodic cues that facilitate intentional inference on the part of the listener: examine the ability of nonspeakers to infer intentions in ID speech. Here we report the results of such a test among the Shuar, an indigenous population of hunter-horticulturalists in the South American rain forest. For this test, Shuar speakers listened to ID speech produced by American English-speaking mothers.

In previous research with this same population, we found that basic vocal emotions were recognized reliably (Bryant & Barrett, in press). Shuar adults were able to identify anger, happiness, fear, and sadness in AD speech produced by native English speakers. This was the first empirical demonstration of vocal emotional recognition in an indigenous culture. In the present study, we performed a direct test of the hypothesis that prosodic features in ID speech function to communicate intentions. If there is a universal relationship between nonverbal vocal cues and intention information in ID speech, then Shuar adults should be able to discriminate between different intention categories in ID speech produced by native English speakers.

The current research involved three related experiments. In the first, a speech discrimination task was used. Subjects listened to single ID and AD utterances and were asked to determine whether each was directed toward an infant or an adult. The second experiment involved an intention discrimination task in which subjects listened to single ID utterances and chose which of two intention categories each exemplified. The third experiment was identical to the second except that all utterances were AD speech. We expected that Shuar subjects would be able to discriminate between ID and AD speech, and that they would also be able to reliably distinguish between intention categories in both types of speech. But because ID speech has exaggerated prosodic cues that serve to disambiguate affective intentions, we expected better performance on intention recognition in ID than in AD speech.

METHOD

Subjects

Three separate experiments were carried out in a single interview session with 26 young adults (14 male and 12 female; age range: 14–54; $M = 28.7$) from a Shuar village in Morona Santiago Province, Ecuador. All Shuar subjects had been taught Spanish as part of a Shuar-Spanish bilingual education program, but Shuar was their first and primary language.

Materials

We recorded eight utterances (four ID and four AD) from eight adult females, all mothers and native English speakers (ages 21–51, $M = 42.8$). The mothers were presented four different pictures of individual babies in contexts appropriate to four categories of ID speech (prohibition, approval, attention, and comfort). For example, the "approval" picture showed a baby climbing stairs, and the mothers were instructed to verbally encourage the baby. They were asked to produce utterances as if they were speaking to their own baby when he or she was the same age. For these same intention categories, the mothers were also asked to speak as they would to another adult (half of the mothers produced the AD utterances first). When recording the AD utterances, the mothers were not shown pictures, but instead had the intention contexts either described to them (when AD speech was recorded first) or repeated in adult-relevant terms (when AD speech was recorded second). They could say anything they wanted (i.e., we provided no scripting or suggestions other than to keep the length under 5 s). All utterances were generated in one or two takes.

TABLE 1
Acoustic Profiles for the Speech Stimuli in the Infant-Directed/Adult-Directed Speech Discrimination Task

	F0 (hertz)						
Speech	Mean	*SD*	Minimum	Maximum	Range	dB *SD*	Mean syllabic duration (ms)
Infant-directed	225	45.3	147	362	215	11.6	449
Adult-directed	203	41.2	140	309	169	13.0	233

All speech was recorded digitally (16 bit, 44.1 KHz, mono) and edited using Cool Edit Pro software (Version 2.1). Some utterance onsets and offsets were edited for length, but very little editing was done within the remaining speech. For the ID-AD discrimination task, one ID speech sample and one AD speech sample were taken from each of four mothers, with all intention categories represented twice (one ID and one AD). For the second and third experiments, all four intention tokens in both ID speech and AD speech were taken from three other mothers. Practice trials were taken from recordings of the eighth mother and unused samples from the mothers used in the discrimination task. The edited files were burned to CDs in four counterbalanced lists.

Acoustic analyses verified that the ID and AD speech samples fit typical acoustic profiles. For the analyses, utterances were resampled to 11.275 KHz to diminish aliasing. All acoustic analyses were done with Multi-Speech, a Windows-based version of the Computerized Speech Lab (Kay Elemetrics Corp., 2004). Tables 1 and 2 display the acoustic analysis results for the stimuli used in the discrimination task and the intention recognition tasks, respectively. The stimuli for the discrimination task differed mostly in pitch range (maximum F0 minus minimum F0) and speech rate (mean syllabic duration, calculated by dividing the total time of the utterance by the number of spoken syllables). Additionally, the ID speech samples had a slightly higher average F0 and slightly more variability in loudness (as measured by standard deviation of decibels). The utterances used in the intention recognition tasks differed not only systematically between ID and AD speech, but also between intention categories. Overall, ID speech had a wider F0 range, a higher mean F0, a higher maximum F0, a slower speech rate, and more variability in speech rate (not shown in Table 1). Our ID speech tokens showed no anomalous characteristics and had acoustic features much like those described previously for ID speech in many languages (Fernald, 1992).

Procedure

Subjects were told they were taking part in a study examining how mothers talk to their babies. We explained that they would be listening to mothers talking either to their babies or to other adults, and we described the four intention categories (prohibition, approval, attention, and comfort), using situational examples to help the subjects' understanding. No speech samples were played or vocalized as examples. The experimenter then described the task of listening to each utterance one time and (a) choosing between two speech categories (ID vs. AD) or (b) choosing between two intention categories. The subjects were reminded that one of the intention categories presented was the actual intention of the speaker when she recorded the utterance. In a single interview session, each subject completed three separate sets of trials. The ID-AD speech discrimination task

TABLE 2
Acoustic Profiles of Infant-Directed and Adult-Directed Utterances Used in the Intention Recognition Tasks

	F0 (hertz)						
Intention	Mean	*SD*	Minimum	Maximum	Range	dB *SD*	Mean syllabic duration (ms)
			Infant-directed speech				
Attention	239	60.2	160	413	253	11.0	296
Prohibition	224	43.2	165	307	142	12.6	316
Approval	239	55.6	163	404	241	9.1	436
Comfort	219	55.1	177	422	245	8.7	306
			Adult-directed speech				
Attention	234	40.3	177	320	143	10.5	277
Prohibition	186	36.9	163	272	109	9.2	270
Approval	202	39.6	159	293	134	8.2	200
Comfort	219	26.0	182	299	117	9.5	219

always came first; it comprised 2 practice trials and 8 experimental trials. Subjects then completed the ID speech-intention discrimination task and the AD speech-intention discrimination task (task order was counterbalanced). Each of these tasks consisted of 2 practice trials and 12 experimental trials (4 intention categories × 3 possible pairings of each category with other categories as response options). All stimuli were presented to subjects on a portable CD player with portable speakers.

The order in which stimuli were presented was partially counterbalanced across subjects (four order lists). Intention categories were counterbalanced for order (first or second listed response option) and pairing (each category paired equally often with every other category). The entire interview, including all practice trials, consisted of 38 trials and took approximately 30 min to complete. Task instructions were given in Spanish, with Spanish and Shuar words used for the category names. Because all subjects were bilingual and the experimenter (H.C.B.) has customarily conversed with these subjects in Spanish, this was the more natural language for the interview, but category labels in both languages were provided to minimize ambiguity regarding the intended categories. Spanish and Shuar words were chosen on the basis of several interviews with Shuar adults from the same community as the experimental subjects.

RESULTS

We tested subjects' ability to discriminate between ID speech and AD speech, as well as their ability to discriminate between different intention categories in both ID speech and AD speech.

ID-AD Speech Discrimination

We expected that Shuar subjects would be able to successfully discriminate between ID speech and AD speech. A logistic regression model was constructed to get estimated logits of overall hit rate and hit rates for both ID and AD speech when they were the correct response. Using Wald chi-square tests, we tested whether these coefficient (β) values were significantly different from zero (equivalent to a chance hit rate of 50%). We also tested whether the values for ID speech and AD speech differed significantly from one another.

As predicted, subjects were able to reliably discriminate between ID speech and AD speech with 73% accuracy overall, $\chi^2(1, N = 26) = 48.03, p < .001$. They performed significantly better on this task for ID speech (77%) than for AD speech (69%), $\chi^2(1, N = 26) = 6.1, p < .05$. But the hit rate on trials with AD speech was still significantly better than chance, $\chi^2(1, N = 26) = 18.66, p < .001$.

Intention Recognition Within ID and AD Speech

Figure 1 shows the hit rates for each intention category in ID speech and AD speech. The overall hit rate for ID speech (75%) was significantly better than chance, $\chi^2(1, N = 26) = 57.91, p < .001$. The overall hit rate for AD speech (64%) was also significantly better than chance, $\chi^2(1, N = 26) = 41.60, p < .001$. Overall intention recognition, however, was better in ID speech than in AD speech, $\chi^2(1, N = 26) = 8.18, p < .01$.

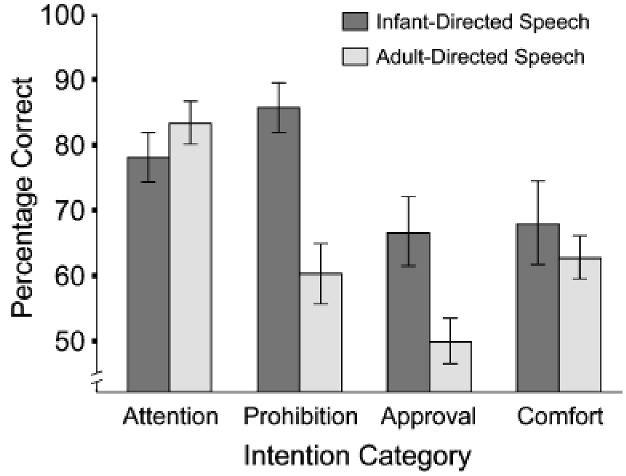

Fig. 1. Hit rates for each intention category in infant-directed speech and adult-directed speech. Error bars represent standard errors of the means.

Tables 3 and 4 show how subjects' judgments were distributed between correct and incorrect categories for every combination of paired intention categories in ID speech and AD speech, respectively. In addition, the tables list hit rates (number of times an intention category was correctly selected divided by the number of pairs in which it was available as a correct choice), false alarm rates (number of times an intention category was incorrectly selected divided by the number of pairs in which it was available as an incorrect choice), and d' values (z-transformed hit rate minus z-transformed false alarm rate).

To check whether hit rates for each intention category within each experiment were better than chance, we constructed a lo-

TABLE 3
Confusion Matrix and Signal Detection Analysis for the Infant-Directed Speech Experiment

	Selected category				
True category	Attention	Prohibition	Approval	Comfort	Total
Attention	**61**	5	5	7	78
Prohibition	8	**67**	0	3	78
Approval	4	9	**52**	13	78
Comfort	6	7	12	**53**	78
Total	79	88	69	76	312
Hit rate	78%**	86%**	67%**	68%**	75%**
False alarm rate	23%	27%	22%	30%	25%
d'	1.52	1.69	1.21	1.01	1.33

Note. The table shows the number of times that each intention category was selected as the answer for the stimuli in each intention category. The main diagonal (in boldface) presents correct categorizations. Responses were pooled across subjects.
**$p < .01$.

TABLE 4

Confusion Matrix and Signal Detection Analysis for the Adult-Directed Speech Experiment

True category	Selected category: Attention	Prohibition	Approval	Comfort	Total
Attention	**64**	12	1	1	78
Prohibition	7	**47**	12	12	78
Approval	10	20	**39**	9	78
Comfort	3	10	16	**49**	78
Total	84	89	68	71	312
Hit rate	82%**	60%†	50%	63%*	64%*
False alarm rate	26%	54%	37%	28%	36%
d'	1.57	0.16	0.33	0.90	0.71

Note. The table shows the number of times that each intention category was selected as the answer for the stimuli in each intention category. The main diagonal (in boldface) presents correct categorizations. Responses were pooled across subjects.
†$p < .10$. *$p < .05$. **$p < .01$.

gistic regression model using experiment (AD speech or ID speech) and intention category (prohibition, attention, approval, or comfort) as categorical variables predicting hit rate. The linear combination of these parameters was used to get an estimated logit of the outcome for each cell. We used Wald chi-square tests to determine whether these coefficient (β) values differed significantly from zero (equivalent to a chance hit rate of 50%).

In ID speech, hit rates for each category were significantly above chance (standard deviations in parentheses): attention—78% (23%), $\chi^2(1, N = 26) = 23.33$, $p < .001$; prohibition—86% (21%), $\chi^2(1, N = 26) = 27.04$, $p < .001$; approval—67% (27%), $\chi^2(1, N = 26) = 8.70$, $p < .01$; comfort—68% (31%), $\chi^2(1, N = 26) = 7.45$, $p < .01$. In AD speech, hit rates were significantly better than chance for two categories and marginally significant for one category (standard deviations in parentheses): attention—82% (19%), $\chi^2(1, N = 26) = 34.69$, $p < .001$; prohibition—60% (28%), $\chi^2(1, N = 26) = 3.62$, $p = .057$; approval—50% (24%), $\chi^2(1, N = 26) = 0$, n.s.; comfort—63% (19%), $\chi^2(1, N = 26) = 10.18$, $p < .01$.

Intention Recognition Between ID and AD Speech

To check for differences in recognition performance between ID and AD speech within each intention category, we constructed a logistic regression model with experiment as the predictor variable and subjects as the cluster variable. This model yielded estimated logit values for our dependent variable of hit rate. We used Wald chi-square to test whether these coefficient (β) values differed significantly from zero.

Attention utterances were recognized at similar rates in ID speech (78%) and AD speech (82%), $\chi^2(1, N = 26) = 0.35$, n.s. Prohibition utterances were recognized at a significantly higher rate in ID speech (86%) than in AD speech (60%), $\chi^2(1, N = 26) = 11.42$, $p < .001$. Approval utterances were recognized at a higher rate in ID speech (67%) than in AD speech (50%), $\chi^2(1, N = 26) = 4.71$, $p < .05$, and comfort utterances were recognized at similar rates in ID speech (68%) and AD speech (63%), $\chi^2(1, N = 26) = 0.55$, n.s.

DISCUSSION

If ID speech is the product of a specialized system designed by natural selection to solve a number of communicative and linguistic problems, then one would expect this behavior to be manifest universally as a species-typical trait (see Fernald, 1992). There is evidence showing that acoustic correlates of intention categories are similar in ID speech across quite different languages (i.e., universals in form-function relationships), but little research has investigated whether or not listeners can accurately infer intentions using only prosodic cues in the speech signal (i.e., without understanding the words). The current study is the first to show that adult listeners in an indigenous, nonindustrialized, and nonliterate culture can easily distinguish ID speech from AD speech, and furthermore, can reliably discriminate between intention categories in both ID speech and AD speech in a language they do not speak.

As predicted, Shuar subjects were better able to discriminate between different intention categories in ID speech than in AD speech. Moreover, in the ID-AD speech discrimination task, hit rates were significantly higher for ID speech than for AD speech. These results are consistent with the hypothesis that ID speech is particularly rich in prosodic cues that disambiguate communicative intentions. Prior studies suggest that F0 provides the greatest proportion of acoustically distinctive information conveying communicative intentions in ID speech (Fernald & Kuhl, 1987), though other simple acoustic features are likely to be important as well (Slaney & McRoberts, 2003). To the degree that particular intentions overlap in the communicative problems that they solve, they will have similarities in their acoustic manifestation in both ID and AD speech. Subjects often confused prohibition with attention utterances (both are designed to elicit attention), as well as comfort with approval utterances (both are designed to communicate and elicit positive affect). In general, the error patterns followed a more predictable pattern in ID than in AD speech. When prosodic information is less reliable for disambiguating purposes, as it is in AD speech relative to ID speech, people's judgments should be more variable and less accurate if no alternative source of information is available.

Shuar adults were able to identify two of the four intention categories (attention and comfort) reliably in AD speech, and prohibition utterances marginally so. Communicating intentions is clearly an important function of verbal communication, and the ability of individuals to reliably identify the intentions of speakers of another language, without the use of semantic information, suggests that the human perceptual system might contain adaptations for inferring intentions from nonsemantic vocal cues, as well as for producing such cues in intentional speech. In AD speech, vocalizations intended to elicit attention were recognized best. This makes sense, given that capturing another adult's attention is often more heavily dependent on acoustical cues than are prohibiting a behavior, showing approval, and providing comfort. The attention utterances contained salient acoustic features likely produced to elicit the attention of another adult. Relative to the other AD samples, the AD attention utterances had higher maximum F0 values, greater F0 range, greater variability in loudness, and (along with AD prohibition utterances) a slower speech rate. Perceptually, the AD attention utterances were relatively unambiguous, as Shuar subjects almost never thought they were either comfort or approval utterances.

Overall, this work provides strong support for the hypothesis that acoustic information in ID speech communicates important intention information recognizable across quite different language families. Given that Shuar adults were able to easily discriminate between affective intentions in a language they have never heard, these results also provide support for the notion that vocal emotional communication manifests itself in similar ways across disparate cultures. In addition, Shuar ID and AD speech samples that we have collected appear to contain features similar to those found in other languages (Bryant & Barrett, 2007). To further verify form-function relationships common to ID speech across different languages (Fernald, 1992), future work should examine how infants respond behaviorally to different intention categories of ID speech in languages they are not familiar with. These results, in conjunction with acoustic analyses, would provide valuable clues for uncovering the universal properties of this species-typical family of signals.

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