

Do you speak E-NG-L-I-SH? A comparison of foreigner- and infant-directed speech

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Abstract

Infant-directed speech has three main roles – it attracts attention, conveys emotional affect, and conveys language-specific phonological information, and each of these roles are reflected in certain components of the speech signal – pitch, rated affect, and vowel hyperarticulation. We sought to investigate the independence of these components by comparing British English speech directed to first language English learners (infants), and second language English learners (adult foreigners), populations with similar linguistic but dissimilar affective needs. It was found that, compared with British adult-directed speech, vowels were equivalently hyperarticulated in infant- and foreigner-directed speech. On the other hand, pitch was higher in speech to infants than to foreigners or adult British controls; and positive affect was highest in infant-directed and lowest in foreigner-directed speech. These results suggest that linguistic modifications found in both infant- and foreigner-directed speech are didactically oriented, and that linguistic modifications are independent of vocal pitch and affective valence.

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1. Introduction

Speech has been shown to be modified to meet the communicative and emotional needs of the target audience. One clear example of such modification is in infant-directed speech (IDS). By comparison with adult-directed speech (ADS), IDS is semantically, syntactically and prosodically simplified (Stern et al., 1983; Kuhl et al., 1997). IDS also exhibits higher fundamental frequency (F_0 , perceived as pitch); exaggerated F_0 contours (Fernald and Kuhl, 1987; Kuhl et al., 1997; Burnham et al., 2002); higher emotional affect (Stern et al., 1983; Fernald and Kuhl, 1987; Kuhl et al., 1997; Trainor and Desjardins, 2002); and hyperarticulated vowels (Kuhl et al., 1997; Burnham et al., 2002).

These modifications appear to be robust both across different cultures/languages (Stern et al., 1983; Grieser and Kuhl, 1988; Fernald et al., 1989; Papousek and Hwang, 1991; Kuhl et al., 1997), and across gender (Fernald et al., 1989). In concert with this robustness, IDS also appears to occur reflexively and unconsciously (Kemler Nelson et al., 1989).

A number of roles for IDS have been mooted. Firstly, it has been suggested that the acoustic exaggerations of IDS engage and maintain infant attention (Fernald and Simon, 1984; Papousek et al., 1991) with pitch being the most prominent acoustic cue compared with amplitude or duration (Fernald and Kuhl, 1987). Secondly, it has been suggested that IDS serves an emotional–affective role; infants prefer IDS over ADS, and are more emotionally responsive to IDS than to ADS (Fernald, 1993; Werker et al., 1994). Moreover, infants' preferences for IDS appear to be based specifically on voice affect (Fernald, 1993; Kitamura and

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Burnham, 1998), with voice pitch serving as a vehicle for the heightened affect (Fernald and Kuhl, 1987; Kitamura and Burnham, 1998). Thirdly, it has been suggested that IDS serves a linguistic–didactic role – recent acoustic analysis studies demonstrate that IDS has a distinctive prosodic structure which may facilitate word learning (Kemler Nelson et al., 1989). Moreover, studies of IDS and ADS in four diverse languages (English, Russian, Swedish, Japanese) show that vowel space (indexed by first and second formant frequencies, F_1 and F_2 , for the corner vowels, /i/, /u/, and /a/) in IDS is expanded compared with ADS (Kuhl et al., 1997; Andruski et al., 1999; Burnham et al., 2002). Such linguistic universality in hyperarticulation has also been shown in ‘clear speech’ experiments which showed that there was equivalent vowel space expansion in crowded (English) vs. sparse (Croatian) vowel inventory sizes (Smiljanic and Bradlow, 2005).

It has been suggested that this exaggeration of the formant space (vowel hyperarticulation) actually assists spoken language acquisition by increasing the physical and perceptual separation between vowels (Kuhl et al., 1997). Indeed one study has shown that mothers’ degree of vowel hyperarticulation in IDS is positively correlated with their infants’ speech discrimination ability (Liu et al., 2003). Thus, it appears that IDS contains acoustic modifications which enhance the discriminability of speech contrasts (see however, Bard and Anderson, 1994; Foulkes et al., 2005; Davis and Lindblom, 2001 for some alternate views).

These three roles (linguistic–didactic, affective–emotional, and attentional) of IDS are, of course, not necessarily incompatible and may co-exist. For example, Fernald (1992) proposed that IDS assumes a mostly attentional and affective role in early infancy but a more linguistic–didactic role towards the end of the first year. An elaboration of this view is that these three components are independent and separable (Burnham et al., 2002). Burnham et al. (2002) tested this by comparing speech under three conditions: mothers talking to their infants, their pets, and unfamiliar adults. The rationale was that pet-directed speech (PDS) should contain similar attentional- and emotional–affective aspects to IDS, but dissimilar linguistic–didactic features. They found that IDS and PDS had equivalently heightened pitch and emotional affect compared with ADS, but that only IDS contained the modification likely to have a linguistic benefit – vowel hyperarticulation.

If speech to first language learners (infants) contains a separable linguistic–didactic component (vowel hyperarticulation), then it follows that speech to other audiences perceived to require linguistic instruction (e.g., foreigners) should contain a similar linguistic–didactic component, operating independently of attentional and emotional–affective components. That is, even if speech to foreigners is less attentionally-oriented (less extreme pitch excursions), and/or less affectively positive than speech to infants, there should be equivalent linguistic–didactic vowel hyperarticulation components in infant- and for-

Table 1

Analysis of possible populations in which speech registers would require linguistic and/or affective modification

		Didactic component	
		High	Low
Affective component	High	Infants	Pets, partners
	Low	Foreigners, elderly, disabled	Un-related/unfamiliar adults

eigner-directed speech. In short, as seen in the contrasts given in Table 1, the linguistic–didactic characteristics of speech should be orthogonal to the attentional and emotional–affective components.

To our knowledge, there are only two published studies which have investigated the *acoustic* properties of foreigner-directed speech (FDS). Papousek and Hwang (1991) found exaggerated pitch contours and pitch range in comparison to adult control conditions in a tonal language; and in a non-tonal language, Biersack et al. (2005) showed no increases in pitch range in speech addressed to foreigners in comparison to control conditions. However, both studies used imaginal situations rather than real interactions, so the results may not reflect realistic communication. Moreover, neither study measured voice affect or vowel hyperarticulation, so the exact emotional–affective and linguistic–didactic characteristics of FDS are, as yet, largely unexplored.

Given the hypothesized functional significance of hyperarticulation in IDS, it is of critical theoretical and practical importance to investigate whether vowel hyperarticulation also occurs in FDS, and in particular, whether it occurs independently of concurrent attentional and affective speech components. To this end, we investigated the attentional (pitch), emotional–affective (rated positive and negative affect), and linguistic–didactic (vowel hyperarticulation) characteristics of speech directed to those learning a second language (foreigner-directed speech), those learning a first language (infant-directed speech), and an adult native language control group. We hypothesized that the phonetic changes found in vowels in IDS would also be evident in FDS, whereas the heightened pitch and positive affect seen in IDS (as compared to ADS) would not be present in FDS.

2. Method

2.1. Participants

Ten British Southern English (Portsmouth, Hampshire region) dialect mothers (mean age 30.7) were recorded in interactions with: (1) a control British adult confederate (one of two English females aged 21 and 22 years with comparable southern English dialects), (2) a foreign adult confederate (one of two Chinese females aged 20 and 24 years with pronounced foreign accents), and (3) their own infant child (5 female, 7 male). The age of the infants ranged from around 4 months to 1 year (mean age around 37 weeks).

2.2. Design

The design was modelled on the repeated measures speech recipient design in Burnham et al. (2002): the repeated measures independent variable here had three levels (infant, foreigner, adult), and there were three dependent variables: pitch (indexed by mean $F0$), vowel space (indexed by mean vowel space plotted using $F1$ and $F2$ values of each of the three corner vowels, /i/, /u/, /a/), and voice affect (rated by independent raters).

2.3. Procedure

In three consecutive sessions mothers were instructed to interact with two confederates (one British and one foreign) and their infants for approximately 5–10 min (order of interactions in each condition was counterbalanced across participants). During each interaction, mothers were left alone with their infant, a foreign accent confederate, or a native British confederate. To facilitate interaction and ensure that instances of the corner vowels were elicited, participants were provided with three soft toys (a shark, a sheep and a small shoe), to provide focus for their conversations. For the infant interaction, they were required to introduce and play with the toys (calling them ‘sheep’, ‘shoe’, and ‘shark’, so to elicit the three corner vowels, /i/, /u/, and /a/); in the confederate interactions, confederates were instructed to conduct conversation around the toys and elicit the target words through discussions on topics which would typically elicit the target words. Example topics which the confederates might have used would be for example: “Which of these toys would you buy for your child?”.

All interactions were recorded in a quiet room in the mother’s home to facilitate natural interaction. A digital recorder (sampling rate: 12 kHz) and Sony electret condenser microphone placed on a table in front of the mother were used.

2.4. Acoustic analysis

The target vowels were analysed for pitch (reflected in $F0$), and vowel space (measured by vowel triangle area in $F1/F2$ space). Vowel portions, /i/, /u/, and /a/, from all instances of the target words ‘sheep’, ‘shoe’ and ‘shark’, were extracted from speech samples using Soundforge 6.0, then analysed using the pitch and formant frequency analysis capabilities of Praat 4.1.19. A total of 496 words were analysed acoustically across conditions (see Table 2) and the individual data were carefully inspected to ensure that there were sufficient observations to make reliable measurements of the vowel sounds. Two measures were derived for each mother: fundamental frequency and vowel triangle areas. The vowel triangle areas were calculated using Autocad software from plots of the first and second formants ($F1/F2$) of the corner vowels, /i/, /u/, /a/. Vowel length was also measured.

Table 2

Total number of words analysed within each recipient (IDS, FDS and ADS) and vowel (word) conditions

	IDS	FDS	ADS	Total
Shark	76	54	54	184
Sheep	60	39	36	135
Shoe	70	63	44	177
Total	206	156	134	496

2.5. Affective ratings

Short (approximately 30 s) excerpts of speech, clear of background noise and interspersed utterances by confederates or infants were excised from each sample, then low-pass filtered with a cut-off of 1000 Hz to render the speech unintelligible, while maintaining its prosodic qualities. These excerpts were then rated for positive and negative vocal affect by 24 listeners (15 females, 9 males, recruited from University of Portsmouth). Following two practice trials, participants rated each sample on the degree of negative and positive emotion using a Likert scale (1 = not at all; 5 = extremely) on a questionnaire based on those from previous studies (Burnham et al., 2002). The scales and the questionnaire were clearly explained to the participants. Order of presentation of speech sample types was randomized across participants.

3. Results

Phonetic (vowel triangle area), acoustic ($F0$), and affective measures were analysed using repeated measures analyses of variance and planned contrasts.

Formant values for $F1$ and $F2$ in the vowels of the target words ‘shoe’ ‘shark’ and ‘sheep’, plus resultant vowel triangles are shown in Fig. 1. It is interesting to note that the degree of difference between the vowels /u/ for ‘shoe’ and /i/ for ‘sheep’ were not as pronounced as they have been in previous studies. However, this result is understandable in terms of the differences between the Portsmouth English dialect compared to that of the American and Australian

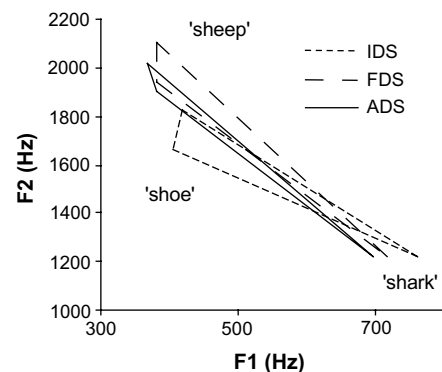


Fig. 1. Hyperarticulation of the three target vowels in the three conditions (adult-directed speech (ADS), infant-directed speech (IDS) and foreigner-directed speech (FDS)) as indexed by differences in $F1$ and $F2$.

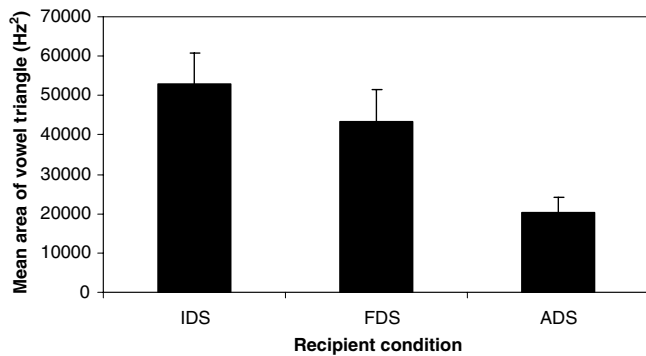


Fig. 2. Mean area calculated from the vowel triangle in $F2/F1$ space in the three conditions (adult-directed speech (ADS), infant-directed speech (IDS) and foreigner-directed speech (FDS)). Error bars show standard error.

English dialects used in previous studies. Notwithstanding the relative closeness of those two vowels, analysis of mean triangle areas (Fig. 2) still showed that vowel space was greater in IDS ($F(1/9) = 12.049$, $p < 0.01$) and FDS ($F(1/9) = 8.060$, $p < 0.05$) than in ADS, and that there was no difference in vowel triangle area between IDS and FDS ($F(1/9) = 0.769$, $p > 0.4$) (Fig. 2). This clearly shows that the phonetic modifications in speech to infants are also found in speech directed to a group with similar linguistic needs – foreigners.

It might be considered that the hyperarticulation differences could be the result of differences in vowel duration, so measurements of vowel duration were made and analysed. Vowel duration was somewhat longer in IDS (mean = 100 ms) than in ADS (68 ms; $F(1/9) = 26.578$, $p < 0.05$), but there was no significant difference between vowel duration in FDS and ADS ($F(1/9) = 2.378$, $p > 0.05$). If anything, FDS tended to have shorter vowels (63 ms) compared to ADS (68 ms). As these trends regarding vowel length, $IDS > ADS > FDS$, did not mirror the vowel area differences, $(IDS = FDS) > ADS$, it would appear that vowel length changes did not impact on the degree of hyperarticulation.

As can be seen in Fig. 3, mothers used higher mean pitch in IDS than FDS ($F(1/9) = 162.228$, $p < 0.01$) or ADS ($F(1/9) = 130.043$, $p < 0.01$), whereas pitch in FDS and ADS was statistically equivalent ($p > 0.1$) (Fig. 3). Given that the vowel triangle data suggests that IDS and FDS have similar linguistic functions, at least regarding vowel hyperarticulation, and with due regard to Table 1, these results suggest that heightened pitch is not a distinctly linguistic modification.

As expected, and as shown in Fig. 4, IDS had higher ratings of positive vocal affect than ADS ($F(1/9) = 60.324$, $p < 0.01$) or FDS ($F(1/9) = 94.442$, $p < 0.01$). Moreover, ADS had higher positive vocal affect than FDS ($F(1/9) = 7.451$, $p < 0.05$) (Fig. 4). Interestingly, a complementary trend was found for negative vocal affect: IDS had less negative vocal affect than both ADS ($F(1/9) = 48.836$, $p < 0.01$) and FDS ($F(1/9) = 64.703$, $p < 0.01$). Surpris-

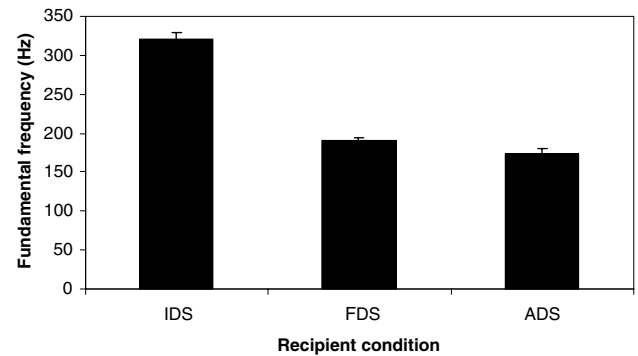


Fig. 3. Mean pitch (fundamental frequency in Hz) for each condition (adult-directed speech (ADS), infant-directed speech (IDS) and foreigner-directed speech (FDS)). Error bars show standard error.

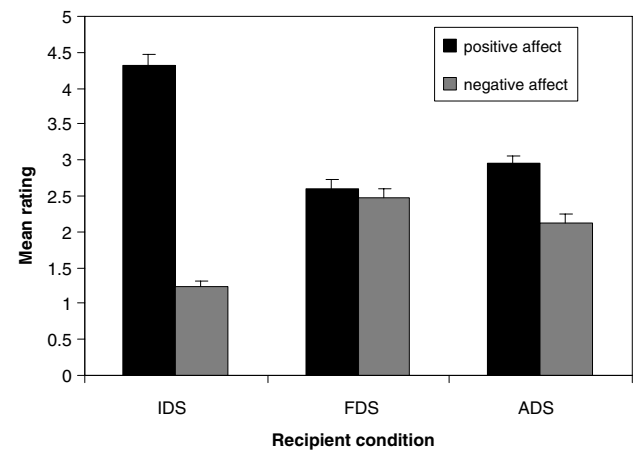


Fig. 4. Mean positive and negative affect rating for each condition (adult-directed speech (ADS), infant-directed speech (IDS) and foreigner-directed speech (FDS)). Error bars show standard error.

ingly, ADS also had significantly lower levels of negative vocal affect than FDS ($F(1/9) = 7.967$, $p < 0.05$) (Fig. 4). So it appears that higher positive affect in the voice is not a distinctly linguistic modification, nor is it a modification that invariably accompanies vowel hyperarticulation. Indeed vowel hyperarticulation here was accompanied by high positive affect in IDS, and high negative affect in FDS.

4. Discussion

These results provide strong evidence for the generality of vowel hyperarticulation as a didactic device for instruction of language learners. It occurs in both IDS and FDS, which are directed to recipients with different emotional yet similar linguistic needs – both infants and foreigners could be perceived to be less competent in (English) language. Moreover, the results support the independence of acoustic, affective, and linguistic characteristics of these speech registers (Burnham et al., 2002): there is equivalent vowel hyperarticulation in IDS and FDS irrespective of the findings that FDS has (i) significantly less positive and more negative affect than IDS, and (ii) lower voice pitch.

These findings support Kuhl's view that vowel hyperarticulation in IDS is a didactic device. Kuhl suggests that hyperarticulation in IDS exaggerates relevant phonetic contrasts by emphasizing extremes of the language-specific phonetic prototypes (Kuhl et al., 1997; Kuhl, 2000, 2004). We suggest that hyperarticulation in FDS serves a similar purpose. Vowel hyperarticulation provides a template of the vowel space of the language in question (Kuhl et al., 1997), and serves to emphasize differences between non-native vowels for the foreigner. In this way, FDS would assist second language (L2) learners in developing the necessary phonemic discrimination skills to understand and produce the new language successfully, just as IDS facilitates infants' speech discrimination (Liu et al., 2003). Of course, the linguistic benefit of FDS for foreigners can only be presumed at this stage, and requires further study whether there is a linguistic benefit, and if so, its strength, nature, and the conditions under which it occurs.

Future work could examine other acoustic measures that may indicate prosodic modifications in speech (e.g. loudness, pitch contours). With regard to pitch contours in particular, we are currently working on novel quantitative approaches to analysing pitch contours and will present those data in due course (see Knoll et al., 2006, for preliminary results). With respect to loudness, our experimental setup would only permit measurement of approximate relative loudness differences in the three conditions and therefore would be of limited value. For this reason, we would suggest that future work should use a setup for measuring absolute loudness levels, which would provide a better, more accurate test of loudness in each condition. Under such conditions, it might be expected that foreigner- and infant-directed speech would be louder (or at least have greater modulation of loudness in the case of IDS) compared to adult-directed speech. Also, given the relative closeness of the vowels /u/ for 'shoe' and /i/ for 'sheep' in this dialect, it may be useful to replicate the result with other contrasts or indeed to determine the vowel distributions in a larger normal population sample size.

The results regarding voice affect are particularly interesting. Consistent with former research, positive affect was higher in IDS than ADS (Burnham et al., 2002; Kitamura and Burnham, 2003). However, we were surprised to find that FDS was actually perceived to express *more negative* affect than ADS, a result that can not be explained in terms of pitch differences (since mean *F0* was more or less equivalent in FDS and ADS). Among the many possible explanations for this are the potential speaker frustration with the need to modify their speech, or even sub-conscious prejudice. Clearly further research is required to separate the many possible extraneous factors that could be at play here. In our study, the foreign confederates (Chinese) would have both looked and sounded foreign to the native English participants. A logical next step would be to separate the factors 'looking foreign' (e.g., Chinese person who is a native English speaker) or only 'sounding foreign' (e.g. Anglo-European person with a pronounced accent). It may

also be useful to look at the 'degree of foreignness' and the effect that this might have on hyperarticulation. Such data could be used to develop models that predict when hyperarticulatory changes begin, as has been done in describing human-computer interaction using auditory input (for example, in Automatic Speech Recognition Systems) (Oviatt et al., 1998).

There are two main conclusions that can be drawn from this study. First, the results clearly show the independence of vowel hyperarticulation from affective modifications in speech production. In previous studies with infant-and pet-directed speech (Burnham et al., 2002), vowel hyperarticulation has always been accompanied by heightened positive affect. Here, vowel hyperarticulation occurs not only in the absence of heightened positive affect in IDS, but even in the presence of heightened *negative* affect in FDS. Second, the results provide strong evidence for the pervasiveness of the didactic aspect of special speech registers – this occurs both when speaking to L1 (infants) and L2 (foreigners) learners of, in this case, English. Clearly, speech is modified with infants to emphasize relevant phonetic contrasts, and also to other populations perceived to be in need of linguistic instruction. The findings support the view that speakers adapt their speech to address the needs of the target audience, combining acoustic, affective and linguistic components as required. In this sense, foreigner-directed speech, despite its tendency to engage negative affect, is at least in part an adaptive and instructive device.

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