Speech production characteristics of parents of hard-of-hearing toddlers

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Research Questions

1. Does child-directed speech (CDS) differ between parents of children who are hard-of-hearing (HH) and parents of children who are typically developing (TD)?

2. Does speech differ between:

-fathers of HH children and TD children?

-mothers of HH children and TD children?

Background

Studies of CDS have shown that when talking to children, parents systematically use altered linguistic forms: simplified syntax, elided morpho-phonological forms, and exaggerated duration and prosody. Notable among these is increased fundamental frequency (f_0; Ferguson, 1964; Fernald, 1989, 1991; Kuhl, et al, 1997). Similarly, the Lombard effect (Lombard, 1911; Fairbanks, 1954; Lane & Tranel, 1971) occurs when talkers alter speech production characteristics based on perceived deficiencies of the listener. Notably, increased f_0 has been documented when a talker addresses a person with a hearing loss (Summers, et al, 1988; Patel & Schell, 2008). Thus, f_0 increases have been documented when talking to children *and* when talking to a listener with a hearing loss. One study shows that mothers of young children with cochlear implants modify f_0 according to the hearing experience of the children (Bergeson, Miller, & McCune, 2006). No studies to date have looked at parental speech to children with mild-to-severe hearing loss. There is also a dearth of research on father's CDS to children with hearing loss.

Method

Participants

TD Families

11 families with a typically developing preschooler.

HH Families

22 families with a preschooler with mild-severe hearing loss.

Sample included boys and girls (mean age of ~30 months) who wore hearing aids and had no other disabilities. All children were involved in a larger longitudinal study.

Materials

Data was collected using the LENA system (Language ENvironment Analysis; LENA foundation, Boulder, CO) and custom software for analysis of f_0 developed in MATLAB.

A small acoustic recording device which records up to 16 hours of raw audio on a solid state drive.

Procedure & Data Analysis

Each family contributed whole-day audio recordings during a typical family day. The recorder was placed in a chest pocket at a fixed position from the child's mouth (7-10cm). 491.2 recorded hours were collected and processed by ASR software. Recordings were automatically segmented at centisecond resolution, and statistical likelihood techniques of the ASR assigned one of about 60 a priori labels to each segment. Labels include *adult male, adult female, key child vocalization, other child vocalization, overlapping vocals, noise, silence*, and *TV/electronic media*. f_0 was collected from segments labeled as parent vocalizations. *t*-tests were used to evaluate difference between groups.

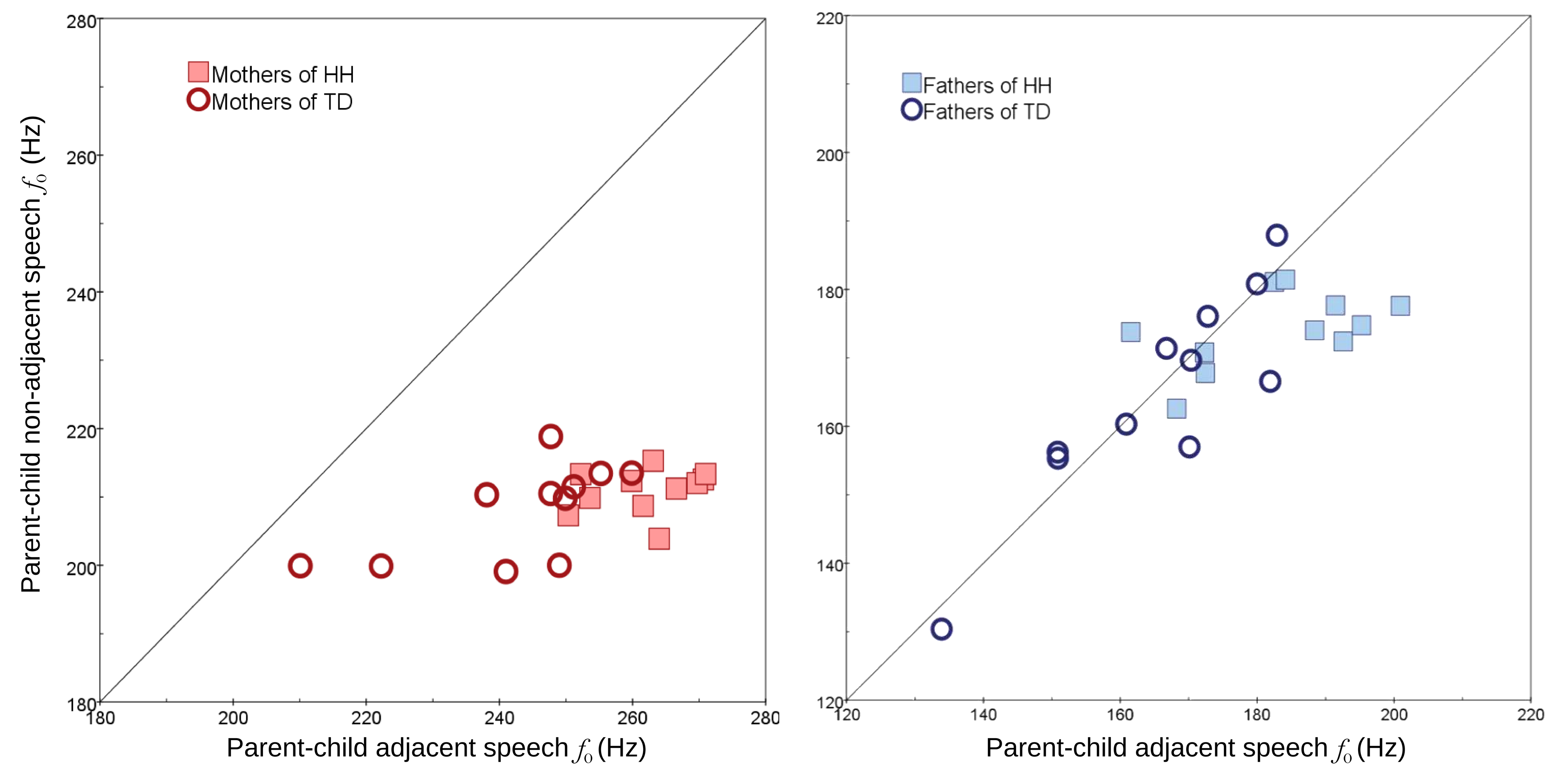

Figure 1. Parent-child non-adjacent speech is plotted on the ordinate and Parent-child adjacent speech is plotted on the abscissa. Mothers are plotted in the left panel in red markers and fathers in the right panel in blue markers. An observation on the bisector indicates equal f_0 in both conditions, and an observation below or above the line indicates f_0 increases in the Parent-child adjacent or the Parent-child non-adjacent condition, respectively.

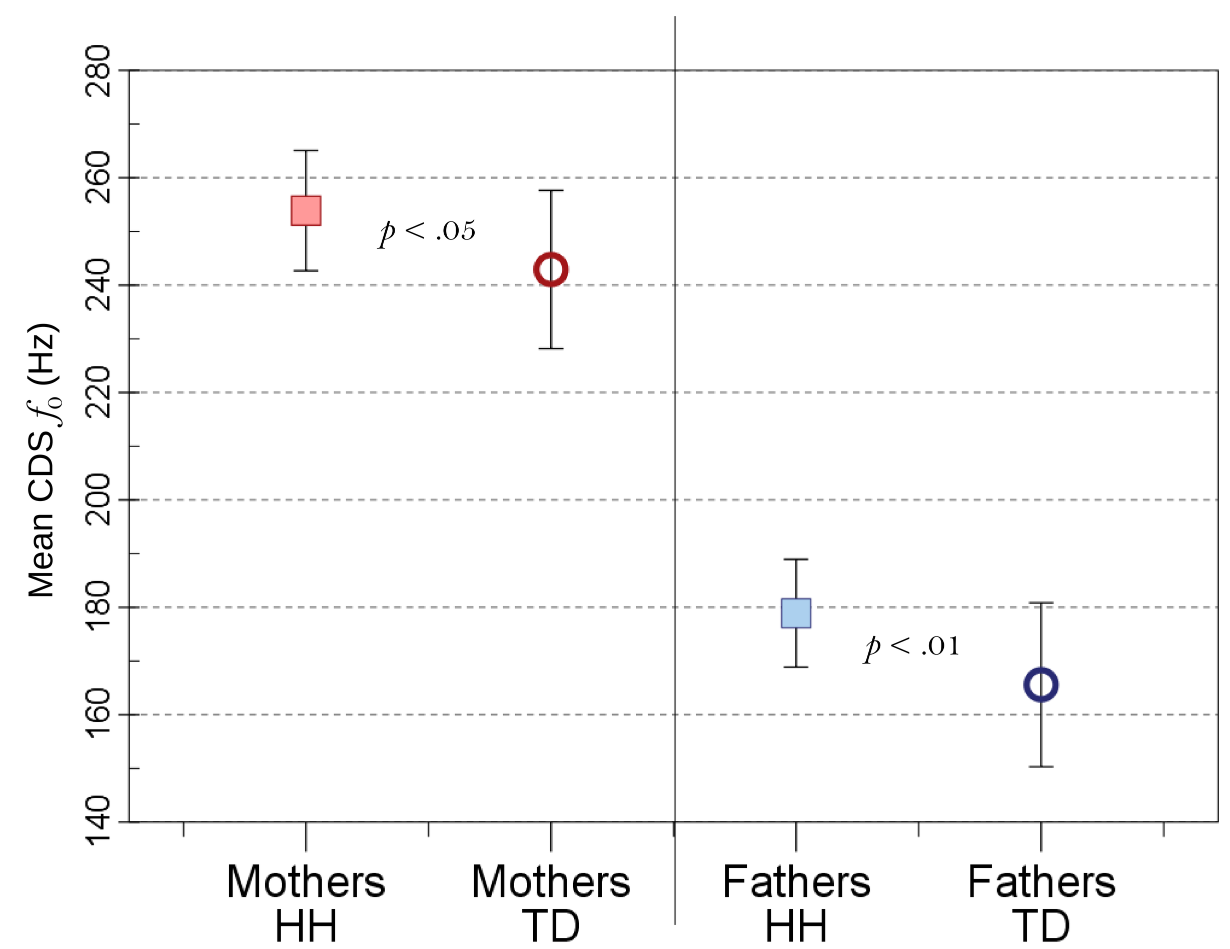

Figure 2. Mean difference in CDS speech f_0 between mothers of hard-of-hearing children with mothers of typically-developing children (left) and fathers of hard-of-hearing children with fathers of typically-developing children (right).

Results

Parents have increased f_0 during CDS

M_{CDS} = 212Hz, *SD* = 12Hz; M_{nonCDS} = 192Hz, *SD* = 8Hz; $t(31) = 3.59$, $p < .01$

The effect of increased f_0 for CDS holds for mothers but <u>not</u> for fathers

MOTHERS: M_{CDS} = 250Hz, *SD* = 13Hz; M_{nonCDS} = 211Hz, *SD* = 5Hz; $t = 18.6$, $p < .01$;

FATHERS: M_{CDS} = 174Hz, *SD* = 13Hz; M_{nonCDS}= 173Hz, *SD* = 11Hz; $t = .55$, $p > .05$

	Mother	Father
TD Child	**Increase f_0** (M_{CDS} = 242; M_{nonCDS} = 207; $p < .01$)	**No change** (M_{CDS} = 166; M_{nonCDS} = 164; $p > .05$)
HH Child	**Increase f_0** (M_{CDS} = 253; M_{nonCDS} = 212; $p < .01$)	**No change** (M_{CDS} = 179; M_{nonCDS} = 178; $p > .05$)

	CDS	ADS
Mother of TD	*M* = 242 *SD* = 14	*M* = 207 *SD* = 7
Mother of HH	*M* = 253 *SD* = 11	*M* = 212 *SD* = 4
	$t(31) = 2.38$ **$p < .05$**	

	CDS	ADS
Father of TD	*M* = 166 *SD* = 15	*M* = 164 *SD* = 15
Father of HH	*M* = 179 *SD* = 10	*M* = 178 *SD* = 6
	$t(31) = 3.01$ **$p < .01$**	

Conclusions

1. **Overall, mothers increase f_0 while fathers show no changes during CDS. Mothers of HH and TD children both show increases in f_0 during CDS; fathers of both HH and TD children fail to show an effect of CDS.**
2. **When looking at parental speech as a whole, (a) fathers of HH children have a higher overall f_0 than TD fathers and (b) mothers of HH children have a higher overall f_0 than TD mothers.**

Future directions

- Do other factors influence how mothers or fathers talk to their children (degree of hearing loss, age or sex of child, etc.)?
- What are the developmental consequences of asymmetry in parental CDS?
- These results and further research could inform how automatic speech recognition can be used in theoretical and applied language research.

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