Perception of gender in ten-year-old children's voices*

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Seven experts perceptually evaluated the connected speech of 205 children and the sustained vowel [a:] of 50 of the children along several voice parameters. Interjudge reliability was high. For both conditions there were significant differences in perceived voice quality between boys and girls. In addition, the listeners were asked to make a judgment on the gender of each child. For connected speech, they correctly decided on the gender of 80.6 per cent of the children. When listening to sustained vowels, the experts identified the sex of the children in 69.5 per cent of the cases. Discriminant analyses based on the significant voice quality variables for both conditions correctly grouped 76.5 per cent and 74 per cent of the children, respectively.

Key words: voice quality, gender, children's voices, perceptual analysis.

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INTRODUCTION

It has been shown that listeners can identify the sex of prepubertal children on the basis of recordings of connected speech (9, 1, 6, 7) as well as sustained vowels (9, 1). Both Bennett and Weinberg (2) and Ingrisano, Weismer and Schuckers (6) found difference in formant frequencies between boys and girls to be one of the acoustic correlates of perceived sexual identity. Formants produced by prepubertal boys are generally lower than those of girls (2, 6, 3), indicating a difference in the size of the vocal tract. However, Kirchner (8) stated that the larynx of a preadolescent boy and girl is likely to be the same size given the same height and weight. It has been suggested that gender specific articulatory behavior, such as difference in jaw opening and lip rounding, could be of significance to the variance in formant frequencies between boys and girls (1). Furthermore, gender related vocal habits could contribute to differences in perceived voice quality between boys and girls. In fact, vocal fry or creak has been found to be a marker of adult male speech, whereas a breathy voice was observed to be common in adult female speakers (4, 5).

The purpose of the present investigation was to find out whether the sex of Swedish ten-year-old children could be identified by perceptual judgment of their voices. More specifically, we wanted to find out whether quality of voice is a cue for gender recognition in children's connected speech and sustained vowels.

METHODS

Subjects

Two hundred and five ten-year-old children, 104 girls and 101 boys, from three geographical areas in Sweden participated in the study. The districts were chosen so as to neutralize any dialectal influence on voice quality.

Recordings and preparation of voice material

The voices of the children were recorded in acoustically reasonably attenuated rooms in their schools using a Sony TCD-D1 (pitch range) DAT tape recorder. A lightweight Sony ECM-55B condenser microphone was mounted on a pair of glasses to ensure a stable and constant microphone distance, ca 15 cm, and to eliminate the risk of air blast. Each child read a short text of ca 30 sec and 50 of them (26 girls and 24 boys) were also asked to sustain the vowel [a:] at habitual pitch and loudness.

Perceptual ratings

The children's voices were perceptually evaluated along visual analog scales by seven female speech-language pathologists. They rated the connected speech

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Table 1. *Mean and range of correctly identified sex by seven listeners for connected speech (N = 205) and sustained vowels (N = 50)*

Subjects	Connected speech			Sustained vowels		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Boys	79.3%	63.0%	89.0%	67.4%	58.3%	75.0%
Girls	81.9%	71.4%	93.0%	71.6%	61.5%	84.6%
Total	80.6%			69.5%		

for Hoarseness, Breathiness, Hyperfunction, Hypofunction, Gratings/high pitched roughness, Roughness, Unstable pitch/quality, Hard glottal attacks, Vocal fry, and Pitch. The vowel samples of 50 of the children (26 girls and 24 boys) were rated for those 6 voice parameters that received high loadings in the Hoarseness factor in a previous experiment with 205 voices (10); in that experiment a factor analysis revealed three perceptual dimensions of major relevance to the perception of voices. The parameters were Hoarseness, Breathiness, Hyperfunction, Gratings/high pitched roughness, Roughness, and Unstable pitch/quality. In addition, the listeners were asked to make a judgment on the gender of each child.

RESULTS

Gender identification

The listeners identified the sex of 80.6 per cent of the children by listening to their reading of a passage and in 69.5 per cent of the children who produced sustained vowels, see Table 1. All seven listeners correctly decided on the gender of 100 (48.8 per cent) of the 205 children from their connected speech and 18 (36 per cent) out of 50 children's sustained vowels.

Perceptual ratings

Interrater reliability was satisfactory or high for all perceptual parameters, the mean interjudge reliability for all voice ratings being 0.81 (Cronbach's alpha).

For connected speech, the boys' voices were rated to be significantly more hoarse ($p = 0.001$), hyperfunctional ($p = 0.000$) and rough ($p = 0.000$) than those of the girls. The boys were also perceived to speak with significantly more hard glottal attacks ($p = 0.007$), unstable pitch/quality ($p = 0.008$) and in a lower pitch ($p = 0.000$). On the other hand, the girls were rated to speak with more vocal fry ($p = 0.038$) and to have significantly more hypofunctional voices ($p = 0.000$) than the boys.

In the case of sustained vowels, the boys' voices were perceived to contain significantly more gratings/high pitched roughness ($p = 0.043$) and roughness ($p = 0.006$) than those of the girls. There was also a tendency for the boys to be rated as more hoarse than the girls ($p = 0.06$).

Discriminant analyses

In order to test whether differences in perceived quality of voice between boys and girls could constitute cues for gender recognition in children's connected speech and sustained vowels, stepwise discriminant analyses were carried out (see Table 2). The analyses were based on all variables that reached significance in the t-tests of the difference between the mean ratings of the perceptual parameters. For connected speech, an analysis based on perceived Hoarseness, Hard glottal attacks, Hyperfunction, Hypofunction, Pitch, Roughness, Vocal fry, and Unstable pitch/quality correctly grouped 79 per cent of the boys and 74 per cent of the

Table 2. *Classification of children according to gender. Discriminant analyses based on significant differences in perceived voice quality for connected speech and sustained vowels*

Group	Connected speech			Sustained vowels		
	N	Predicted group membership		*N*	Predicted group membership	
		Boys	Girls		Boys	Girls
Boys	100	79	21	24	15	9
		79.0%	21.0%		*62.5%*	37.5%
Girls	105	27	78	26	4	22
		25.7%	*74.3%*		15.4%	*84.6%*
	Cases correctly classified: 76.5%			*Cases correctly classified: 74%.*		

Table 3. *Classification of children that had been correctly classified according to gender by all listeners. Discriminant analyses based on significant difference in perceived voice quality for connected speech (N = 100) and sustained vowels (N = 18)*

Group	Connected speech			Sustained vowels		
	N	Predicted group membership		*N*	Predicted group membership	
		Boys	Girls		Boys	Girls
Boys	48	45 *93.8%*	3 6.3%	7	5 *71.4%*	2 28.6%
Girls	52	4 7.7%	48 *92.3%*	11	0 0.0%	11 *100%*
	Cases correctly classified: 93%			*Case correctly classified: 88.89%*		

girls according to gender. For sustained vowels, 62.5 per cent of the boys and 84.6 per cent of the girls were correctly classified. In that case, the analysis was based on listeners' ratings of degree of Gratings, Hoarseness and Roughness.

The strength of perceived voice quality as a cue for listeners' identification of gender in children was tested with discriminant analyses involving only those children that were correctly classified according to gender by all listeners (Table 3). For connected speech, the analysis correctly grouped 93.8 per cent of the boys and 92.3 per cent of the girls according to gender. For sustained vowels, 71.4 per cent of the boys and 100 per cent of the girls were correctly classified.

CONCLUSIONS

Our study of perception of gender in ten-year-old children rendered the following conclusions:

- The sex of Swedish ten-year-old children could be identified by perceptual judgment of their voices in connected speech as well as in sustained vowels.
- There was a difference in perceived voice quality between boys and girls both for connected speech and sustained vowels.
- Quality of voice was found to be a cue of significance for gender recognition in children's voices.

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SAMMANFATTNING

Bedömning av kön hos tioåringars röster

Tvåhundrafem tioåringars löpande tal och 50 av

barnens uthållna vokaler bedömdes av 7 erfarna röstlogopeder. Lyssnarna skattade rösterna med avseende på ett antal röstkvalitéparametrar. Interbedömarreliabiliteten var genomgående hög. För löpande tal befanns pojkarnas röster vara signifikant mer hesa, hypertona och skrovliga. De hade också fler hårda ansatser, mer instabil röstklang och lägre grundton, medan flickornas röster var mer knarriga och hypofunktionella. När det gällde uthållna vokaler, skattades pojkarnas röster som mer skrapiga, skrovliga och hesa.

Lyssnarna ombads också bedöma vilket kön talaren hade. De gjorde en korrekt bedömning av 80,6% av barnen utifrån deras löpande tal. När experterna lyssnade på uthållna vokaler, kunde de rätt avgöra barnens kön i 69,5% av fallen. Diskriminantanalyser baserade på de signifikanta röstkvalitévariablerna gjorde korrekta könsindelningar för 76,5% av de barn som läste en text och 74% av dem som höll ut en vokal. När endast de barn, vars kön hade identifierats av samtliga 7 lyssnare inkluderades i en diskriminantanalys, grupperades barnen korrekt i 93% respektive 88,89% av fallen. Det visade sig således att röstkvalité utgör en betydelsefull ledtråd vid bedömning av kön hos tioåringar utifrån såväl löpande tal som uthållna vokaler.

YHTEENVETO

Sukupuolen tunnistus kymmenvuotiaiden lasten ääninäytteistä

Tutkittiin 205 puhe- ja 50 pitkää ääntönäytettä, jotka olivat kymmenvuotiaiden lasten tuottamia. Seitsemän kokenutta kuulijaa arvioi ääninäytteistä erilaisia ääntä kuvaavia piirteitä. Tutkijoiden välinen korrelaatio oli korkea. Puhenäytteistä arvioituna olivat poikien äänen käheämpiä, puristeisempia ja karkeampia. Heillä oli myös enemmän kovia alukkeita, epävakaampi äänensävy ja matalampi perustaajuus, kun taas tyttöjen äänet kulostivat narisevammilta ja hypofunktionaalisemmilta. Poikien pitkät äännöt kuulostivat karheammilta ja käheämmiltä.

Kuulijoita pyydettiin myös arvioimaan puhujan sukupuoli, joka osui oikeaan 80,6%:ssa puhenäytteistä. Pitkän äännön perusteella sukupuoli arvioitiin oikein 69,5%:ssa. Äänen laatua kuvaavien muuttujien avulla osuttiin oikeaan 76,5%:ssa puhenäytteistä ja 74%:ssa pitkistä äännöistä. Kun vain ne lapset, joiden sukupuolen olivat kaikki seitsemän kuulijaa arvioineet oikein, otettiin mukaan analyysiin ryhmiteltiin oikein vastaavasti 93% ja 88,9% tapauksista. Osoittautui siis, että äänen laatu antaa merkittäviä vihjeitä kymmenvuotiaan sukupuolesta.