THE RELATION BETWEEN PERCEIVED HYPERNASALITY OF CLEFT PALATE SPEECH AND ITS HOARSENESS

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Imatomi, Setsuko 1; Arai, Takayuki 2

1. Phonetics Laboratory, Sophia University,
2. Dept. of Electrical and Electronics Eng., Sophia University

7-1, Kioi –cho, Chiyoda-ku
Tokyo 102-8554
Japan
Tel: +81-3238-3492
Fax: +81-33238-3492
e-mail:s-imatom@hoffman.cc.sophia.ac.jp

ABSTRACT

Formerly, we had reported that rating hypernasality of speech in cleft palate patients is affected by the presence of hoarseness, especially “rough hoarseness”. In the present study, we further investigated the effects of “breathy hoarseness”, something frequently observed in cleft palate children, on the rating of hypernasality. We also controlled the degree of breathiness by adding harmonic components to source signals. Based on a perceptual experiment we confirmed that the rating of hypernasality was also affected by breathiness, that it was highest proportionate to the degree of harmonic components in breathiness.

INTRODUCTION

The effect of hoarseness on rating of hypernasality in the assessment of cleft palate speech has been reported previously [1,2,3]. In those studies, we examined the effects of the presence of "roughness", one of two major types of hoarseness, in order to make a new rating scale for hoarse voices. Imatomi (1999 a) and Imatomi (1999 b) reported that roughness which was synthesized by pitch-synchronous waveform editing method, lowered the rating hypernasality [1,2]. Imatomi (2000) divided the speech signal into its source and filter by inverse filtering, and demonstrated that the presence of roughness in the source generally lowered the rating of hypernasality [3].

The other main type of hoarseness is " breathiness", which is a focus of this investigation. In order to answer the question, 'Why is hypernasality less obvious in the presence of hoarseness?' the current study investigates two factors relating to breathiness: 1) the change of rating hypernasality according to the degree of breathiness, 2) the effect of "breathiness" on the rating of hypernasality.

PROCEDURE

Speech Samples

Four samples were obtained: one was taken from the normal, one from the child with voice problem, and the rest from sample tape of cleft palate speech [4]. They consisted of the Japanese vowels /a/ and /i/. The perceptual characteristics of each sample were normal, breathy, mild to moderate hypernasal, and severe hypernasal.

Synthesis of Stimuli

To synthesize the stimuli, we combined sources and filters as follows:

1) Each of four original samples was divided into its source signal and system function (filter) by an inverse filtering based on the improved cepstrum technique.

2) The glottal pitch cycles of the source signal of the breathy speech sample were marked semi-automatically, i.e., picking peaks of low-passed signals and hand correction. We then added an impulse with six levels of magnitude to the source signal for each glottal cycle:

level 0: no impulses were added (the original source signal);

level 1-5: the magnitude was increased proportionally to the level.

3) Six levels of source signals of the breathy speech sample were combined with three filters,

each of which was obtained from the speech sample with three different degrees of hypernasality:

[6 breathy sources x no hypernasal],

[6 breathy sources x hypernasal (mild to moderate)], and

[6 breathy sources x hypernasal (severe)].

Eighteen stimuli were obtained in total.

Preparation of Stimuli for Rating

Three kinds of hypernasality (none, mold to moderate, severe) at 6 levels of breathiness were repeated three times. Original samples were further added to the set of stimuli to check the reliability of ratings. Consequently, 114 (both 57 for /a/ and /i/) arranged in random order were developed for rating.

Perceptual Experiment

Three experienced speech pathologists with normal hearing served as raters. They were asked to rate the hypernasality of the stimuli on the five-point scale shown in Table 1. The stimuli were presented to each subject on Microsoft power point running on PC. Prior to the experiment, standard samples for rating were presented.

Table1.- Five-point scale for hypernasality rating

Rate of hypernasality
0:no hypernasality 1:mild hypernasality 2:mild to moderate hypernasality 3:moderate hypernasality 4:severe hypernasality

RESULTS

All three raters had highly reliable responses in the three trials. Fig. 1-6 show the mean rating scores of hypernasality of the stimuli in the three trials. The X axis shows the kinds of sources, the Y axis shows the three raters, and the Z axis shows the rating score of hypernasality.

1) The change of rating score of hypernasality according to the degree of breathiness

The results showed roughly that the rating scores were higher as the number of level of source increase. (Fig. 1,2,3,4, and 6).

2) The effect of breathiness on the rating of hypernasality

The results differed with the levels of hypernasality in the original samples. Breathy sources (level 0) lowered the rating scores of hypernasality when the sources were combined with mild to moderate hypernasal filters (Figs. 2 and 5), and severe hypernasal filters (Figs. 4 and 6). When the sources were combined with no hypernasal filters, hypernasality was perceived unexpectedly by breathiness (Figs.1 and 3). Stronger effects of breathiness were observed for /i/ for than for /a/. Differences among raters were also observed. Especially for severe hypernasal /i/, the difference of effects of breathiness between rater 2 and rater 3 was prominent (Fig. 6)

Figure 1. -The rating scores of hypernasality among sources no hypernasal /a/

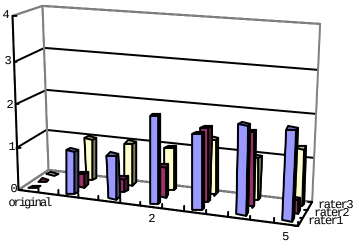


Figure 4. -The rating score of hypernasality among sources no hypernasal /i/

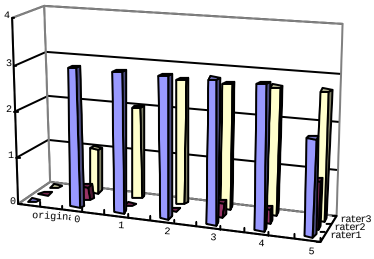


Figure 2. -The rating score of hypernasality among sources mild to moderate hypernasal /a/

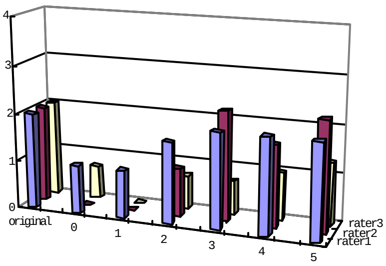


Figure 5. -The rating score of hypernasality among sources mild to moderate hypernasal /i/

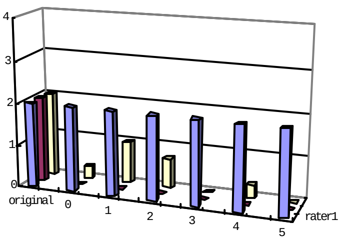


Figure3. -The rating score of hypernasality among souces severe hypernasal /a/

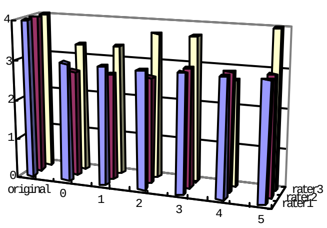
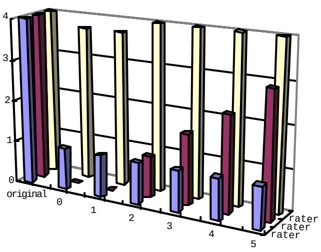


Figure 6. -The rating score of hypernasality among sources severe hypernasal /i/



DISCUSSION

The two acoustic correlates of hoarseness are perturbation in the fundamental period and laryngeal noises. The former relates to roughness [5], and the latter to breathiness [6]. The pitch-synchronous editing in our previous study yield perturbation, especially jitter, in normal voice, and we believed it decreased the degree of perceived hypernasality [1,2]. This time we succeeded in synthesizing different degrees of hoarseness by addition of harmonic components to breathiness, and we showed that perceived hypernasality decreased according to the increase of harmonic components. We surmise, then, that any irregularity in speech sound may affect perceived hypernasality.

The reason hoarseness decreased the rating of hypernasality has been considered in our previous studies. Previously, we were not certain that the spectral change of the stimulus from the addition of hoarseness was the cause of decreased perceived hypernasality [1,2,3,]. Therefore, we examined the spectral envelopes of each stimulus in this study. No prominent difference in spectral envelopes among the six degrees of breathy sources was found. However, the spectral envelope was different within the original three kinds of samples; no hypernasality, mild to moderate hypernasality, and severe hypernasality. Consequently, we suggest that perceptions of hypernasality with and without hoarseness might work differently. We need to investigate the perception of hypernasality further.

From a clinical point of view, the effects of breathiness on the rating of hypernasality warned us of the potential for misdiagnosis regarding the velopharyngeal function of cleft palate patients. Breathiness affected the rating score of hypernasality in a more complex way than roughness did. It differed among the levels of original hypernasality, between the vowels, and among raters. A more detailed study will be needed in order to make a new rating scale applicable to various voices.

CONCLUSIONS

In this study the effects of breathy hoarseness on rating of hypernasality were investigated. The results showed more variety in vowels and raters than rough hoarseness. The degree of breathiness, which was controlled on a harmonics-to-noise ratio (HNR), affected the rating of hypernasality. The higher the HNR of source, the more hypernasality was perceived.

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