EFFECTS OF HOARSENESS ON HYPERNASALITY RATINGS

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ABSTRACT

We investigated how hoarseness effects perceived hypernasality ratings in order to make a rating scale for hoarse voices. Thirty stimuli, of which 18 were target stimuli (three each for voices with and without hoarseness at three levels of hypernasality), and of which 12 were foil stimuli. These voices were listened to by four experienced speech pathologists. They were asked to rate hypernasality on 5-point scale. Perceived hypernasality decreased with hoarseness for a severely hypernasal voice, but results varied among the listeners for voices with no and moderate hypernasality.

1. INTRODUCTION

In a normal individual, the ability to separate the nasal cavity from the oral cavity by the movement of the velum toward the posterior nasopharyngeal wall, called “velopharyngeal competence” is exercised during swallowing, speaking, and blowing [1]. Children with a cleft palate who have a congenital fissure in the palate of the mouth may show “cleft palate speech”, for example, hypernasality, nasal emission, and some compensatory articulation, even after their clefts have been repaired by surgery. This is because velopharyngeal competence gets worse as the mouths of children grow [2],[3].

Ratings of hypernasality by auditory trained speech pathologists are frequently used to assess clinically velopharyngeal competence in clinical settings, because perceived hypernasality in vowels reflects the degree of velopharyngeal competence. For “mixed voice” having of hypernasality and some other voice disorders, it has been thought to be difficult to assess velopharyngeal competence by an auditory rating. Though a sample tape of cleft palate speech [4] provides a reference point for rating typical hypernasal voices, “mixed voices” such as hypernasal voices with hoarseness have not yet investigated.

We examined the effect of hoarseness on hypernasality ratings by a perceptual experiment using synthesized voices in order to make a new scale for hoarse voices. As an analysis/synthesis system for hoarse voice, Kasuya and Endo [5] have developed a vocoder system using the ARMA model. Their system analyzes the pitch period, the root-mean-square amplitude, and the spectrum; these parameters are then used for synthesizing stimuli. In this study, we synthesized a hypernasal voice with hoarseness by a pitch-synchronous editing method. A target signal was truncated at every pitch period, and the pitch segments were concatenated with perturbation.

2. STIMULI

The stimuli for ratings were synthesized by editing pitch-synchronous waveform from three kinds of speech samples having no, moderate and severe hypernasality.

2.1 Speech samples

Samples were obtained from the speech of normal and cleft palate children, and four patients with laryngeal problems. They produced the Japanese vowels /a/ and /i/ in repetition tasks. The sample sounds were digitized with 16 kHz sampling rate with 16 bit quantization.

2.2 Synthesis of stimuli by pitch-synchronous waveform editing

To obtain a hypernasal voice with hoarseness, we synthesized the stimuli in the following way:

1) The pitch period sequence Px[k] was computed from a sample of hoarse voice x[n] and Py[k] from an input speech signal y[n].

2) The signal y[n] was truncated at every pitch period indicated by Py[k].

3) The sequence Px[k] was normalized by its mean value and shifted with a bias.

4) The resultant sequence of 3) was multiplied by the mean of Py[k].

5) The output signal was composed by concatenating the pitch segments from 2) based on the new sequence 4) (zero samples were padded between every two consecutive pitch segments).

2.3 Stimulus sets for ratings

Thirty sets of stimuli were developed, of which 18 were target stimuli (three each for voices with and without hoarseness at three levels of hypernasality) and 12 were foil stimuli. Each set was organized as follows:

Number, /a/ ___ , /i/___ , /a/ ___ , /i/___

(/a/, /i/ produced by speech pathologist)

Each stimulus was embedded into the places of ___ in each set, in form of repetition task.

Two kinds of stimulus tape were prepared , with each containing 30 sets of stimuli in two different ramdom orders.

3. PERCEPTUAL EXPERIMENT

Four experienced speech pathologists with normal hearing were asked to rate hypernasality of the stimuli on the 5-point scale shown in Table 1 .

The stimuli were presented to the four listeners separately at their comfortable level over a headphone from a cassette tape recorder (SONY TC-D5M). Prior to the experiment, a training session was held for each listener. In the session examples of each rating category of hypernasality and their stimuli were presented for exercise.

Table 1 5-point scale for hypernasality rating

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

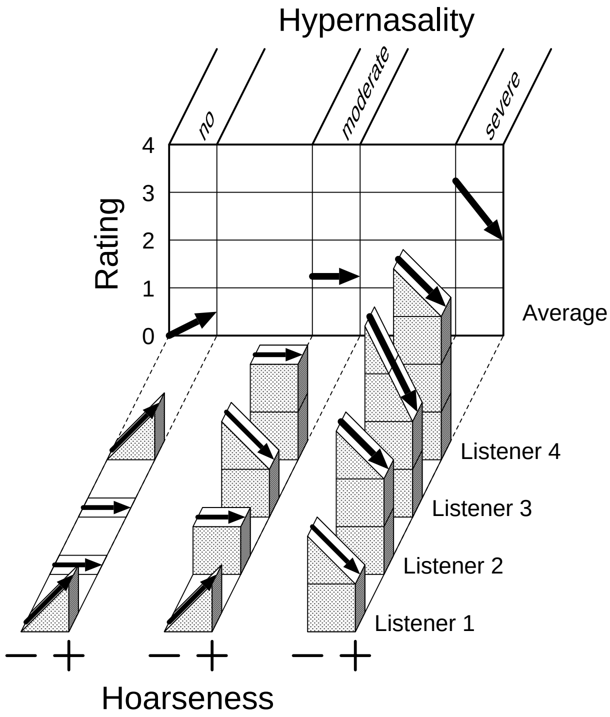

Figure 1 The change of hypernasality with hoarseness

4. RESULTS

The variation of the rating given in three trials was within one point for all four listeners. Figure 1 shows the variation in rating observed twice or more in three trials by each listener. As indicated in Figure 1, for voices without hypernasality, hoarseness did not increase hypernasality very much. In moderately hypernasal voices, the effect of hoarseness on hypernasality varied from listener to listener. For severely hypernasal voices, hoarseness decreased the hypernasality. This result suggests that a hoarse voice tends to be rated as less hypernasal than one without hoarseness.

5. DISCUSSION

5.1 Synthesizing speech with hoarseness by pitch-synchronous editing

Pitch-synchronous analyses (Imaizumi [6], Muta et al. [7], Kasuya et al. [5]) yield the acoustic correlates of hoarseness, such as pitch period perturbation, amplitude perturbation, spectral perturbation, and glottal noise. In this study, to make the stimuli, we extracted the pitch period perturbation from a speech sample with hoarseness and added this perturbation to the pitch period sequence of an arbitrary speech signal. The resulting edited waveform has a new pitch period perturbation. The editing process also implicitly caused additional spectral perturbation and noise. This effect may be caused by increased higher-frequency energy from zero-padding. It seems that these processes contributed to add hoarseness.

5.2 Why hoarseness decreased the hypernasality rating

As described in Section 5.1, the pitch-synchronous editing caused a spectral change, which seemed consistent because of the consistent editing process. In the perceptual experiment, the change of rating increased as the level of hypernasality increased.

To explain why hoarseness decreased the rate of hypernasality, we formed two hypotheses:

Hypothesis 1: As a result of the spectral change

> According to the literature, it is pointed out that the acoustic correlates of hypernasality mainly appears on the spectral envelope of a speech signal [8],[9]. It is possible that the spectral change by adding hoarseness weakens the spectral characteristics of hypernasal voice. Actually, when a person speaks hoarsely, he/she might using the glottis as a part of the articulation organ, and this might cause a spectral change.

Hypothesis 2: It is not dependent on the spectral change

> The rate of hypernasality decreased, even though the spectral change by editing was consistent. This suggests that the spectral change does not cause any change in the perceptual impression, but there might be some other factors, such as psycho-acoustical effects.

We need further investigation to judge which hypothesis is better.

5.3 Clinical application

The findings from this study revealed that hoarseness may change perceived hypernasality, decreasing it, in severely hypernasal voices.

The clinical management of cleft palate patients differs with their velophryngeal competence. It has been pointed out that as soon as possible any surgical or prosthetic intervention should be considered for the patients with severe velopharyngeal incompetence [10],[11]. Long-term follow-up studies exhibited that patients with mild to moderate velopharyngeal competence may need secondary velopharyngeal surgery [12]. One or two steps changes on hypernasality ratings observed in this study may lead to a wrong clinical diagnosis of velopharyngeal competence of the patients in clinical settings.

It has been frequently that patients with severe velopharyngeal incompetence have a high occurrence of voice disorders [13],[14],[15], or laryngeal symptoms [16]. Though one can use nasopharyngeal fiberscopy and cephalometry as a help, still auditory assessment by a speech pathologist is the best way in the diagnosis of young children. Further investigation of the effect of some types of hoarseness on hypernasality ratings is needed.

6. CONCLUSION

In this study the effects of hoarseness on hypernasality ratings were investigated in order to make a rating scale for hoarse voices. The results differed with the level of hypernasality in the original voices. A decrease of perceived hypernasality was observed in severely hypernasal voices, though the ratings given by listeners various varied for voices with no and moderate hypernasality.

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