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Study on the perception of lateral misarticulation and its acoustical characteristics

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Summary

1 Introduction

Lateral misarticulation (LM) is a type of misarticulation in which the tongue dorsum contacts the hard palate continuously, forcing air out from the retromolar region to the buccal groove. This kind of speech presents particular distortion, and which has been diagnosed depending on auditory impressions of speech clinicians.

In order to diagnose a speech as LM objectively using acoustical characteristics, we should discuss following two points: (1) relations between spectral envelope features and auditory impressions of speech clinicians, and (2) relations between articulatory and acoustical characteristics.

In this work, at first, we analyze physical structures of LM and normal /f/ speech.[1] [2] [3] Especially, we analyze the time variable structures. In the second experiment, we examine auditory impressions of synthesized speech waves with specific spectral envelope bands replaced. Moreover, we simulate vocal-tract acoustics in the way using an electrical analog vocal-tract model.

2 Analysis: Comparison of Spectral Envelope Series

This experiment compares spectral envelopes of LM (9 persons) with those of normal speech (10 persons). The data was analyzed using the improved cepstrum method.

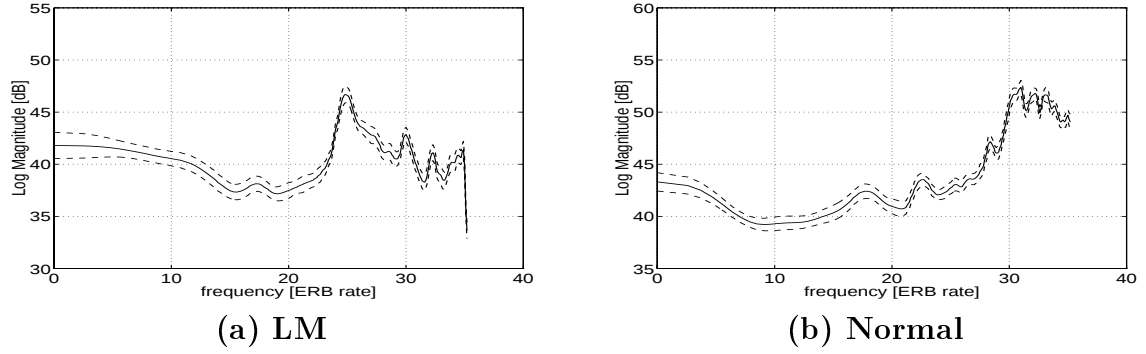


Fig1 : Means and standard deviations of spectral envelope sequences including 150 frame spectra

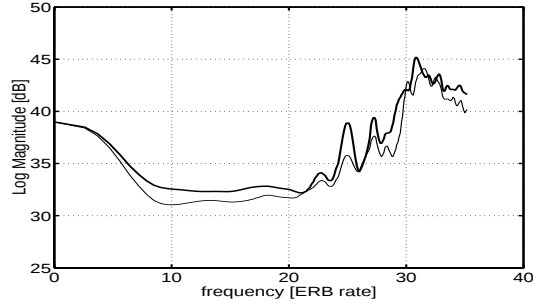


Fig2 : Spectral envelope(fine line : normal speech , thick line : LM speech)

Fig.1 shows the means and standard deviations of spectral envelope sequences including 150 frames spectra for LM and normal speech (1 frame = 6.4ms). Fig.2 shows spectral envelope of one speaker who can make LM and normal speech.

The spectral features of LM are follows:

1. There is a substantial peak around 25 to 26 ERB rate (3.14 to 3.52 kHz).
2. The spectral envelopes of the LM are flat in the frequency band above 32 ERB rate, whereas, normal speech has a plateau (Fig.1 (b)).
3. Variation of peak heights with time around 25 ERB rate is more considerable than that of other peaks.

In addition ,Fig.2 shows difference between two envelopes is found only at 25 ERB rate.

These results suggest that the peaks around 25 ERB rate and their power variation with time are significant physical characteristics for speech clinicians to identify LM.

3 Experiment:Hearing tests of speech with replaced spectral envelopes band.

In order to examine whether the spectral features found in the above-mentioned analysis is responsible for the unique timbre of LM, we performed hearing tests using synthesized speech.

Filtered and mixed speech waves,whose spectral envelope bands around 25 ERB rate or over 32 ERB rate have been replaced, are presented to five speech clinicians to judge the similarity of auditory impression with LM.

This experiment indicates the following three facts.

1. There is the most important characteristic of LM in the peaks around 25 ERB rate, and the larger the peak level goes up, the more frequent the speech wave is recognized as LM.
2. The variation of peak heights with time around 25 ERB rate is very helpful for recognizing LM. On the other hand, if peak heights around 25 ERB rate is stable, the speech is recognized as normal.
3. If the spectral envelopes above 32 ERB rate are flat, speech clinicians recognize the speech as distorted completely. Then they judge the auditory impression from the spectralenvelopes peaks around 25 ERB rate.

4 Simulation of vocal-tract acoustics of LM

To discuss the relationship between the articulatory gesture and acoustical characteristics of LM, we simulate vocal-tract acoustics in the way using an electrical analog vocal-tract model.

If the tongue dorsum maintain broad contact with the hard palate during LM production, the length of tongue construction becomes long, and area of back cavity becomes small.

The simulations confirmed that, resonance frequency changes according to length of tongue construction, and acoustic characteristics becomes similar to LM.

5 Conclusion

The three experiments were carried out to discuss the following: (1) relationship between perceptual diagnoses of LM by speech clinicians and their acoustical characteristics, and relationship between articulatory and acoustical characteristics.

These experiments showed that:

1. The spectral envelopes of the LM have a vivid peak around 25 ERB rate, which varies with time almost periodically. Moreover, the spectral envelopes of the LM are flat in the frequency band above 32 ERB rate, whereas, normal speech has a plateau.
2. From the replacement of the spectral envelopes, the spectral envelope characteristic of the LM is mainly near-periodical variation around 25 ERB rate.
3. According to length of tongue construction or area of back cavity, the vocal tract transfer function is changed. The peak of the spectral envelope of the LM is determined by the position and length of the tongue construction in the vocal tract.

References

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