

Title	スペクトル変形聴覚フィードバックによる音声生成・知覚の相互作用に関する研究
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# Research on interaction of speech production and perception by transformed auditory feedback

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The speaker is always controlling as becoming an utterance like the intention it by feedback the speech sounds where oneself originates to auditory organ. This feedback is called auditory feedback and bears the key role in the speech production.

Kawahara et al. proposes the measurement technique which is called Transformed Auditory Feedback (TAF) and using TAF with pitch modifications revealed that there was a compensatory response to pitch perturbations. B.S. Lee revealed a tendency that utterance becomes difficult if the time delay of about 200ms is inserted in the feedback voice. It is only a fundamental frequency and a time delay that Kawahara paid attention. How the production side of the speech sounds shows the reaction when other perceptual information like the spectrum etc. changes is not known. The following is thought as the factor.

- The time which can be used to feed back is limited.
- The ability of the computer was not enough.
- It is difficult to do the resynthesis of the voice in real time.

# 1 Purpose of this research

In this research, we pay attention to the spectrum which is an important physical quantity in the voice. We control the spectrum of the voice feedback to the auditory organ. We investigate whether the voice generation side shows some reactions for the change of the spectrum which is one of perceptual information.

## 2 Experiment system

### 2.1 Transformed Auditory Feedback

TAF is a general method to detect the effects of auditory feedback using parametric perturbations that are inserted into an auditory feedback path. Figure:1 shows the conceptual diagram of the sound.

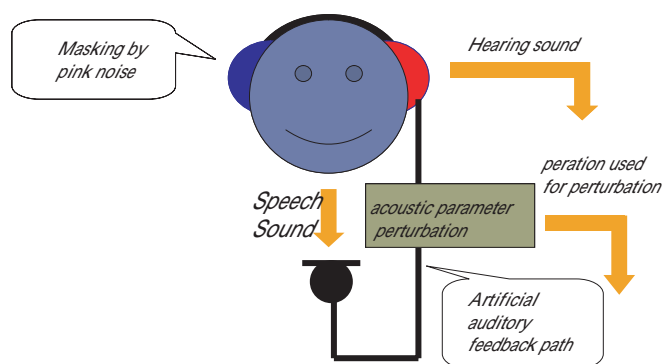


Figure 1: Outline of experiment by TAF's

### 2.2 Outline of experiment system

Figure:2 shows the outline of experiment system. An artificial auditory feedback path is made between the voice production and speech perception with a Capacitor mike and a headphone.

The perturbation is given to the spectrum of the feedback voice and it feedback to the auditory organ. The pink noise of 70db has been added from 65db to the feedback voice to mask the natural sidetone and bone conduction sound.

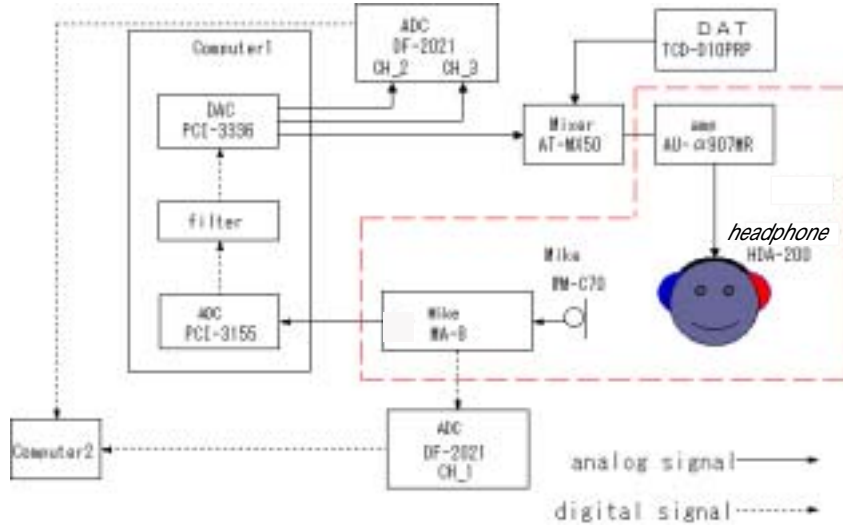


Figure 2: Outline of experiment system

### 3 Preparation for filter

In this research, notch filter is used to give the perturbation to the spectrum of the feedback voice. We made the notch filter to remove F2 of /i/. The width of the removal of the notch filter is from 200Hz to 500hz. Table 1 shows the specification of the filter that we designed.

Table 1: Specification of filter

Specification item	Specification
Order	30
Stopband edge frequency	cutoff $\pm$ 100(Hz)
Passband ripple	3(dB)
Stopband attenuation	20(dB)

Table 2: Specification of Filter

## 4 Actual experiment

### 4.1 Purpose

To investigate the interaction of the voice generation and perception in a spectrum control, I do the experiment which gives the filter processing to

the feedback voice.

## 4.2 Method

### Testee

Three postgraduates who have normal hearing.

### Utterance voice

Continuous vowel /aiai.../.

### Prepared filter

I prepared the filter which removed F2 of /i/ from 200Hz by the width of 500Hz as a filter used to give the perturbation to the spectrum of the feedback voice.

### Experimental method

- Preparation We talked for ten minutes through an artificial feedback path which consisted of the mike and the headphone to reduce the influence of listening with the headphone.
- Instruction to testee We asked the testee for a constant utterance.

Table 3: Folmant Position

	/a/		/i/	
Testee	F1(Hz)	F2(Hz)	F1(Hz)	F2(Hz)
A	680	1230	300	2000
B	850	1500	250	2200
C	900	1500	200	2400

- Recorded data In the measurement technique of TAF, the power output to the signal and the perturbation used for the perturbation is necessary for the analysis. We recorded two signals and signals which showed the change point of the filter.

### 4.3 Analytical method

In this research, STRAIGHT was used for the analysis. We calculated spectrum envelop at time which was from the result of analysis, and observed the change in Formant forma. figure 3 shows the outline of the analytical method.

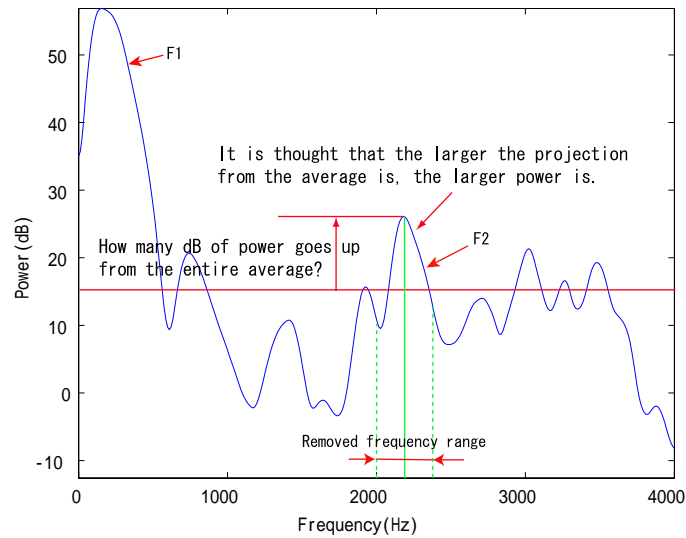


Figure 3: outline of the analytical method

## 5 Experimental result

### 5.1 Result for /ai/

The following reactions were seen on the voice production side.

- Amends operation to try to raise power of removed band by several dB, and to emphasize characteristic frequency region, Formant.
- Amends operation which starts searching for accurate characteristic frequency region, Formant position.

Figure 4 and Figure 5 shows one example of the result.

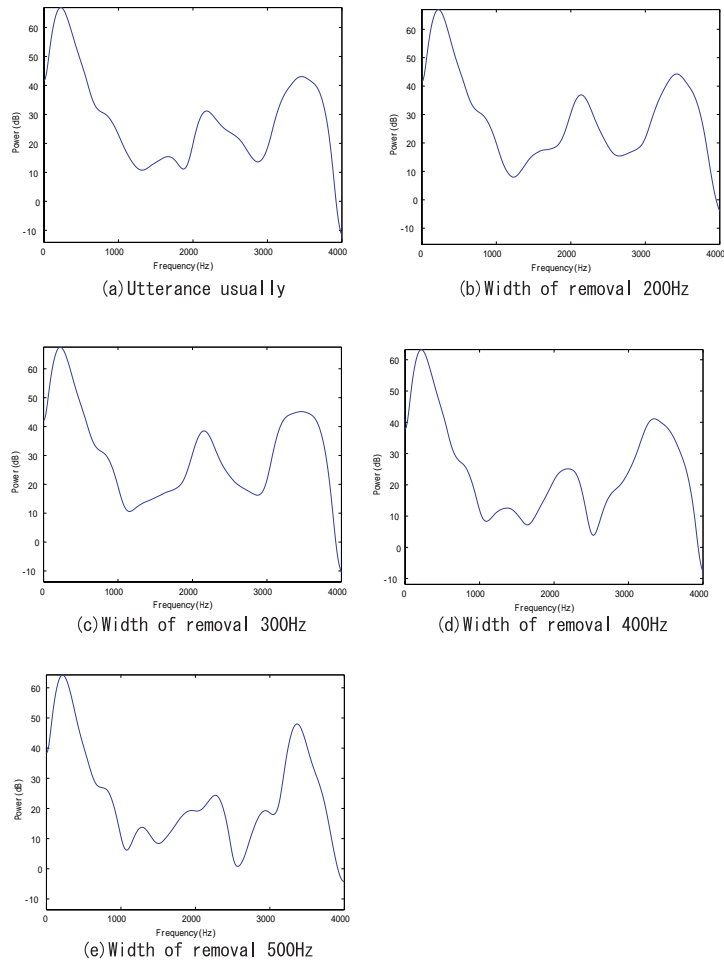


Figure 4: Example of spectrum envelope when width of removal is gradually expanded: The power of the removal band usually goes up by several dB then the utterance, but the spectral shape does not usually change so much with the utterance.



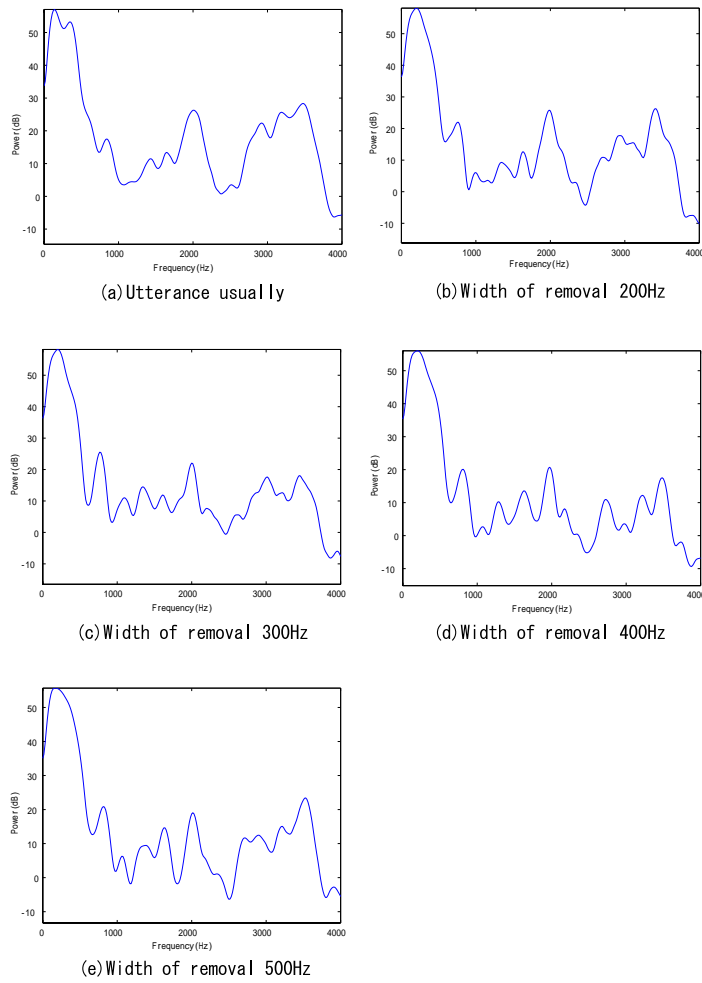


Figure 5: Example of spectrum envelope when width of removal is gradually narrowed: The change in big power has taken place on both sides of F2 removed when the width of the removal is 500Hz. If the width of the removal is reduced, the change in power becomes small. The spectral shape when the width of the removal is 200Hz looks like at the usual utterance.

## Consideration

The power ratio of the formant frequency and the characteristic frequency region, Formant is important to keep the phoneme of the vowel. The increase and decrease of power to happen by the removed band is thought to be one of the amends operation which exists during the voice production which starts maintaining the characteristic frequency region, Formant emphasizing the removed band to keep the phoneme and perception.

Whether the change in the spectral shape seen in the experiment which gradually narrows the width of the removal starts searching out an accurate position of the characteristic frequency region, Formant by raising the power of a peripheral band is thought.

## 6 Summary

In this research, we investigated the interaction of the voice generation and speech perception in a spectrum control by using measurement technique TAF. As a result, the following shown amends operation was guessed.

- Amends operation to try to raise power of removed band by several dB, and to emphasize characteristic frequency region, Formant.
- Amends operation which starts searching for accurate characteristic frequency region, Formant position.

### Problem in the future

We investigate how the muscle and the tongue around the mouth have moved while the amends operation has happened.

## References

- [1] B.S.Lee, Effect of Delayed speech feedback, J,Acoust.Soc.Am.22, 824-826 ,1950.
- [2] Hideki Kawahara, Julia Catalina Williams, Effects of Auditory Feedback on Voice Pitch Trajectories:Characteristic Resposns to Pitch Perturbations, ATR HIP Res.Labs, Vol.2 of 2, pp145–160, 1996.