Investigation of Relations between Capabilities of Speech Production and Phonemic Restoration

Yuki Koba (510037)

School of Information
Japan Advanced Institution of Science and Technology

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1 Introduction

Speech production and perception are the two opposite sides of human speech communication: the encode process and the decode process, where the same code may be used in the process. The speech chain has been proposed to explain this close relation of speech perception and speech production. Many studies have been conducted to clarify such a relationship. As a result, it has appeared that there is an interaction between the two processes. One of famous hypotheses is the motor theory of speech perception, which suggests that perceiving processing of a speech sound is reference with to the articulation. The convincing evidence has not been obtained yet in this hypothesis, however, various research results supported the motor theory recently ant the research faces a new phase. Then, if speech production influences speech perception like this, we can naturally speculate that for normal people, if they have excellent speaking skill, they would also possess an outstanding capability of speech perception. To verify our speculation, in this study, we used speech materials of tongue twister to evaluate subjects' speaking skill and used a phonemic restoration approach to quantify their perception capability.

2 Investigation of relation between speaking skill and perception capability

In this section, we conducted an experiment to investigate the correlation between speaking skill and perception capability. Subjects' speaking skill was evaluated by uttering tongue twister speech materials. On the other hand, the perception capability was evaluated in terms of the correct answer rate of the phonemic restoration, while phonemic restoration is a phenomenon in which human can restore lost information from a damaged speech sound

to some extent and understand it correctly when the noise is inserted in the damaged part. In the phonemic restoration experiment, tongue twister speech were used as the speech materials in the listening test. The speech signal of the recorded materials was removed periodically to generate incomplete speech by programming and then white noise was inserted into missing parts. Subjects were asked to listen each sentence ten times and write down the phoneme characters that they learnt. The restoration rate was investigated and used for evaluate their perceptual capability.

In the experiment of speech skill evaluation, the same subjects were asked to utter the tongue twister sentences, which were used in the phonemic restoration experiments. The speaking skill of the subjects was evaluated using MOS method by judgers who are different from the subjects. Then, we investigated the correlation between speaking skill and perception capability.

As a result, the subjects having high speaking skill showed higher restoration rate. It implies that speaking skill and perceptual capability of human is developed simultaneously. Moreover, the result showed a tendency that when the sentences are easier to be pronounced they are also easier to be perceived, and vice versa. This may suggest that the same approach is used in the encoding and the decoding processing.

3 Process of speech production which influences speech perception

What is the concrete process of speaking that influences perception? When a person speaks an utterance, he/she usually build a plan for uttering by anticipating the following phonemes in the utterance. On the other hand, when a person perceives an utterance, the anticipatory function on linguistic information or on other cues is helpful in human cognition. This function is considered to play an important role in phonemic restoration process. From this point of view, we speculate that the anticipation exists in both speech production and perception. For this reason, we conducted an experiment to investigate the relation of the speech planning and the anticipation in perception.

4 Investigation of correlation between speech planning and anticipation in phonemic restoration

In this section, effect of the speech planning is evaluated by the method of using tongue twister, while the effect of the anticipation of the subjects is evaluated by phonemic restoration experiment in which normal sentences was used.

In the phonemic restoration experiment, we prepare the speech materials for phonemic restoration by controlling the phonemic information but not periodically replace the speech

signal by the noise. Subjects were asked to listen sentences and write down the phonemes that they perceived. The correct answer rate accounts for the restored phonemes that were only predicted from context information.

In the speech planning experiment, subjects who participated in phonemic restoration experiment were asked to utter tongue twister sentences. To reduce the effect of anticipation in speech planning, each sentence was displayed part by part which was controlled by the subjects. In this situation, the subjects have no time to scan the utterance throughout, so that they can hardly schedule speech planning. After four or five days, the same subjects were asked to pronounce the same sentences after the full text was displayed on a screen in about ten seconds, during which they have enough time for speech planning. Then, judgers differing from the subjects evaluated the speaking skill with and without the planning effects by using MOS method. The planning skill of the subjects is defined using the utterance improvement rate between two situations.

As a result, there is no correlation between the restoration rate and speaking skill without a speech planning. On the other hand, correlation is shown with a speech planning. Moreover, there is larger correlation between the restoration rate and the utterance improvement. This implies that the stronger planning capability the better anticipatory capability in perception. We may say that the anticipation is playing important roles in human's speech production and perception. If a person has a strong anticipation capability, he/she would have excellent speaking and perceiving capabilities.

5 Conclusion

This study clarified that an individual speaking skill has high correlation with speech perception. It is found that speech planning capability is positively proportional to the anticipatory capability in phonemic restoration. This finding cannot be direct evidence to prove the motor theory of speech perception, while it supports the motor theory in the way that speaker and listener share the same anticipatory strategy.