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A Study on Effects of Sound Masking on Speech Intelligibility

Seung Ho Choi
Dept. of Electronic and IT Media Engineering
Seoul National University of Science and Technology
Seoul, Korea
e-mail: shchoi@seoultech.ac.kr

***Abstract*—** This study relates to the effects of sound masking on speech intelligibility. The International Standards such as ANSI SII and ITU-T PESQ were used for the evaluation on the speech intelligibility under masking noise environments. Also, for the subjective evaluation, the listening test was performed by people. Experimental results on speech intelligibility proved that sound masking method is effective for masking the unwanted speech signals of other people.

Keywords*-sound masking, speech intelligibility, ANSI SII, ITU-T PESQ*

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I. INTRODUCTION

This study relates to a masking sound, which is a big issue all over the world now. Sound masking is a technology to mask unwanted sound signals such as speech signals of other people. Sound masking can be effectively used in an environment coming from the unwanted signals. For example, it can concentrate on studying and study rooms, etc.

In this study, it is developed to measure the degree to which someone can hear the unwanted signal such as speech signal under sound masking noise environments. The ANSI Articulation Index (AI) [1], the Speech Intelligibility Index (SII) [2], and the ITU-T P.862 PESQ (Perceptual Evaluation of Speech Quality) [3] are widely used for the speech intelligibility test. Also for subjective speech intelligibility test, the listening evaluation was performed by people.

II. PERFORMANCE EVALUATION METHODS

Speech intelligibility index AI (S3.5-1969) of ANSI divides the speech as a component of the frequency bands and reveals the information that contributes to speech intelligibility at each band. The AI is standardized by ANSI in 1969 and a speech intelligibility index SII (S3.5-1997) that is an improved version of the AI is standardized in 1997. In this study, the SII values are obtained from the levels of SNR and the spectra of noise signals. The SII value is in the range of from 0 to 1.

The ITU-T PESQ is a standard method for evaluating the speech quality using a cognitive model evaluation method, which compares a signal having passed through the system with the original signal. The PESQ value has a value from 0.5 to 4.5. The system environment of this study uses 10 noise signals such as white noise that is added to the speech signal at each SNR.

A subjective listening test can be adopted for the verification of the usefulness of the masking sound. This test is a listening test for speech intelligibility under noise environments.

III. EXPERIMENTAL RESULTS

A. *Database*

The speech database used in this study is a PBW (Phonetically Balanced Words) set that a male announcer uttered the three words from three to 20. Sample rate of the audio signals is 16 kHz. Also the noise signals were consisted of 10 sound signals, such as white noise, birdsong. The noise signals were recorded via a high-performance condenser microphone AKG C1000S.

Figure 1 shows the waveform of the audio signal before the noise signal is mixed. As shown in the figure it can be seen that the signal components of the waveform and spectrum are represented in detail. Figure 2 is an example of a signal waveform and frequency spectrum of the speech plus noise signals at SNR 0 dB. When the noise signals are mixed as shown in the figure it is difficult to distinguish the type of the waveform of the audio signal since much of the speech signal spectrum are buried by the noise signal.

B. *ANSI SI*

For the SII, the experiment used a total of 18 bands between 0 and 8 kHz by 1/3 Octave unit and were based on the SPL values of speech signals as shown in Figure 3. Experimental results are shown in the Figure 4.

C. *ITU-T PESQ*

PESQ test was performed using a mixture of 20 speech signal and 10 noise signal from each of -20 dB up to 30 dB. Experimental results, as shown in the Figure 5.

D. *Listening Test*

In this study, in addition to the performance evaluation by the international standard method such as SII and PESQ, the subjective assessment was performed by listeners. The listener group is consisted of 5 men and 5 women who do not have problems with listening comprehension. They were given the mixed signals of the 20 words with each word from -20 dB to 30 dB. Table 1 represents the relationship between the SII and the word recognition rate (WRR) results. The results show the high correlation between the objective measure (SII) and subjective measure (WRR).

IV. CONCLUSION

This study relates to the effects of sound masking on speech intelligibility. For the objective evaluation, the International Standards such as ANSI SII and ITU-T PESQ were used. Also, the listening test for subjective evaluation was performed by people. Experimental results on speech intelligibility proved that sound masking method is effective for masking the unwanted speech signals of other people.

ACKNOWLEDGMENT

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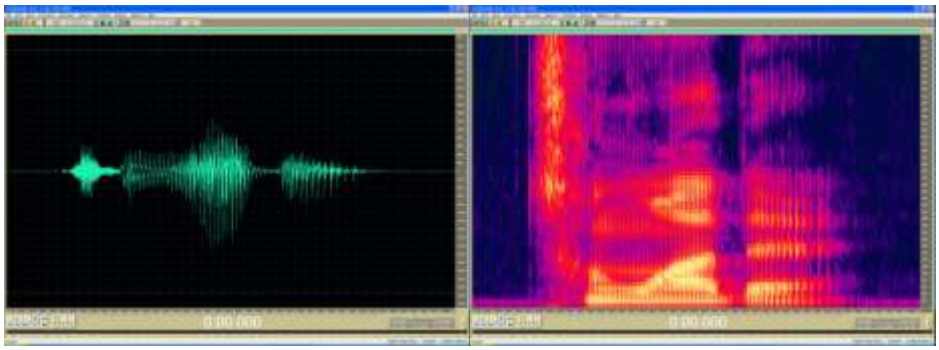

(a) (b)

Figure 1. Examples of (a) speech waveform and (b) speech spectrum.

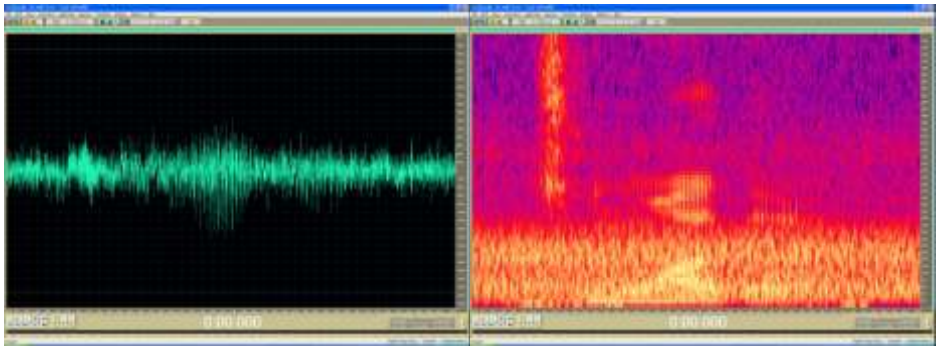

Figure 2. Examples of (a) mixed waveform and (b) mixed spectrum at SNR 0dB

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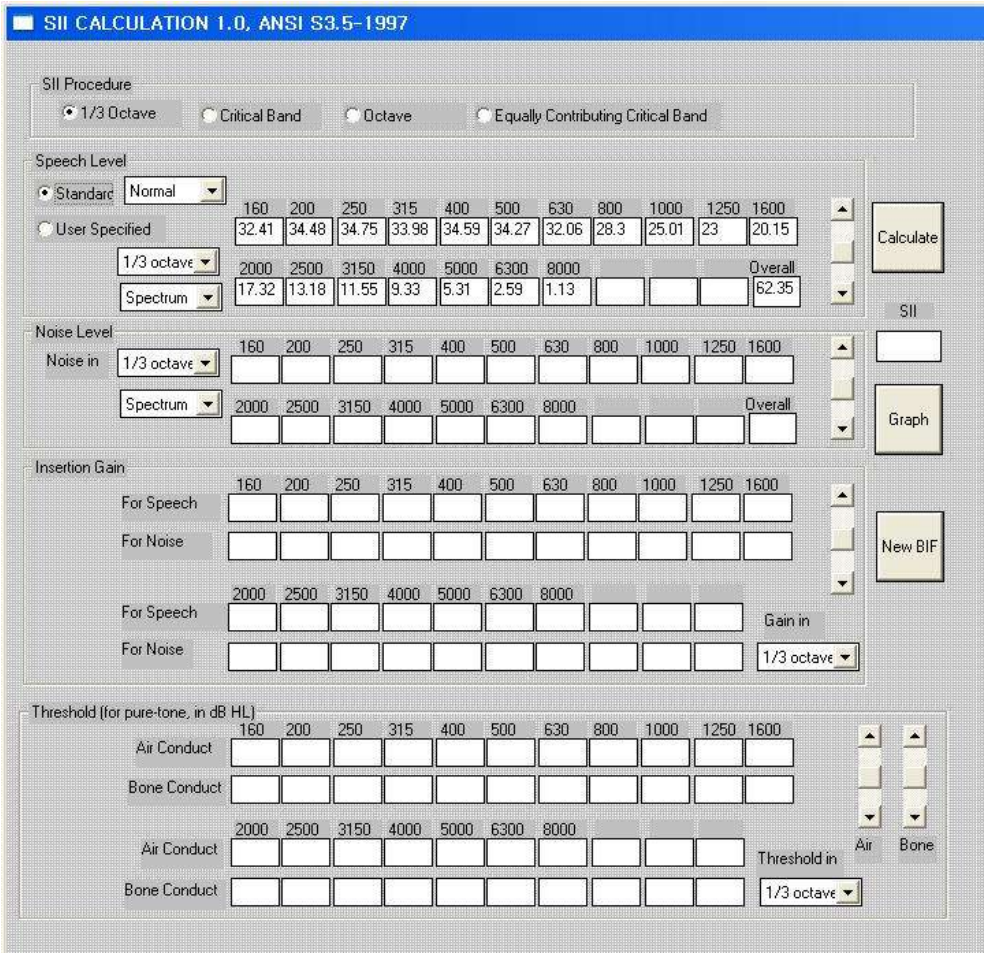

Figure 3. Standard tool for SII calculation [4]

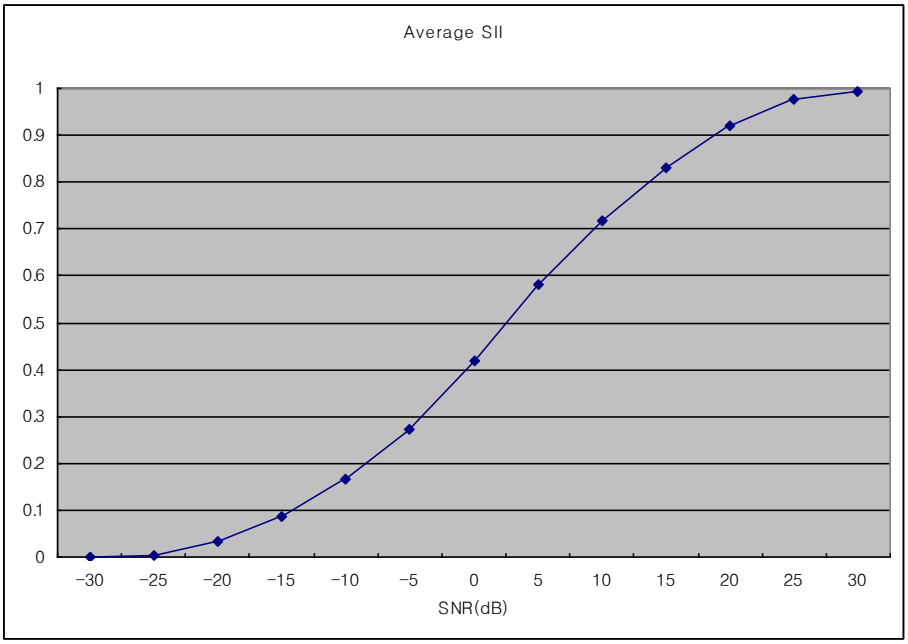

Figure 4. SII Results at each SNR

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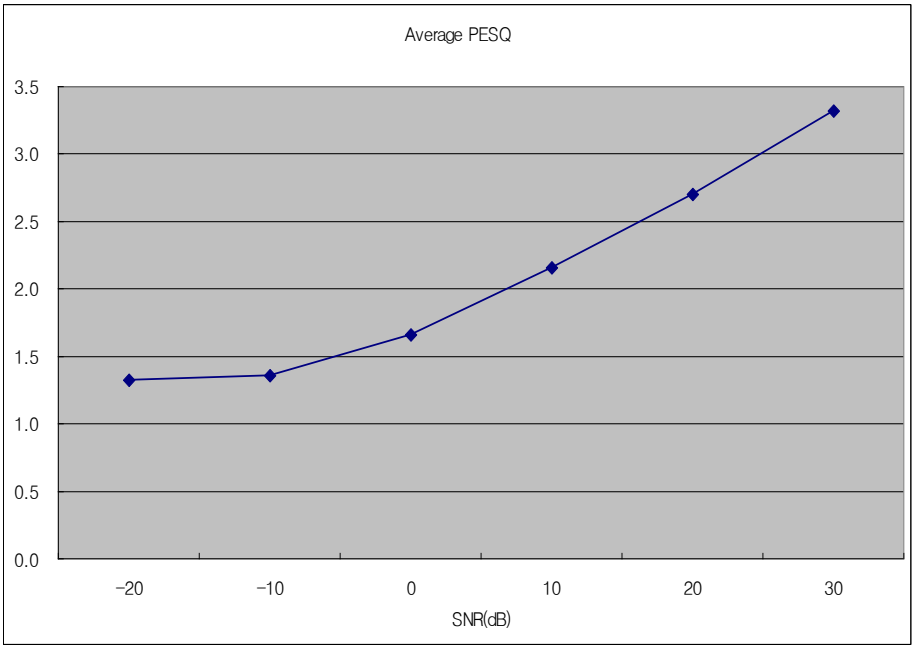

Figure 5. PESQ Results at each SNR.

Table 1 Comparison of SII and WRR

SNR(dB)	SII	WRR(%)
-20	0.0338	0.0
-10	0.1647	25.0
0	0.4181	91.5
10	0.7162	97.0