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Title	目的音と背景音のスペクトル変調・時間変調情報を用いた聴覚探索の研究
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Abstract

In our daily lives, listening to sound improves our lives in many ways. Listening to music for healing and enjoying conversation are examples of this. Sound can take in information actively or passively. This information can be used to defend against foreign enemies or to plan actions to take.

Of all the sounds used to improve human life, sound sign are particularly familiar to humans. Among these, alarm sounds are often used. Sound alarms play an important role in comfort because they guide people's behavior.To ensure that the message of the alarm sound is conveyed to all, the alarm sound itself is designed in accordance with guidelines and JIS, which indicate universal design considerations.

These have been studied in noise-free environments. However, noise exists in the real environment. The alarm sound may not convey the message correctly because of interference from the noise. Therefore, it is necessary to ensure that the alarm tone message is conveyed correctly even in the presence of noise. In order for the alarm sound message to be conveyed correctly in the presence of noise, the relationship between noise and alarm sound must be known.The problem of listening to an alarm sound in the presence of noise is defined as an auditory search problem for detecting the target sound in the presence of background noise. The important finding is that the target sound is correctly detected when the message of the alarm sound is correctly conveyed.

Previous research of the auditory search task have focused on the fluctuation of the amplitude envelope of the target and background sounds. Sugita investigated this by mixing time-varying sounds (amplitude-modulated sounds, frequency-modulated sounds, narrow-band noise) and pure tones in a single channel. As a result, the search time increased with the number of interfering sounds when the pure sound was used as the target sound, while the search task for time-varying sounds was independent of the number of pure sounds. They claimed that the temporally fluctuating sound may have popped out. Asemi examined the asymmetry of the auditory search task in the presence or absence of variation in the target and background sounds. The results indicate that it is easier to detect a changing target sound relative to an unchanging background sound than it is to detect an unchanging target sound relative to a changing background sound. Kusaba considered the auditory search problem when both the target and background sounds are variable. The results showed that the target sound is easily detected when the correlation coefficient between the amplitude envelopes of the target and background sounds is low. The results showed that the target sound is more likely to be detected when the correlation coefficient between the amplitude envelope of the target and background sounds is low. Yano defined the movement of the amplitude envelope, proposed a method to control it, and examined the auditory

search problem focusing on differences in movement.

These results indicate that temporal fluctuations in sound are important for the auditory search. On the other hand, humans perceive sounds that fluctuate not only in the temporal direction but also in the frequency direction. Spectro-temporal modulation (STM) information analysis is a method for capturing both temporal and frequency variations of sound. This is a method in which variations in the amplitude of a sound in the time direction are indicated as time modulation (TM) information, and variations in the spectrum in the frequency direction are indicated as spectral modulation (SM) information. If stimuli can be created considering TM and SM information, target and background sounds can be created considering fluctuations in the temporal and frequency directions. These stimuli can be used to present both temporal and frequency perspectives on the auditory search.

This paper aims to clarify the relationship between easily detectable target and background sounds using spectro-temporal Modulation (STM) information. Experimental stimuli generated created based on the STM information. Auditory search tasks were conducted using the generated stimuli. The results of the auditory search task will be used to examine the relationship between target sound and the background sounds that are likely to be detected. Once this relationship is clarified, we can expect to conduct a simulated evaluation of auditory search using STM information. It also leads to the consideration of guidelines for designing sound alarms as an engineering application.

Three experiments were considered in this study; 1. Experiment focusing on SM information; 2. Experiment focusing on TM information; 3. Experiments focusing on the SM and TM information of target and background sounds, respectively.

In the experiment focusing on SM information, a one-way ANOVA with the center frequency of the background noise as a factor showed no main effect.Thus, the relationship between the SM information produced by narrow-band noises with two different center frequencies indicated that the target sound was easily detectable.

In the experiment focusing on TM information, as in the previous experiment, a relationship of ease of detection when the amplitude envelopes of target and background sounds are different. Not only that, but it was also found that the carrier wave affected the ease of detection. However, it was not clear what affects the carrier wave. Therefore, experiments focusing on the bandwidth of the carrier wave and experiments focusing on the center frequency of the carrier wave were conducted. The results showed that auditory search tasks with different amplitude envelopes were more likely to be detected when the bandwidth was wide.

In experiments focusing on the SM and TM information for the target and

background sounds, respectively, it was shown that the bandwidth condition affects the detectability of the target sound, even when the amplitude envelope movement is the same.

These results indicate the following three relationships between target and background sounds. 1. the target sound and the background sound have a relationship with different amplitude envelopes; 2. the center frequencies of the narrow-band noise used for the target sound and the background sound are different; and 3. the relationship is that the width of the target sound is narrower than the spectral width of the spectral modulation information of the background sound.

STM information is known to be related to the spectro-temporal receptive field (STRF). This finding and the experimental results suggest that the auditory search task cued not only information processing in the auditory peripheral system but also features processed in the STRF.