# Relationships between Subjective Auditory Impression and Brain Cortical Activities for Time-varying HVAC Sound

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***Abstract*— Relationships between subjective coolness and preference induced by time-varying HVAC (heating, ventilating and air conditioning) sound and magnetic cortical activities were investigated. Scale values of coolness and preference for each stimulus were obtained by Scheffé's paired comparison tests. Magnetoencephalographic (MEG) measurements were carried out, and variation of auditory magnetic fields (AEF) and spontaneous oscillations were investigated. In terms of the coolness, most of subjects have a peak of the scale value at modulation frequency around 0.6 Hz. P2m amplitude of AEFs in right temporal region and the temporal stability of low-gamma band oscillation were significantly changed in association with the coolness. In terms of the preference, lower scale values were shown above 0.8 Hz, and temporal stability of alpha band oscillation was significantly changed in association with the preference.**

## I. Introduction

Evaluations of environmental sound using neurophysiological indices have been attempted in recent years.Some studies on brain cortical activity corresponding to auditory impression have been made [1, 2]. These study report significant relationships between subjective preference and annoyance of sounds and temporal stability of alpha band oscillations.

This study aimed to obtain useful information to evaluate auditory impressions objectively using neurophysiological indices. Relationships between scale values of subjective coolness and preference induced by HVAC (heating, ventilating and air conditioning) sounds and magnetic cortical activities were investigated.

## II. Method

Auditory stimuli were synthesized from the recorded noise of an actual vehicle HVAC system using linear predictive coding (LPC) [3], and were amplitude modulated sinusoidally to give time variation, Seven stimuli were generated by changing the modulation frequency from 0 Hz to 3.2 Hz.

First, scale values of coolness/preference for each stimulus were obtained by Scheffé's paired comparison tests. Eight subjects (7 males and 1 female, 21-39 years old) participated in the test.

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Next, Magnetoencephalographic (MEG) measurements were carried out. Five subjects among participant of the paired comparison tests took part in the measurements. Four stimuli including the most and least cooled/preferred stimuli were selected for each subject. Auditory magnetic fields (AEFs) of the on/off-responses for each stimulus were obtained by averaging of over 72 epochs, and their root mean squares (RMS) were investigated. Also, the effective duration of the normalized autocorrelation function (ACF), $\tau_e$, of spontaneous oscillations (theta: 4-8 Hz, alpha: 8-13 Hz, beta: 13-20 Hz, low-gamma: 20-50 Hz) in four regions (left and right temporal, parietal and occipital) according to stimuli were investigated. A large $\tau_e$ value indicates high temporal stability of the oscillation.

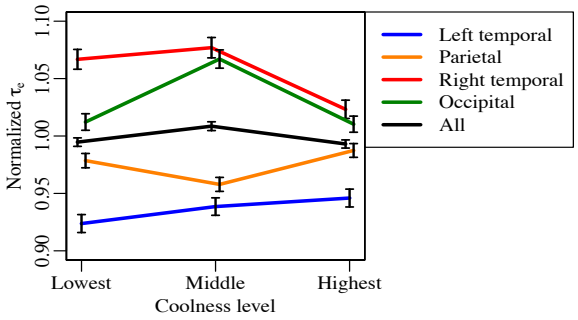


Figure 1. Relationships between normalized $\tau_e$ of low-gamma oscillation and coolness level (Lowest: the least-cooled, Middle: the intermediate, Highest: the most-cooled ). Error bars indicate 95 % confidence interval.

## III. Result and Discussion

Fig. 1 shows relationships between the normalized $\tau_e$ of low-gamma band and the coolness level. In terms of the coolness, significant effect of coolness level on low-gamma band oscillations was shown ($p < 10^{-8}$). The changes of P2m amplitude in right temporal with varying of scale value were shown at most subjects. In terms of the preference, significant effect of preference on alpha band oscillations was shown ($p < 0.05$). These results indicate that the temporal stability of some oscillation activities and some amplitude of AEFs can be an objective index of auditory impressions at least fot the HVAC sounds.

## References

[1] Y. Soeta *et al*., "Magnetoencephalographic responses corresponding to individual subjective preference of sound fields," *J. Sound Vib.*, vol. 258, no. 3, pp. 419–428, 2002.

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