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Comparison of sound stimuli by Japanese and German subjects using electroencephalogram and the method of magnitude estimation

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ABSTRACT

It is known that there is a little difference between Japanese and Westerners in the perception for sounds. It may be caused by the differences of their culture and different parts of their brain where the sounds are perceived. In order to make the causes clear, a few experiments were performed. The electroencephalogram (EEG) of twelve Japanese subjects and nein German subjects were measured without sound stimuli. Then their EEG was measured while being exposed to sound stimuli. As these stimuli, white noises, road traffic noises and three kinds of bird singings were used. In addition to the measurement of EEG, the subjects were asked to judge the "noisiness" of the sound stimuli by "the method of magnitude estimation". The results may be summarized as follows: (1) For all kinds of sound stimuli, the values of the "noisiness" evaluated by Japanese were higher than by Germans, but for white noises, there were no significant differences between the two. (2) In regard to EEG, the personal differences between individuals were not small. But the differences between Japanese and Germans were not clear except bird singings. In regard to electric potentials of alpha-2 waves, there were also differences in bird singings between the two.

1 INTRODUCTION

It is known that there is a little difference between Japanese and Westerner in the perception for sounds on the basis of experimental results by Tsunoda, *et al.* [1], [2]. Normally the speech was dominant in the left cerebral hemisphere and the noise was mainly in the right in both Japanese and Westerner. However, the natural sound such as bird singing was occupied dominantly in the left cerebral hemisphere for the Japanese as the comfortable sound, where as for the Westerner, it was registered in the right cerebral hemisphere as the noise. The dominant cerebral hemisphere for various kinds of sounds is shown in Figure 1. It may be caused by the differences of their culture and habit in daily life. In order to know the responses in the brain to 17 sounds, a few experiments were performed.

The electroencephalogram (EEG) of Japanese and German subjects (as the Westerner) were measured while being exposed to 17 kinds of sound stimuli. In addition, they were asked to judge the "noisiness" of the sound stimuli by "the method of magnitude estimation". A study for comparison of Japanese and German brain forms have been done by Zilles, Kawashima *et al.* [3]. From the data of EEG, electroencephalographic topographies were composed. As their personal differences between individuals were not small, they were also investigated.

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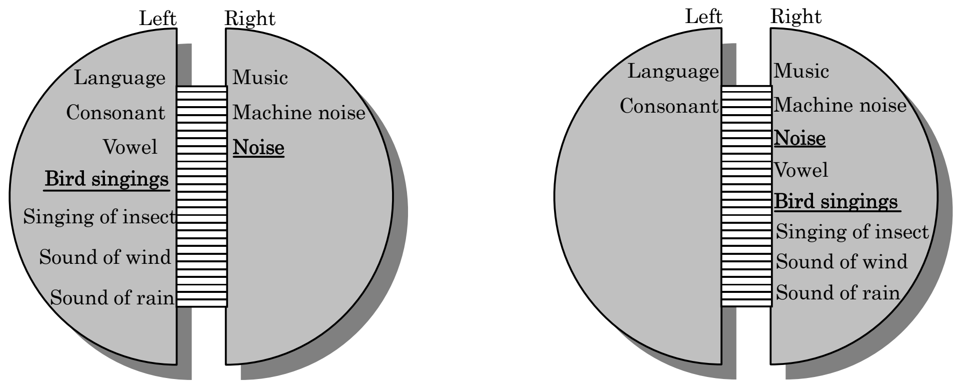


(a) : The Japanese (b) : The Westerner

Figure 1: Mechanism of cerebral hemispheric dominance.

2 EXPERIMENT

2.1 Experimental System

The apparatus for this experiment is listed in Table 1. For the Japanese subjects, in a hemi-anechoic room in Meiji University in Japan, and for German subjects, in a quiet acoustic laboratory room in TU Muenchen in Germany. The experimental system was composed as followed: The 8ch bio-amplifier (BA1008, DIGITEX Lab.) was set up with sensitivity of 50 microvolt, time constant of 0.1 sec and 30 Hz treble cutoff filter. The subjects were fitted with the 10 electrodes based on international ten-twenty system. The disposition of the 10 electrodes for measurement of EEG is shown in Figure 2. The 10 electrodes were points of F_3, F_4, C_3, C_4, P_3, P_4, O_1, O_2, A_1 and A_2. As the points of references, A_1 and A_2 were used.

Table 1: Apparatus for this experiment.

Measurement of EEG	Presentation of sound stimuli
8ch bioelectrical amplifier (BA1008, DIGITEX Lab.)	Integrated amplifier (PM-17SA, MARANTZ)
Head amplifier (BA-U001, DIGITEX Lab.)	Loudspeaker (G7, SONY)
Ag/AgCl electrodes (AP-C011-15, DIGITEX Lab.)	

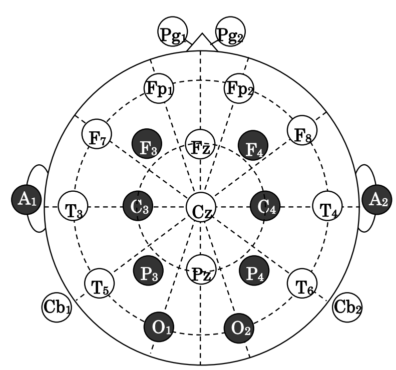


Figure 2: Points of measurement based on the ten-twenty electrode system.

2.2 Sound Stimuli

As sound stimuli, for this experiment four levels of white noises, four levels of road traffic noises and three levels of three kinds of bird singings were used. The white noises were selected as neutral sounds, and the traffic noises were used as common sounds in daily life. It was known that the bird singing were occupied dominantly in the left cerebral hemisphere as comfortable sounds for the Japanese, but for the German, they registered in the right cerebral hemisphere as noises [1], [2]. Therefore bird singings of "Japanese nightingale (J:Uguisu)", "little cuckoo (J:Hototogisu)", and "white-eye (J:Mejiro)" were chosen for comparison of the dominant cerebral hemispheres of Japanese and German subjects. These sound stimuli and their sound levels are shown in Table 2. A measurement of the sound levels of the stimuli used L_{Aeq}.

Table 2: Sound stimuli and their sound pressure levels

The kinds of sound stimuli	$L_{Aeq,\,10sec}$ (dB)
White noise	55, 65, 75, 85
Road traffic noise	
Japanese nightingale	50, 60, 70
Little cuckoo	
White-eye	

The sound stimuli were presented in random order through a loudspeaker in front of the subjects. Each sound stimulus was succeeded by a standard white noise at 75 dB. The standard white noise lasted 10 sec and each sound stimulus also 10 sec. The interval between the standard white noise and the sound stimulus was 2 sec, and the interval between pairs of stimuli was 5 sec. The presented pattern of sound stimuli is shown in Figure 3.

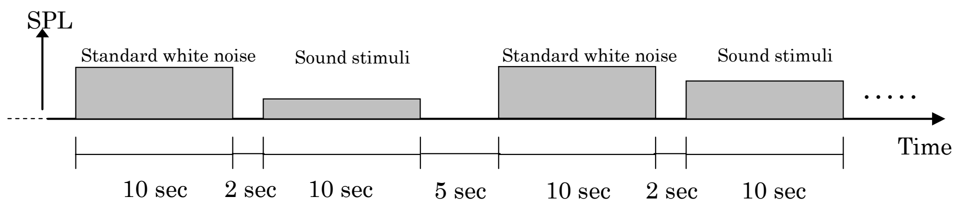


Figure 3: The presented pattern of sound stimuli.

2.3 Subjects

12 Japanese and 9 German subjects who had normal hearing took part in this experiment. The Japanese subjects were university students, (6 male and 6 female) and their ages were in the twenties. One of male subjects was left-handed. All of the German subjects were male, ranging in age from twenties to sixties. One of them was left-handed. The distance between a subject and a loudspeaker was 2 meters.

2.4 Experimental Procedure No.1

For the first experiment, in the laboratories (hemi-anechoic room in Japan and quiet acoustic laboratory in Germany), the subjects' EEGs were measured by using the above experimental system. The subjects were sitting down on a chair while measuring EEGs. At first their EEGs were measured without sound stimuli under the conditions of the subject' eyelids open at rest, and then they were also measured while subject' eyelids closed at rest

Next, their EEGs were measured while being exposed to the sound stimuli under the condition of subject' eyelids open at rest.

2.5 Experimental Procedure No.2

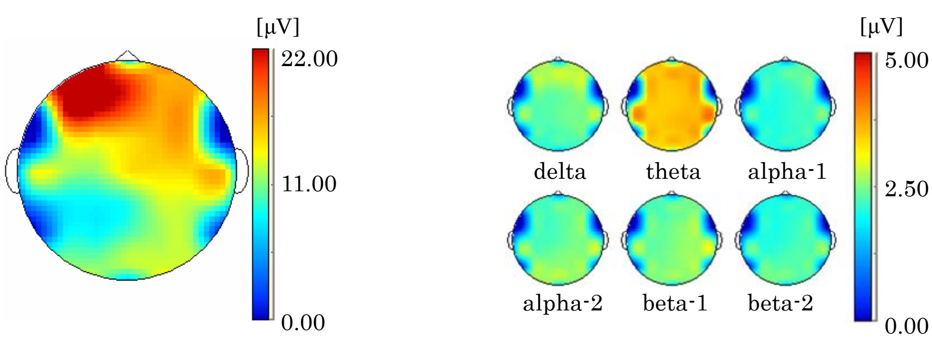
In the second experiment, the subjects were asked to judge the "noisiness" of the sound stimuli. Their EEGs were not measured. The experimental system, subjects and sound stimuli were same as the first experiment. The values of "noisiness" of the sound stimuli were estimated by "the method of magnitude estimation" using white noise at 75 dB as a standard. The standard was defined as 100, and subjects were asked to estimate the sound stimuli in relation to the standard by using of appropriate numbers. The sound stimuli were presented twice per one stimulus. The values of the arithmetic means of the two numbers of the estimated values for each subject were calculated as the datum of the “noisiness”. As values of “noisiness” of each sound stimulus, the geometric means of all subjects were used.

2.6 Analysis of EEG

According to frequency range of EEG, the waves have their own names. The frequency ranges and their names are shown in Table 3. The experimental results were analyzed in every frequency range. Electroencephalographic topographies were composed of these EEGs. The electroencephalographic topographies were shown as the electric potential distribution and the two dimensional display of frequency range. An example of them is shown in Figure 4.

Table 3: Frequency ranges of EEG and their name.

Name of EEG	Frequency range (Hz)
Delta wave	2-4
Theta wave	4-8
Alpha-1 wave	8-10
Alpha-2 wave	10-13
Beta-1 wave	13-20
Beta-2 wave	20-30



(a): Electric potential distribution (b): Two dimensional display of frequency range

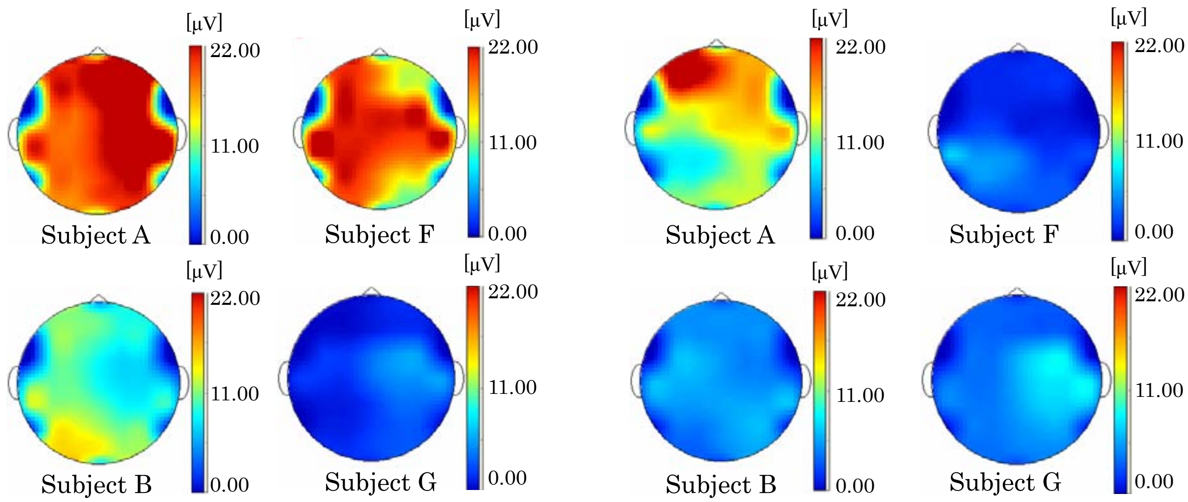
Figure 4: An example of electroencephalographic topography (Subject A, eyelids closed at rest).

3 RESULT AND DISCUSSION

3.1 Personal differences between Individuals

Personal differences between individuals were recognized particularly their electric potentials on their electroencephalographic topographies. In regard to the values of “noisiness”, as there were no great differences among the subjects, the personal differences were not investigated. But the personal differences of their electroencephalographic topographies were sometimes larger than the differences between Japanese subjects and German subjects.

At first electroencephalographic topographies under the conditions of their eyelids closed at rest and open without sound stimuli were investigated. When the subjects closed their eyelids, large personal differences were recognized in both Japanese and German. Besides the responses of their electric potentials while their eyelids closing at rest were higher than while their eyelids opening at rest, besides the values varied widely among the subjects. The causes were supposed that the condition of their eyelids closing was not different from their daily lives and they thought many things without visual stimuli. On the other hand, when the subjects opened their eyelids at rest, their electric potentials were very low except a few subjects. Figure 5 (a), (b) are shown the typical examples of electroencephalographic topographies of German subjects comparing of while their eyelids closing and opening at rest.



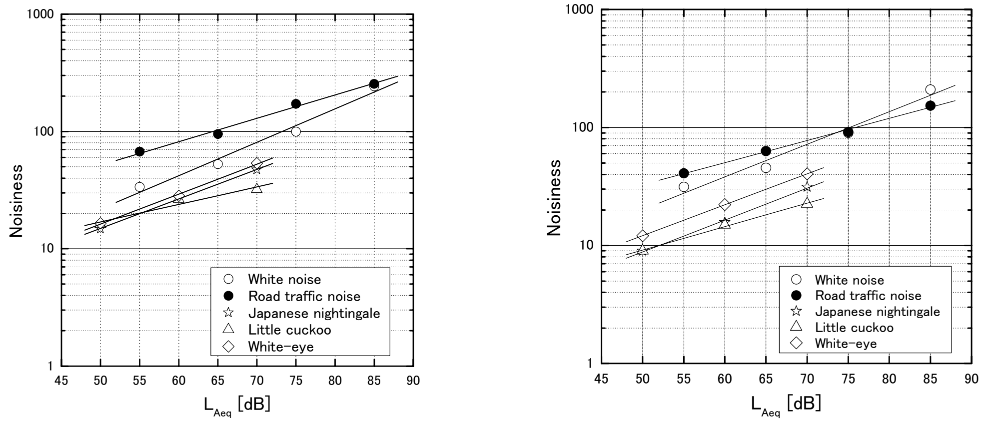
(a): Eyelids closed at rest (b): Eyelids open at rest

Figure 5: Typical examples of electroencephalographic topographies of German subjects.

Next, personal differences of the electroencephalographic topographies while being exposed to various kinds of sounds were investigated. If electric potentials of encephalographic topographies for a certain subject were always higher or lower than the others, or he or she always strongly responded to a special stimulus, it may be individual characteristics. But in this experiment such a case was not found. Therefore these experimental results were observed each sound stimulus about the electric potential distributions of the subjects and their scatter among the subjects comparing Japanese with Germans.

3.2 Estimated value of "noisiness"

Estimated values of "noisiness" for each sound stimulus were calculated as the geometric means of the values by all subjects for both Japanese and Germans. The relation between sound levels and estimated values of "noisiness" for each sound source are shown in Figure 6 (a), (b). For all sound sources, Japanese subjects estimated the sound stimuli noisier than German subjects. But only for the white noises, both Japanese and German subjects estimated the "noisiness" similarly to each other. The causes were supposed that the white noise is typical neutral noise for all subjects and most subjects had experience hearing the noise.



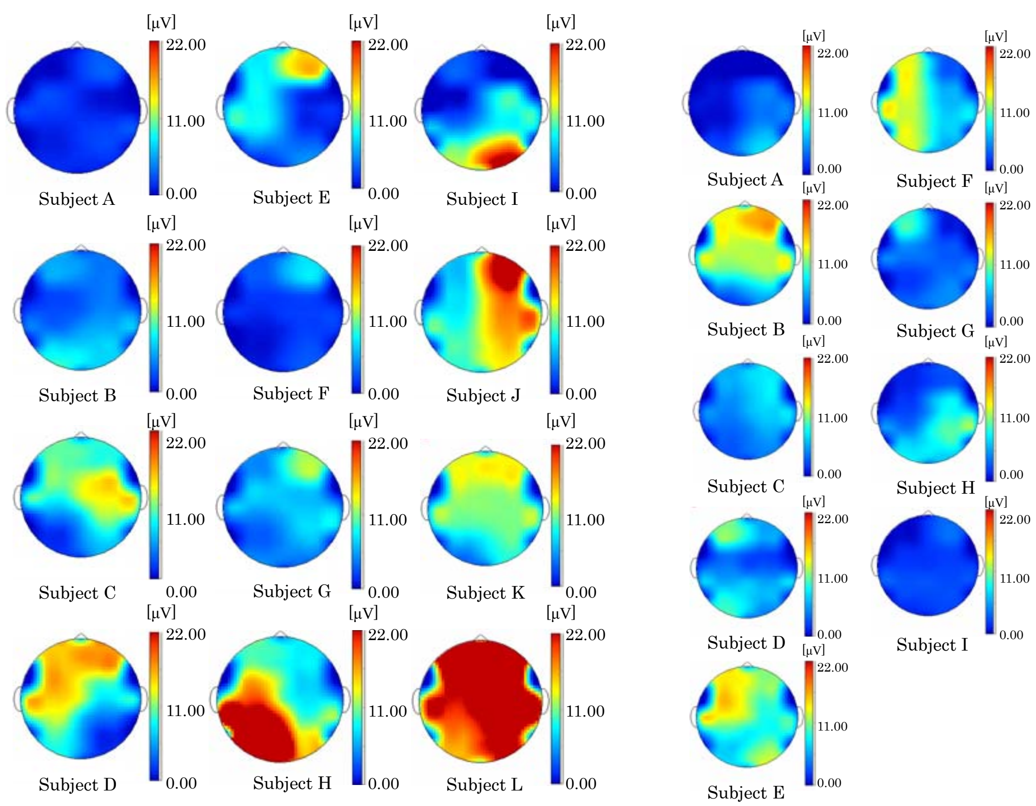
(a) : Japanese (b) : Germans

Figure 6: Relation between sound levels and estimated values of “noisiness”.

3.3 Electroencephalographic Topography

3.3.1 White noise (55, 65, 75 and 85 dB)

Although Japanese and German subjects similarly estimated the “noisiness” of white noises, the electric potentials on the encephalographic topographies of Japanese were much higher than Germans’. The cases of 85 dB are shown in Figure 7 (a), (b).



(a) : Japanese (b) : Germans

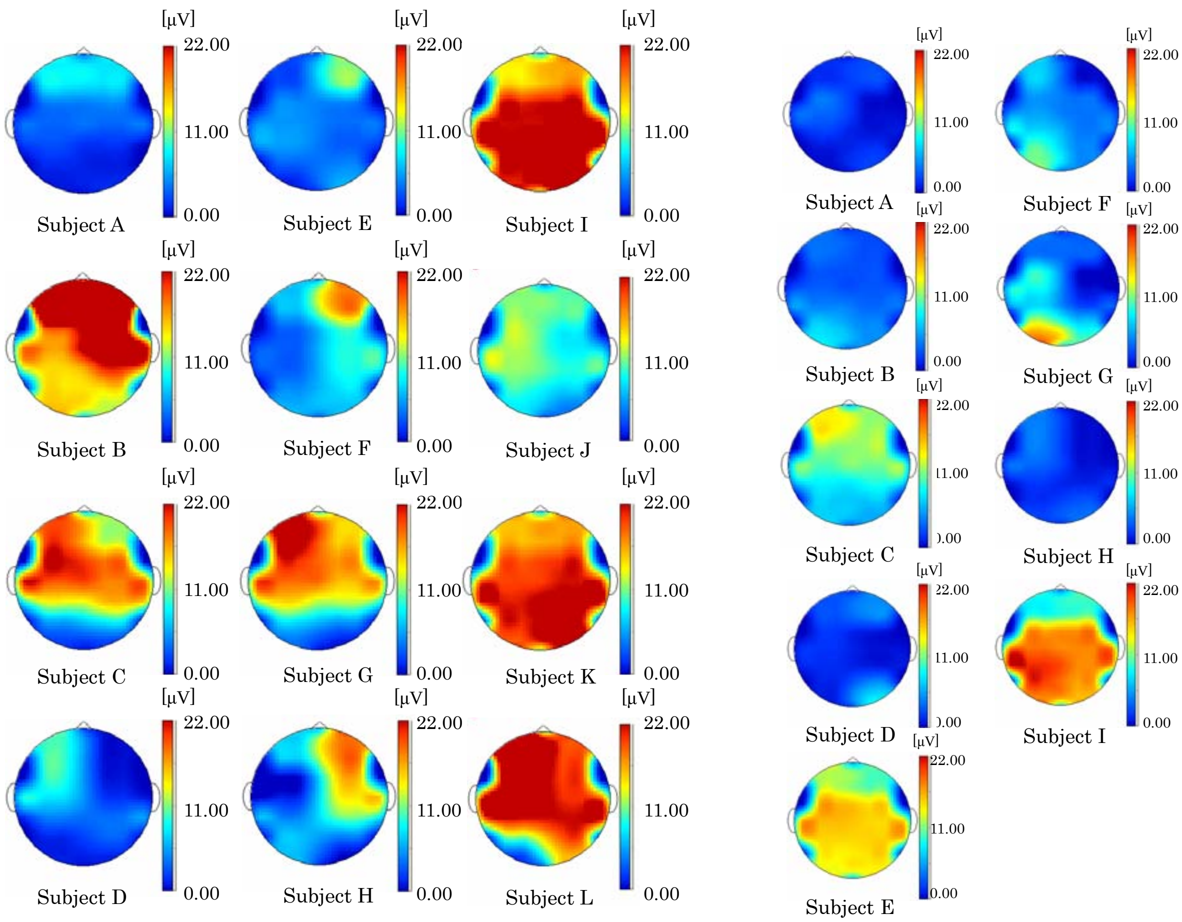
Figure 7: Electroencephalographic topographies (White noise 85dB).

The reasons were supposed that German subjects were accustomed to hear white noises, as all of them were members of an acoustic laboratory. But the Japanese subjects belonged to department of architecture, so only some people had heard white noise. Their dominant cerebral hemispheres were not clear.

3.3.2 Road traffic noise (55, 65, 75 and 85 dB)

The electric potentials on the electroencephalographic topographies for Japanese were also much higher than Germans'. The electric potentials for Germans' were not so high, even at high sound level, but for Japanese, as the sound levels increased their electric potentials also increased. Particularly at the highest sound level, 85 dB, the difference between Japanese and Germans showed up as displayed in Figure 8 (a), (b). In regard to the "noisiness" of road traffic noises, Japanese estimated them noisier than Germans at every sound level. Their regression lines were parallel to each other as illustrated in Figure 9.

The causes were supposed that Germans were accustomed to hear road traffic noise, because they were frequently driving on the high way (Autobahn) at full speed. But in Japan, the road traffic noises were not so loud, because the roads were always too crowded to drive speedy generating loud traffic noise in Japan.



(a): Japanese (b): Germans

Figure 8: Electroencephalographic topographies (Road traffic noise 85dB).

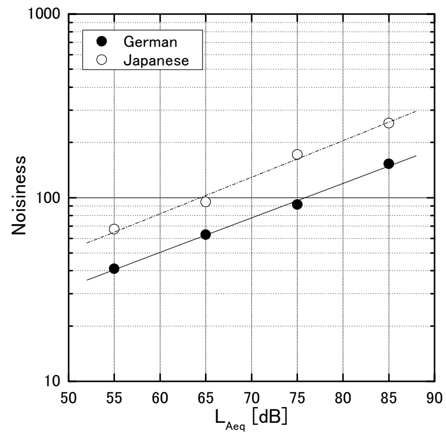
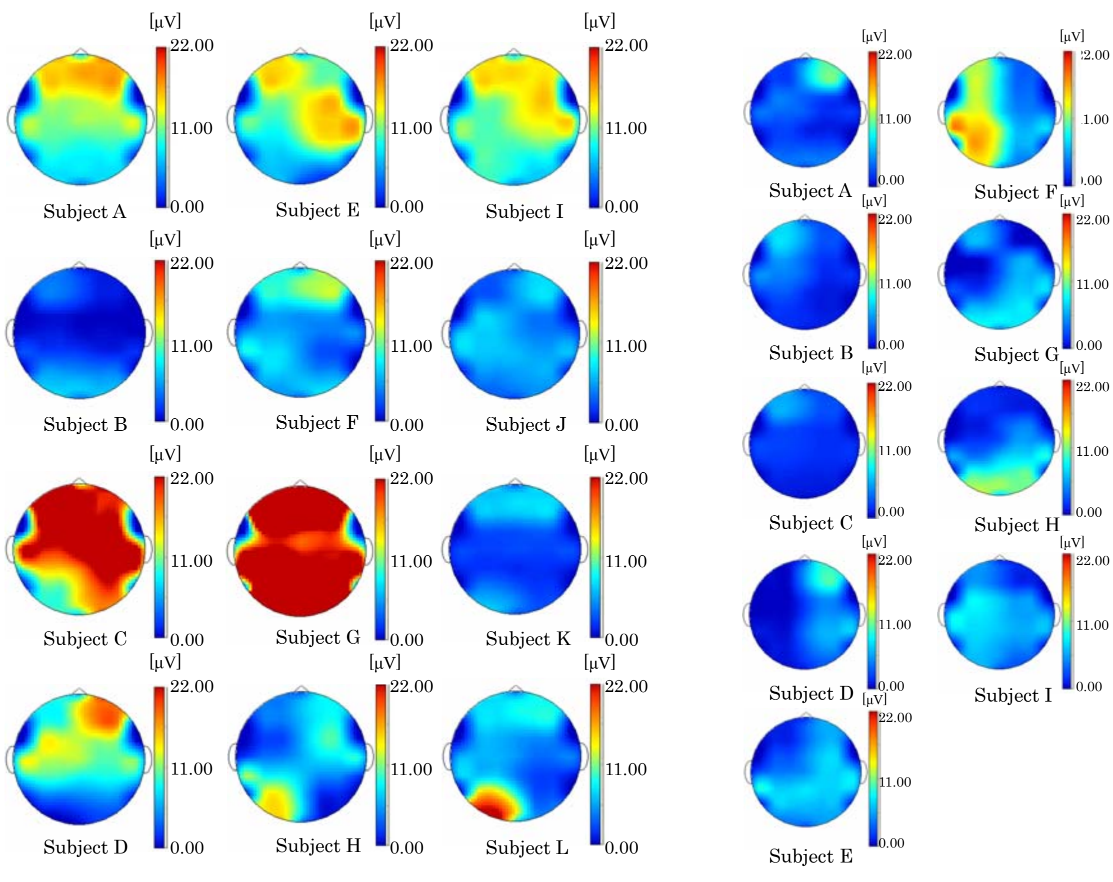


Figure9: Estimated values of noisiness comparison Japanese with Germans.

3.3.3 Bird singings (50, 60 and 70 dB)

As the sound levels of bird singings are not so loud, the sound levels of sound stimuli were 50, 60, and 70 dB were used. Japanese and Germans' electroencephalographic topographies of the songs of "Japanese nightingale" at 50 dB are shown in Figure 10 (a), (b).

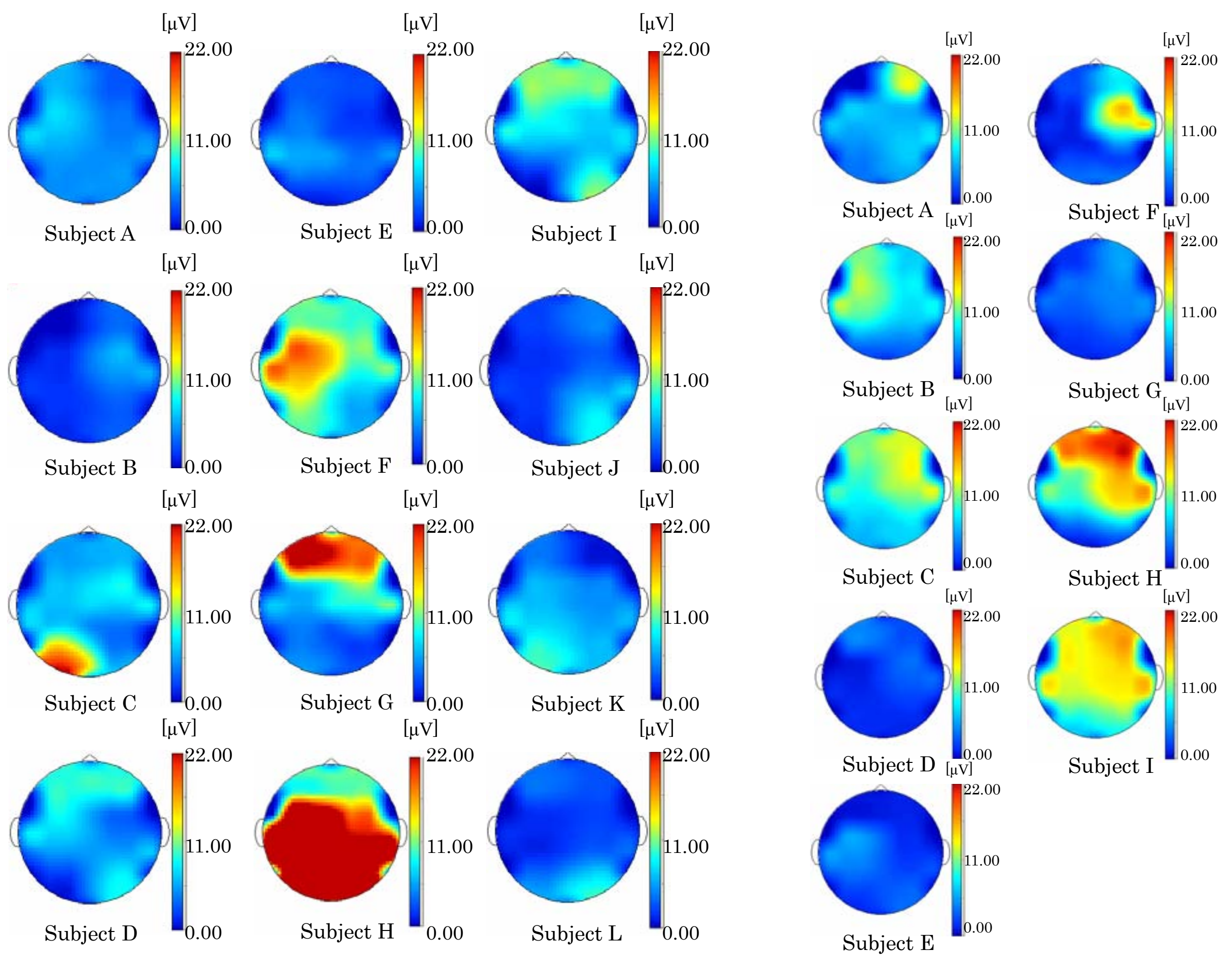


(a): Japanese (b): Germans

Figure 10: Electroencephalographic topographies (Japanese nightingale 50dB).

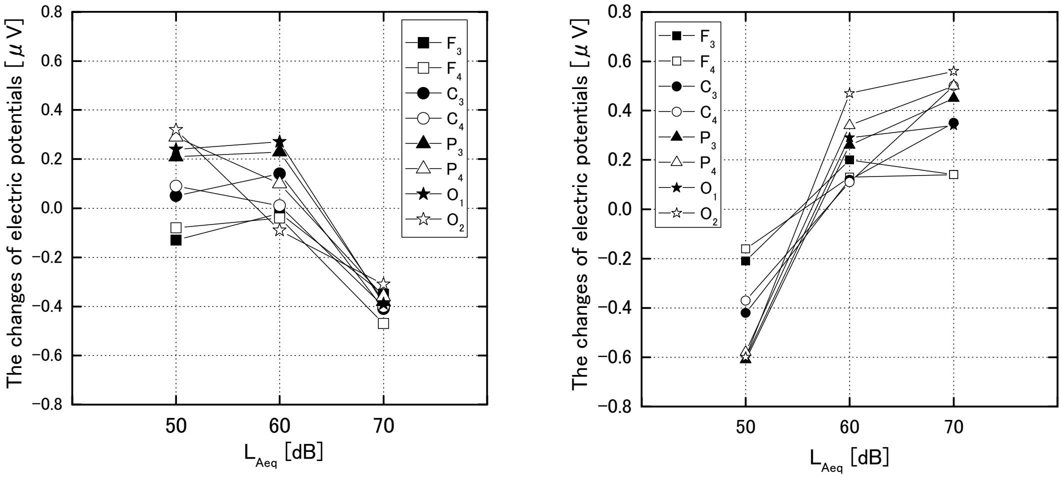
"Japanese nightingale" is famous for beautiful voice in Japan. Therefore the electric potentials on the electroencephalographic topographies for Japanese were much higher than Germans' at every sound level. Generally speaking, Germans responded slightly to the bird singings of "Japanese nightingale" at every level. As is evident from Figure 10, their dominant cerebral hemispheres were not clear.

Observing the electroencephalographic topographies of "little cuckoo", the degree of electric potentials of both Japanese and Germans were similarly at every sound level. But it was clear that Japanese dominant cerebral hemispheres were left at 50dB, and at 70 dB, Germans' were right in line with Tsunoda's experimental results [1], [2]. It was suppose that the songs of "little cuckoo" at 50 dB were looked like comfortable sound in a quiet place for Japanese. But at 70dB they might be noises for Germans, because of the unrealistic loudness. Results are shown in Figure 11 (a), (b). In addition to this, the changes of electric potentials of the alpha-2 waves with sound levels were different between Japanese and Germans as in Fig 12 (a), (b). Generally it is said that the alpha waves increases, when a person feels comfortable. But Germans' alpha-2 waves increased, when they felt noisy. The reasons were not clear.



(a): Japanese (50 dB) (b): Germans (70 dB)

Figure 11: Electroencephalographic topographies (little cuckoo).



(a): Japanese (b): Germans

Figure 12: Changes of electric potentials of alpha-2 waves (little cuckoo).

The electric potentials on their electroencephalographic topographies of the songs of "white-eye" for Japanese and Germans resembled each other, and the degree of their responses was similar to Japanese nightingale's. The difference of the values of "noisiness" between Japanese and German was also small. Germans' dominant cerebral hemispheres were sometimes (at 50 dB) right as Tsunoda's experimental result [1], [2], but sometimes (at 70 dB) were not clear.

4 CONCLUSION

The purpose of this study was to know differences of Japanese and German subject's EEGs, and their dominant cerebral hemisphere while being exposed sound stimuli. The subjects were measured their EEGs, and then they were asked to judge the "noisiness of the sound stimuli. From the results of EEGs, their electroencephalographic topographies were composed. The results were analyzed comparing their electroencephalographic topographies with the estimated values of "noisiness". Japanese estimated the sound stimuli noisier than Germans except for white noises. Besides, observing their electroencephalographic topographies, Japanese electric potentials generally higher than Germans'. Their dominant cerebral hemispheres were not clear, but concerning bird singings, sometimes they were recognized.

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