Can we separate the kind of drinks using only EEG ?

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Summary: The motivation of this study is to analyze the difference between two kinds of "drunkenness" which are alcoholic and non-alcoholic beverage using electroencephalogram (EEG). Though non-alcoholic beverage does not contain alcohol components, there are people who complain of drunkenness due to drinking non-alcoholic beverage. In the experiment, we measured EEG of subjects who drank two kinds of beverages. The difference is evaluated by support vector machine (SVM). SVM was validated with cross validation using the detected features. As the results, the separation rate recorded 76.3%. By clarifying the difference between drunkenness due to alcoholic and non-alcoholic beverages, we tried to establish a method to identify drunkenness automatically.

Introduction: In this paper, we focus on drunkenness, and attempt to elucidate the difference between two kinds of "drunkenness" which are alcoholic and non-alcoholic beverage. We tried to analyze the difference of two kinds of "drunkenness" using electroencephalogram (EEG). EEG is an electrical signal acquired from the human scalp noninvasively and reflect nerve activity. Furthermore, we used the simple EEG measurement device to reduce the burden on subjects.

One effect of alcoholic beverages is drunkenness. Drunkenness caused by alcoholic beverages is a phenomenon that alcohol components reach the nerve cells of the brain via blood, paralyze the parts of the brain, and deteriorate that function. The paralyzed parts are different depending on the amount of alcohol consumption. In the first stage, alcohol components paralyze the cerebral cortex. In the second stage, alcohol components paralyze the limbic system and the cerebellum. In the third stage, alcohol components paralyze the hippocamp. In the final stage, alcohol components paralyze the bulbar, and people at this stage are put at risk of life[1]. In the first and second stage, people feel refreshed. However, there are disadvantages of alcoholic beverages such as not being able to drive a car after drinking and being unable to drink during pregnancy. Attempting to overcome these drawbacks is non-alcoholic beverage.

Though non-alcoholic beverages contain no alcohol component, there are people who complain of drunkenness by non-alcoholic beverages. The standard of drunk driving is determined by the amount of exhald ethanol. Therefore, even if we drink non-alcoholic beverages, it will not be drunk driving. However, it id unknown what kind of state drunkenness by non- alcoholic beverages is. We can think that a change of emotion is probably occur. In the past research, drunkenness was normally detected by questionnaire, but questionnaire is subjective[2]. Therefore, we used EEG to analyze drunkenness objectively. The measurement point was prefrontal cortex reflecting changes of emotion. By clarifying the difference between drunkenness due to alcoholic and non-alcoholic beverages, we made the usefulness of non-alcoholic beverages apparent.

Material and method:

A. EEG measurement: In the experiment, subjects sat on a chair and wore an EEG measurement device. The electrode is circular with the diameter of 16 mm, and characteristic impedance is 1.5 V / 95mA maximum average current. The sampling frequency of this device is 512 Hz. The measurement point was Fp1 based on international 10-20 system. We selected Fp1 because Fp1 reflected emotion. The EEG in resting state were recorded for 60 seconds with their eyes opened. After that, subjects drank the alcoholic or non-alcoholic beverage. After drinking, The EEG in resting state were recorded for 60 minutes with their eyes opened. In this 60 minutes, subjects scored points by 7 levels for the degree of own drunkenness every 10 minutes. The experiment was done twice per one subject. Subjects drank the non-alcoholic beverage in the first day, and the alcoholic beverage in the second day without knowing the kind of beverage.

B. Criteria including: Before experiment, we conducted subject screening for 141 people. 61 people (56 males, 5 females; age: 28.0±7.98 years) was selected as subjects of the experiment for the reason that they were easy to get drunk (scored 4 points or more for non-alcoholic beverage) or hard to get drunk (scored 1 point for non-alcoholic beverage).

C. Subjects: In this paper, EEG data of several subjects were not used for analysis because of lack of the reliably of scores. Subjects who scored higher for the alcoholic beverage than for the non-alcoholic beverage were judged as highly reliable.

Analysis: In order to analyze the difference between the drunkenness by alcoholic and non-alcoholic beverages, support vector machine (SVM) was applied, and cross validation was used as evaluation method.

A. Pre-processing: In this step, two types of pre-processing were applied for raw EEG data to extract pure EEG components. First, the filter processing with 8th order butterworth bandpass filter at 1-30 (Hz) was applied to remove the artifacts. It is necessary to filter the measured data to obtain only EEG data from raw EEG data. Second, output was divided into data of 1 second, and the maximum and minimum value in 1 second was acquired. The threshold was set so that the number of divided data was 70% of the total, and the divided data including the voltage exceeding the threshold was excluded from analysis. This process is to remove artifacts caused by blinks.

B. Classification: In this step, features selection, classification, and evaluation were described.

For features selection, Fast Fourier transformation (FFT) was used. FFT is a method that a signal is considered as the sum of sine and cosine waves with different frequencies and converted the signal to the frequency domain. After FFT, power spectra was calculated every 1 Hz by setting the time window to 1 second. Power spectra were calculated and normalized per subject so that the maximum value of spectra is 1 and the minimum value is 0 to enable comparison among different subjects. For comparison, we used two samples *t*-test ($p<0.05$). Two samples *t*-test was conducted to verify the difference in EEG power spectra between two individual samples. The two samples *t*-test was used to determine any statistically significant difference between drunkenness by alcoholic and non-alcoholic beverages.

In the classification, SVM was used to confirm whether the kind of drunkenness can be identified by EEG. The power spectra at which the significant difference was detected by two samples *t*-test was used for classification as the features. Subjects with high points are defined as subjects who are drunk highly. High points was 4 to 7 points. We tried to classify subjects who were drunk with the alcoholic beverage and subjects who were drunk with the non-alcoholic beverage. As the evaluation, we used Leave-one-out cross validation.

Results and discussions: Fig. 1 shows the power spectra of EEG of drunkenness state due to alcoholic and non-alcoholic beverages. As the results of two samples *t*-test, significant differences were found at 2 and 4 Hz frequency bins ($p<0.05$). 2 and 4 Hz frequency bins at which significant difference were found were used for features of SVM. Drunkenness by alcoholic and non-alcoholic beverages can be classified with the accuracy of 76.3% by SVM.

We think about why 2 and 4 Hz frequency bins of drunkenness by alcoholic beverages are higher significantly than one by non-alcoholic beverages. Generally, EEG of 1-4 Hz is called delta wave. Delta wave is said to dominate during sleep. From these, the significant difference of 2 and 4 Hz frequency bins found in two kinds of drunkenness caused by alcoholic and non-alcoholic beverages indicates that sleepiness is induced when subjects drank alcoholic beverages.

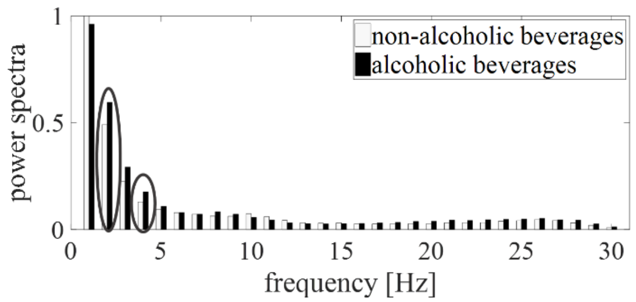

Fig.1 Power spectra of drunkenness (Significant difference was detected at 2 and 4 Hz frequency bins by two samples *t*-test ($p<0.05$).)

References:

1. Eric R. Kandel, et al., PRINCIPLES OF NEURAL SCIENCE, medical science international, 1981.
2. Katharine A, et al., AUDIT-C as a Brief Screen for Alcohol Misuse in Primary care, ALCOHOLISM : CLINICAL EXPERIMENTAL RESEARCH, 31(7), 1208-1217, 2007.