

# THE DEVELOPMENT OF EQUIPMENT TO DETECT ALCOHOL IN THE HUMAN BODY

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## ABSTRACT

This paper describes the development of equipment to detect alcohol in the human body. When drivers want to switch the engine on by the ignition-key, the equipment judges whether or not they have drunk alcohol. The theorem of the equipment to detect is based on the electrodermal activity. The comparison between the method and two kinds of equipment of breath alcohol detections on the market is performed. Their equipment has shown the higher level just after drinking alcohol, but they reveal lower levels when time has passed of drivers who were drunk. On the other hand, the method shows the same events of the values and questionnaires of volunteers.

## INTRODUCTION

Many traffic accidents are a result of drinking and driving. In order to prevent accidents, much research has been performed such as interlock systems. The detector is applicable to measure breath alcohol concentration rapidly and easily. But they have some weak points and are troublesome for drivers to use. Furthermore, they are inaccurate to measure alcohol concentration. Because the breath with alcohol exhaled from alveolus is diluted through the trachea. Therefore, some new detectors to measure accurately alcohol concentration are hoped to be developed.

## BACKGROUND

There are many reports regarding traffic accidents caused by driving while intoxicated. In Japan, accidents by drivers who drink alcohol are decreasing. On the other hand, in the United States, there are much accident data reported by the government. There are many dangerous situations by drinking drivers even though accidents did not happen. It is said that when a serious accident occurs, there are 29 minor accidents waiting to happen by the Heinrich's Law. From economic cost for society is huge. It is hoped that new type of detectors are of an interlock system.

One of the authors has been studying the Electrodermal

Activity (EDA) applied to detect driver's conditions such as drowsiness, fatigue and alcohol concentration included in basic researches [1]~[7]. There are two methods of electrodermal activity. One is the endosomatic recording and the other is exosomatic recording [8]. Here, the endosomatic recording is used.

Figure 1 and Figure 2 show the test results summarized comparison before drinking alcohol and after alcohol. Figure 1 shows the test results after drinking alcohol by the EDA, compared to ordinary conditions. Also it is verified to the usual digital detector of alcohol by respiration. Figure 2 reveals the test results performed under various conditions. As shown in the Figures, it is clear that differences between the condition after drinking alcohol and other conditions. Additionally, the fast Fourier's transform (FFT) carries out analyses of wave shapes for each condition. Each wave has characteristics corresponding each condition.

In order to detect alcohol concentration, breath alcohol concentration detectors are used in the actual market. Their measurements show a higher level just after drinking alcohol, but they reveal a lower level when time has passed though drivers were drunk. On the other hand, the method shows the same events of the values and questionnaires of volunteers.

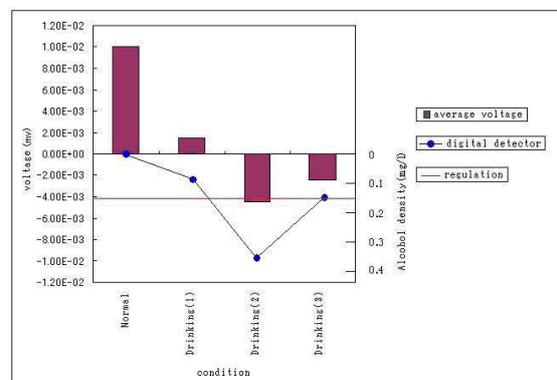
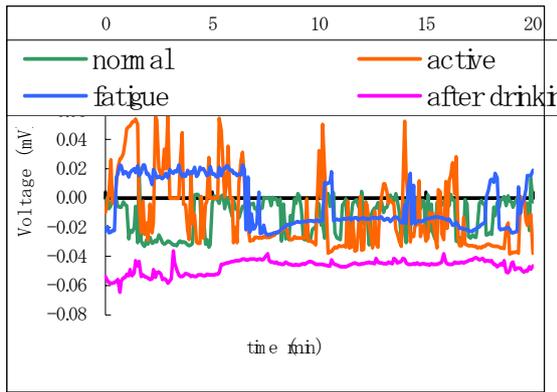
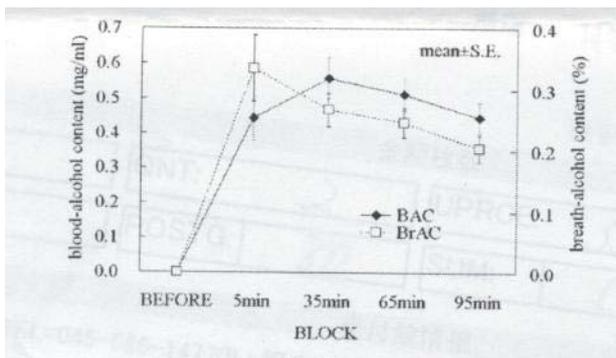


Figure 1 Test result after drinking alcohol by the Electrodermal Activity [7]



**Figure 2 Test results performed under various conditions [2]**

Figure 3 shows the relationship between the blood-alcohol content and the breath alcohol content [8]. The horizontal axis is the time (minute), the left vertical axis is the blood-alcohol content (mg/ml) and the right one is the breath-alcohol content (%).



**Figure 3 Relationship between the blood-alcohol content and the breath alcohol content [8]**

As shown in the Figure 3, the higher level content just after drinking alcohol shows in the breath-alcohol but they reveal the lower level compared to the blood-alcohol content when time has passed.

Based on these tests, the sensor of detecting alcohol needs to develop reliable sensors as the interlock system.

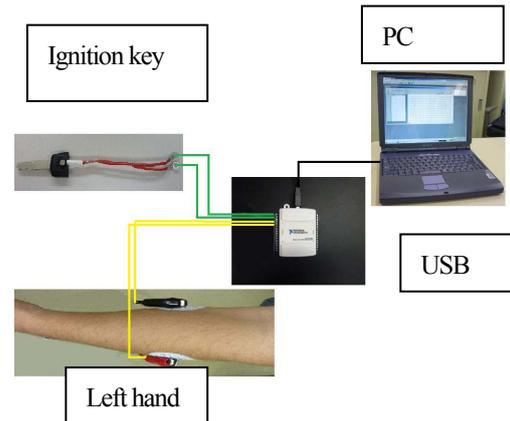
## METHLOGY

Human beings have many physiological characteristics such as brain waves, pulse rate, body temperature, and reveal facial expression, blink number and etc. Electrodermal Activity (EDA) is one of the physiological characteristics. And it is selected among them as the equipment to inspect drowsiness or fatigue. Researches by using it have been studying by many researchers. There are two methods of electrodermal activity. One is an

endosomatic recording and the other is an exosomatic recording [9]. In this study the endosomatic recording is used.

### 1) Equipment

Figure 4 shows the system of the electrodermal activity. One sensor places on the left hand, and the other inserted on the ignition key sets on the ignition key and pinched with right fingers. The sensor of the electrode is made of the Ag-AgCl. They are connected to the USB with eight channels by harnesses and the USB connected to the PC.



**Figure 4 System of measurement of the EDA**

Recently, the detector is applicable to measure the breath alcohol concentration rapidly and easily. In this study, two types of the breath alcohol detector are available for testing. The type A (CA2000) has the piece in the mouth and the type B (SOCIACX) is to breathe upon the piece.

### 2) Experimental Conditions

/ Measurement of a certain volunteer by using the EDA in a day and a week

/ After drinking alcohol, measurement of many volunteers by using the EDA, and the comparison between the EDA and the breath alcohol equipment

/ Carrying out subjective questionnaires of intoxicated feelings to voluntaries

/ Analysis of data

The contents of volunteers are shown in the Table 1.

**Table 1 Contents of volunteers**

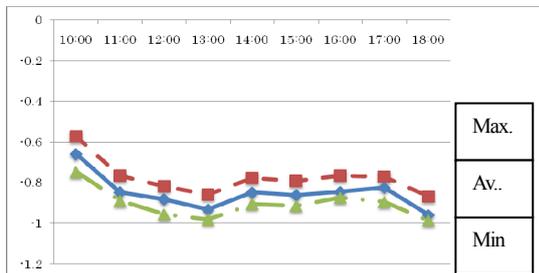
	Age	Number
Male	20 to 34	10
Female	22 to 24	4

## EXPERIMENTAL RESULTS

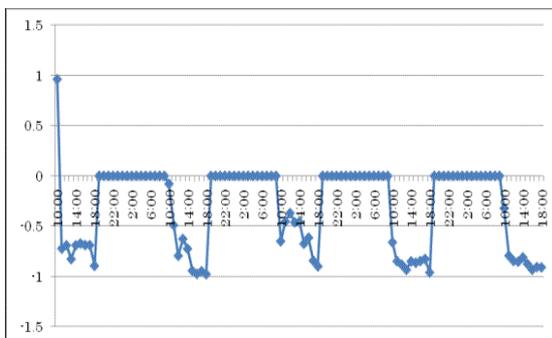
### 1) Basic measurement

As described above, tests were performed owing to take various basic parameters such as kinds of electrodes, the distances of each electrode, both hands set with electrodes and etc.

In this study, the fluctuation of EDA of a certain volunteer in a day and a week is measured. The Figure 5 shows the results of the fluctuation of the EDA in a day. The Figure 6 shows the results of fluctuation of it in a week. As shown in these figures, the EDA's values of common life are steady states. The horizontal and vertical axes show the time (hour) and the level of the EDA (mV).



**Figure 5 Fluctuation of EDA of a certain volunteer in a day (Maximum, minimum and average of waves)**

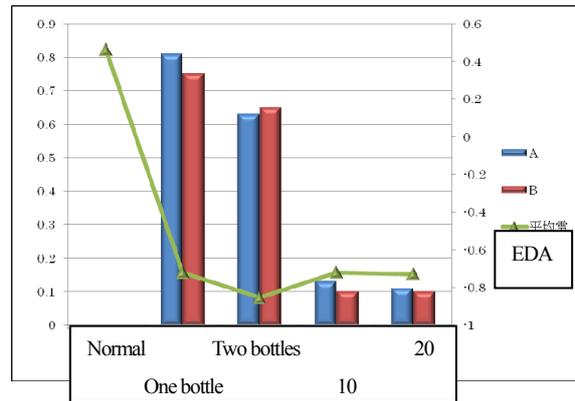


**Figure 6 Fluctuation of EDA of a certain volunteer in a week (Average of waves)**

### 2) EDA after drinking alcohol

Results of the EDA after drinking shows the Figure 7 compared with two breath alcohol concentration equipment. Just after drinking alcohol, the values of the EDA have the tendency of decrease from non-alcohol condition and slightly recovery when time has passed. On the other hand, the values of the breath alcohol concentration increase just after drinking and as time's passing though taking more drinking, the values decrease by using both breath alcohol equipment. The horizontal axis shows the number of the beer (350cc with 5 % alcohol per one bottle) and passing time (minute). The left vertical axis shows the alcohol concentration (mg/ml) and

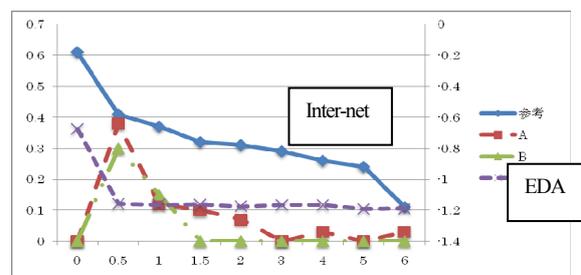
the right vertical axis does the absolute values of the EDA (mV).



**Figure 7 Results of the EDA and both breath alcohol equipment after drinking alcohol**

The comparison between the data from inter-net with the breath alcohol concentration and two measurements of this time performs. Conditions such as drinking alcohol are as same as inter-net data. Figure 8 shows the results of comparisons of them. As shown in the Figure, two breath alcohol concentration equipment of this time reveal higher level just after drinking alcohol and show lower level as time passes. On the contrary, the data of the inter-net the level decrease gradually. The vertical axis indicates that the upper poison is the high concentration.

The value of the EDA indicates a constant level as the alcohol would remain in the body.



**Figure 8 Comparison between the data from inter-net with the breath alcohol concentration**

These measurements of the alcohol concentration show the different values among the equipment of the breath alcohol.

### 3) The relationship between the experimental data and the results of volunteer's statements

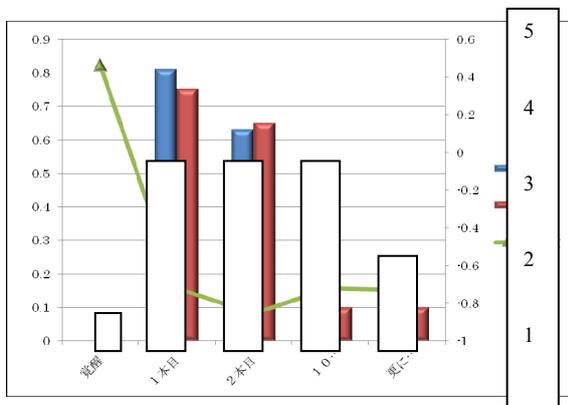
The comparison between data of EDA and questionnaires to volunteers performs according to contents shown in the Table 2, in which are subjective

questionnaires of intoxicated feelings to volunteers. Contents consist of three parts such as condition, content and score. The content is divided two parts. One is physical questionnaire and the other is feeling. The volunteers answer to questions. Also, the score makes up five levels.

**Table 2 Questionnaire to volunteer**

Condition	Content	Score
	/Physical questionnaire /Feeling questionnaire	
Serious drunk	/Having nausea /Occurring to do nothing	5
Strong drunk	/Feeling dizzy in standing /Feeling disgust	4
Recognition of drunk	/High temperature /Drunk slightly	3
Slight drunk	/Becoming skin red /Feeling refreshing	2
Normal		1

The Figure 9 shows the relationship between experimental data and the results of volunteer's statements. The right vertical axis added in the Figure shows the score.



**Figure 9 the relationship between experimental data and the results of volunteer's statements**

Though the values taken by two alcohol equipment are lower levels as the time passes, the statements of the volunteer reveal the high score after drinking alcohol.

#### 4) Data analysis

Many experimental tests are performed to volunteers as shown in the Table 1. Data show the various patterns according to the individualities in these tests. So data are

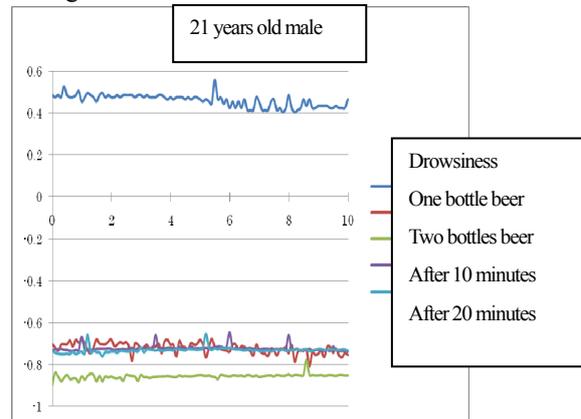
needs to analyses and evaluate.

First, the First Fourier Transfer Analysis (FFT) and the minimum square method of EDA are studies. Here, the minimum square method is used.

Next, as the data reveals the difference of the individuality, the amplitude, length, and frequency of waves of EDA are evaluated.

#### (1) Absolute value of wave

The evaluation of data is made by the absolute value of waves as shown in the Figure 7. Also, The evaluation of data is made by the absolute value of waves as shown in the Figure 10.

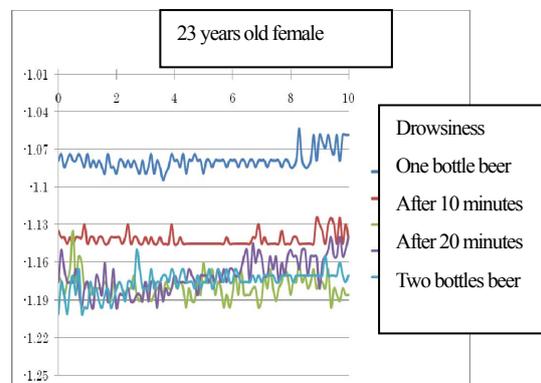


**Figure 10 Evaluation of data is calculated by the absolute value of waves**

Both measurement results show different values at the same conditions due to difference of individuals.

#### (2) Amplitude value of wave

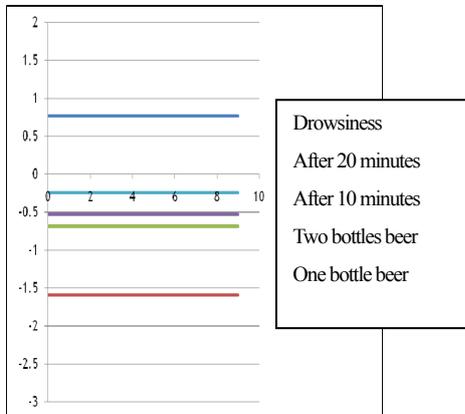
The evaluation of data made by the amplitude value is shown in the Figure 11.



**Figure 11 Evaluation of data is calculated by the amplitude value of wave**

### (3) The least squares method

There are many filters to analyses data. In this case, the least squares method is applicable to use. And the evaluations of data are calculated by the absolute or amplitude of waves as shown in the Figure 12.



**Figure 12 Evaluation of data is calculated by the amplitude value of wave after analyzing filter**

### CONSIDERATIONS AND CONCLUSIONS

Some results of our research are summarized as follows:

- 1) The values of the Electrodermal Activity (EDA) of human beings in daily life are consistent.
- 2) The values of the EDA measured on the both hands and on the ignition-key show the same.
- 3) Measurements of alcohol concentrations by using the breath testing equipment how a high level just after drinking alcohol, but show a lower level when the time has passed.
- 4) Measurements of alcohol concentrations by using the EDA show a constant level when time has passed.
- 5) Both measurements show different values at the same conditions due to difference of individuals.
- 6) According to the questionnaires of volunteers, the recordings of the breath alcohol become lower though they experienced drunken conditions. On the other hand, recordings by the EDA show the same drunken situations as the feelings of volunteers. The reasons are that the breath with alcohol exhaled from alveolus is being diluted though the trachea. These dilutions do not show the accurate values.
- 7) Though the recordings of the alcohol concentrations by the EDA depend on the difference of individuals, they can be solved by the computational post-treatments such as the Fast Fourier's transform (FFT).

It is possible to develop the detector of lock inter system by using the EDA. If the system can be developed, many drivers could be prevented from causing serious accidents.

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