Facial Expression Effect on Signal Quality and the Attention Level of Mindwave

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ABSTRACT The ability of single electrode electroencephalography (EEG) device such as Neurosky Mindwave has been widely explored in the field of Brainwave Computer Interface (BCI). It has been applied to the devices that are designed specially for people with communication difficulties and severe motor disabilities due to low cost wireless EEG and feasible for daily life usage. Many studies make use of the attention level to be a signal to control automated application such as a wheelchair or home appliance. Thus, this study was to investigate the effects of different facial expression on the attention and signal quality value using Neurosky Mindwave. The brainwave sensor was placed on the forehead frontal point (Fp1) and transmits the electrical impulses wirelessly to Arduino Mega via Bluetooth HC05. The microcontroller was programmed to process the brain signal accordingly and display corresponding output. The testing was executed by frowning and winking with the left and the right eyes. The respondent had to follow the instruction to do these three facial expression. The time gap between two activities were ten (10) to fifteen (15) seconds approximately. The real time data of signal quality and attention value was monitored on CoolTerm. It was found that there were various attention value of the respondent when they executed the activities depending on their focus at that time. However signal quality of 25 could be obtained from all respondents when frowning. This value can be considered as an input signal for control mechanism with if further testing are implemented on a prototype to validate the finding.

KEYWORDS: Brainwave, EEG, Attention, BCI, Single Channel
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INTRODUCTION

Brain-Computer Interface (BCI) is not only beneficial for medical support but also other applications such as for educational application (Magrizef *et al*., 2020) and entertainment. The methods can be classified as invasive and non-invasive. Non-invasive BCI was rated as a high priority design requirement (Collinger *et al*., 2013). It can be executed by using electroencephalography (EEG) with the standard International 10-20 electrode site placement strategy (Erik & Lauren, 2016). It was difficult to identify the emotion through facial expression. However, the placement strategy allows true emotions to be known. It was identified easier from the reading of brain wave frequencies that are at a certain level in the classification of waves such as alpha, beta and gamma (Ismail *et al*., 2016). Besides that, with thirty-one (31) active wet electrodes following the 10-20 system of American Clinical Neurophysiology Society Guideline 2 for electrode placement, the BCI users could control TV channels, the digital door-lock and the light with high percentage of accuracy (Minju *et al*., 2019)

It is important to have sensors that are simple and easy to be handled for daily life usage. One of them is NeuroSky Mindwave Mobile. It was introduced as a wireless EEG device with single electrode. The measurement is not as precise as multiple electrodes but the existence such device encourages researchers to investigate its ability to control devices such as wheelchair or home appliance. eSense (attention and meditation eSense) of the Mindwave is algorithms that had been patented to interpret both alpha and beta waves into a unique level-based display (Neurosky®, 2014). Its value ranges from 0 to 100.

The voltage level of electrical signals generated from muscular movements, called electromyography (EMG) is higher compared to signals generated by brain cells and strongly detectable through such a sensor along with EEG signals (Sujay *et al.*, 2019). Even though it is not beneficial for traditional method, it can be a signal for controlling different devices and applications. Therefore, in this paper we investigate the attention and signal quality value from different facial activities using single electrode (Neurosky Mindwave). The value identified from frowning, winking with the left and right eyes could be as a potential signal to control any other connected devices using Bluetooth.

RELATED WORK

From the past studies, there was a combination of attention value from eSense meter and high alpha reading from the eye motion (as a trigger) for turning the wheelchair to the right and left. However, the percentage of failure to turn the wheelchair to the required directions were more than 50%. This was because the movement could not be classified with only one trigger (Permana *et al*., 2019). The system was designed by Aiswarya *et al*. (2019) was for controlling home appliances (example: bulb, fan etc.) with the help of human attention level. In order to switch on the appliances, user should put their attention towards object. If average of attention (from 20 readings) were greater than the threshold value, the appliances would be switched on. The threshold value of the attention was 40 to activate the system. The same method was applied to switch them off. The attention level between 40 to 59 is considered as neutral while the attention level that less than 40 is categorized as less and poor attention (Neurosky, 2009). Since the focus of users would be different as classified by (Norasyimah *et al*., 2020) from thirty (30) respondents, the threshold value for attention level in controlling the devices might need to consider gender of the user. From the statistical analysis obtained in the experiments, there was a significantly different of attention level between male and female in the forward movement of the wheelchair. The signal quality and the level of attention had been applied to move the wheelchair (Fouziah *et al*., 2017) while the number of eye blinks detected was for selecting the mode of wheelchair directions. The wheelchair was moved to the backward by using the signal quality of 26 whenever the eyebrow was lifted. The project conducted by Afishah *et al*. (2019), the signal quality of 26 or 51 was applied to stop the wheelchair. Sujay *et al*. (2019) had interpreted jaw tension and eye blinking through the analysis of EMG signals to accomplish the movement control of a wheelchair in all possible directions.

METHODOLOGY

Respondents

In preliminary test, a total of five healthy and normal respondents were at the age from sixteen (16) to twenty-two (22) years old as shown in Table 1. Testing was conducted by instructing them to wink with the right eye, wink with the left eye and frown.

Table 1. Gender and age of the respondents

Respondent	Gender	Age
1	Female	17
2	Male	16
3	Male	17
4	Female	16
5	Male	22

Electrode Placement

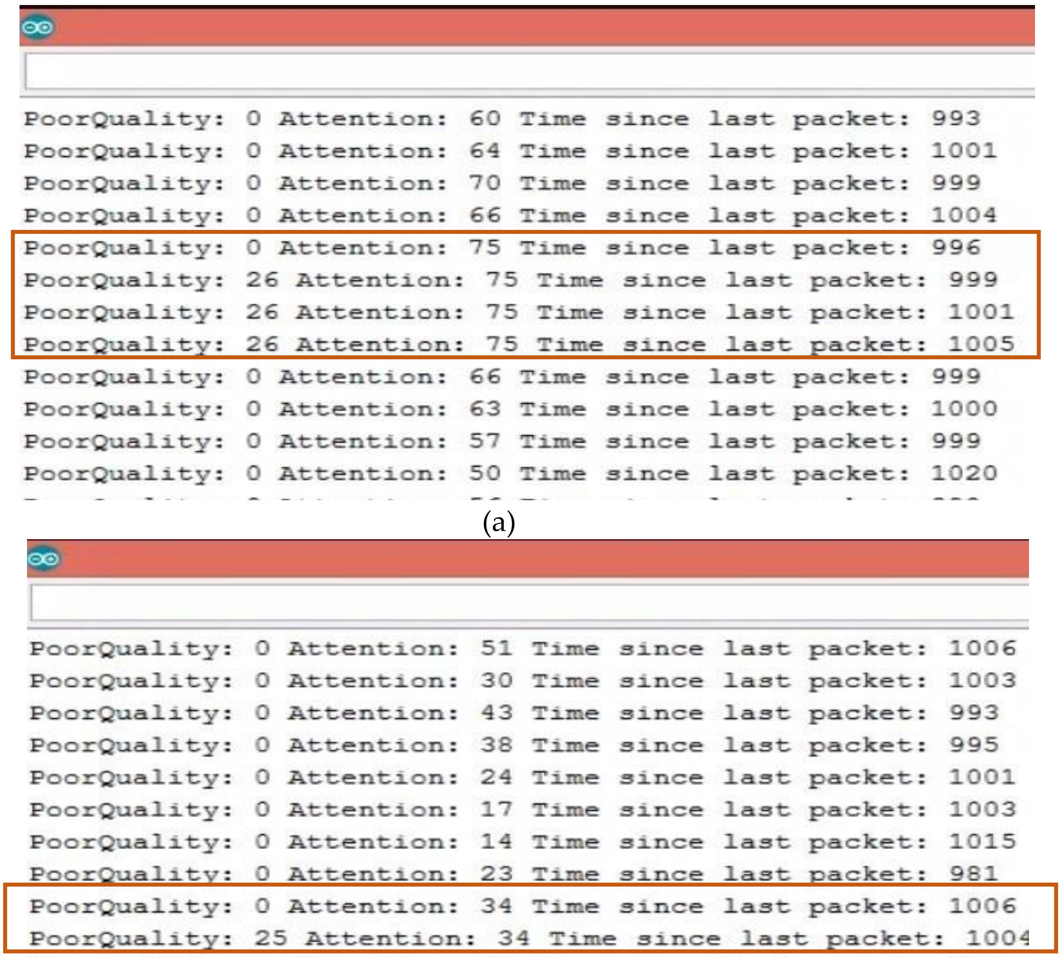
The Neurosky Mindwave headset with single electrode generates data of human brain activity. The brain signals data (alpha and beta) were interpreted and transferred to the processing board, Arduino ATMEGA2560 via Bluetooth HC05. The signals were transmitted with reference pick up voltages on the skin at the forehead at point Fp1 (Erik & Lauren, 2016) which was at upper left eyebrows and the ear.

Data Visualization

The data of signal quality (*PoorQuality*) and attention value (*Attention*) could be visualized using either the Arduino serial monitor or CoolTerm. They can be used for real time monitoring with the baud rate of 9600. They cannot be used simultaneously because only one serial port could be opened at one time. However, the CoolTerm has additional feature that allowed the data to be saved to a text file such as excel as shown in Figure 2.

RESULT AND DISCUSSION

Figure 1 and Figure 2 show the examples of the data that were displayed on the Arduino and CoolTerm serial monitor. They were classified according to the attention and signal quality value.



```
PoorQuality: 0 Attention: 60 Time since last packet: 993
PoorQuality: 0 Attention: 64 Time since last packet: 1001
PoorQuality: 0 Attention: 70 Time since last packet: 999
PoorQuality: 0 Attention: 66 Time since last packet: 1004
PoorQuality: 0 Attention: 75 Time since last packet: 996
PoorQuality: 26 Attention: 75 Time since last packet: 999
PoorQuality: 26 Attention: 75 Time since last packet: 1001
PoorQuality: 26 Attention: 75 Time since last packet: 1005
PoorQuality: 0 Attention: 66 Time since last packet: 999
PoorQuality: 0 Attention: 63 Time since last packet: 1000
PoorQuality: 0 Attention: 57 Time since last packet: 999
PoorQuality: 0 Attention: 50 Time since last packet: 1020
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(a)

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PoorQuality: 0 Attention: 51 Time since last packet: 1006
PoorQuality: 0 Attention: 30 Time since last packet: 1003
PoorQuality: 0 Attention: 43 Time since last packet: 993
PoorQuality: 0 Attention: 38 Time since last packet: 995
PoorQuality: 0 Attention: 24 Time since last packet: 1001
PoorQuality: 0 Attention: 17 Time since last packet: 1003
PoorQuality: 0 Attention: 14 Time since last packet: 1015
PoorQuality: 0 Attention: 23 Time since last packet: 981
PoorQuality: 0 Attention: 34 Time since last packet: 1006
PoorQuality: 25 Attention: 34 Time since last packet: 1004
PoorQuality: 0 Attention: 40 Time since last packet: 994
PoorQuality: 0 Attention: 41 Time since last packet: 1000
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(b)

Figure 1. Example of the signal quality and attention value for different facial expression on Arduino serial monitor by (a) winking with the left eye and (b) frowning

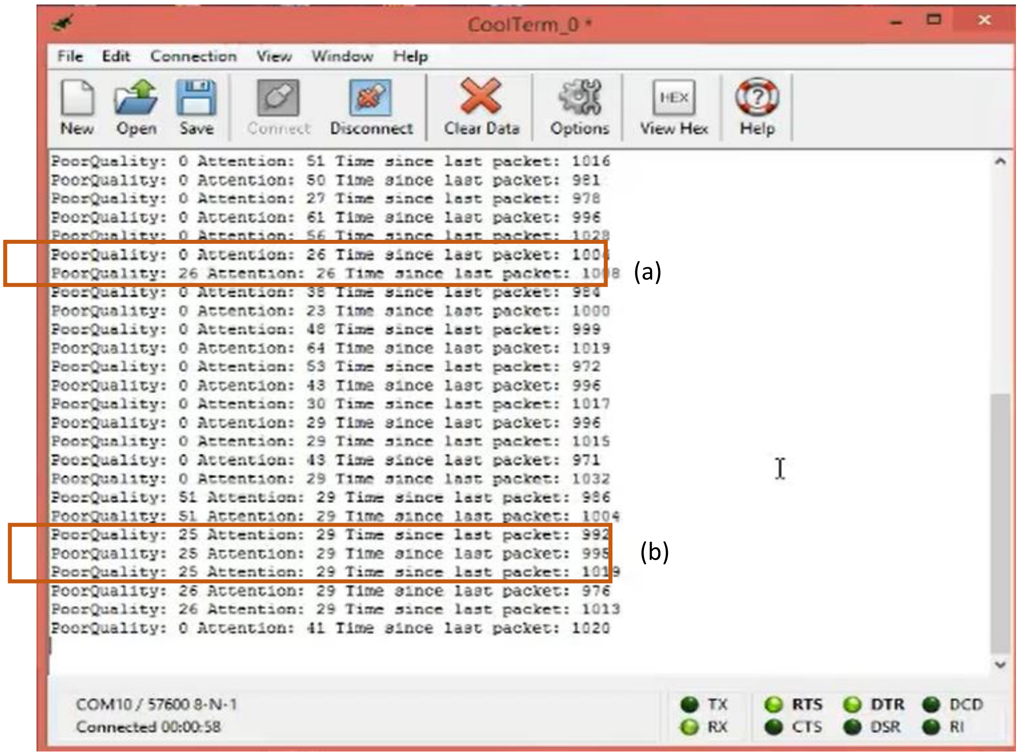

Figure 2. Example of the signal quality and attention values for different facial expression on CoolTerm serial monitor by (a) winking with left eye and (b) frowning.

By frowning, *PoorQuality* was 25 as recorded in Table 2. However, the attention value for each respondent was different depending on their focus at that time. This also occurred when the respondents were asked to wink with the left eye as shown in Table 3. The signal quality was 26 but each respondent has different value of attention. The signal quality could be dropped slightly whenever the forehead movement was detected. 0 indicates an excellent quality of the signal while 200 is for the poorest quality of the signal (Abu Bakar *et al.*, 2017).

Table 2. Data collected for frowning

Respondents	Data	
	Signal Quality	Attention
1	25	34
2	25	48
3	25	100
4	25	34
5	25	70

Table 3. Data collected for winking with the left eye

Respondents	**Data**	
	Signal Quality	**Attention**
1	26	48
2	26	44
3	26	48
4	26	48
5	26	61

The attention value of each respondent before doing the required facial expression did not change even though the signal of the expression was detected. For an example, Figure 1(a) shows the current *PoorQuality* was 0 and attention value was 75. When the left eye was winked, *PoorQuality* became 26 and attention value remained at 75. Based on Figure 1(b), the attention value remained at 34 even though *PoorQuality* changed to 25 when frowning. Despite of that, each respondent had different attention level depending on their focus during the testing. As a result, the signal quality of 25 can be considered as a potential input to control the connected electronic devices.

When the respondent winked with the right eye, the signal quality was not affected and remain at 0 as recorded in Table 4. The position of the electrode was at point Fp1 which few centimeters away from the right eye. Therefore, the forehead movement was not detected near the electrode.

Table 4. Data collected for winking with right eye

Respondents	Data	
	Signal Quality	Attention
1	0	21-61
2	0	16-80
3	0	1-69
4	0	30-48
5	0	57-83

CONCLUSION

It can be concluded that significant value of signal quality (*PoorQuality*) could be obtained by frowning as well as winking with the left eye. The signal quality of 25 can be considered as a potential input to control the connected electronic devices when the respondent frowned. In getting the signal quality of 26, respondents can also wink with the left eye instead of lifting the eyebrow. The attention value can vary to any value depending on the respondents' focus or attention level during the testing. As the focus level of people is different, thus, further testing on a prototype is still under investigation by considering respondent from different group of age and gender. This is required to validate the signal quality of 25 so that a practical system for people with motor disabilities can be developed.

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