

# Brain waves' measurements on the aha experience in the cognition of a melody

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## ABSTRACT

The “aha experience” means flashing caused in the process of a creative problem solving. Moreover, it means a mental experience which arises momentarily at the time of obtaining the insight. This research was conducted about the “aha experience” from the viewpoint of the brain science. The “aha experience” in the auditory cognition was achieved by using a “hidden melody” which was composed based on the melody known widely. A listener can experience the “aha experience” when he finds an original melody in a hidden melody. The changes in brain activity with EEG (electroencephalogram) during the “aha experience” were examined by measuring a momentary brain wave at the time of flashing. The result shows that the alpha wave in the frontal lobe increases at the moment of the “aha experience”.

## INTRODUCTION

The “aha experience” means flashing caused in the process of a creative problem solving. Moreover, it means a mental experience which arises momentarily at the time of obtaining the insight. Recently, a variety of research was conducted about the aha experience from the viewpoint of the brain science [1], [2]. However, most of the research concerns the cognition in learning and of a visual image, but the research on the aha experience in the auditory cognition that uses music or sound materials is hardly done. In the present study, the aha experience was achieved by music from the view point of a melody cognition. The changes in brain activity with EEG (electroencephalogram) during the aha experience were examined by measuring a momentary brain wave at the time of flashing.

## AHA EXPERIENCE BY MUSIC

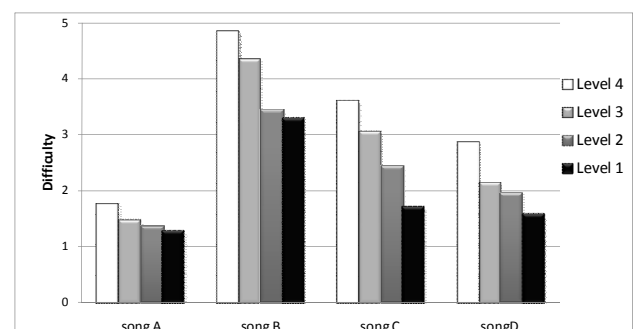
The aha experience was achieved by using a “hidden melody” which was composed based on the melody known widely. It is called “aha music” after this. A listener can experience the aha experience when he finds an original melody in an aha music.

### Aha Music

Four kinds of aha music with a different difficulty was created based on one melody. Level 4 is the most difficult, and level 1 is easy. This difficulty is defined as follows.

$$\text{Difficulty} = \frac{\text{Numbers of note of each aha music}}{\text{Numbers of note of an original melody}}$$

Two Japanese nursery rhymes (song A and B) and two melodies known worldwide (song C by J.J.Rousseau and song D by W.A.Mozart) were used as an original song for creating an aha music. The aha music of sixteen with four levels of different difficulty was composed for the listening tests. Figure 1 shows the difficulty of each aha music composed from original songs. The total of 45 males and females aged 21 to 47 participated in this test. In the aha music with a high difficulty, the half of subjects could experience the auditory aha experience and all subjects could do in the aha music with lower difficulty [3], [4].



**Figure 1.** Difficulty of each aha music from original songs (song A and B: Japanese nursery rhymes, song C by J.J.Rousseau and song D by W.A.Mozart).

The relation between the correct rate of melody cognition and the difficulty of each aha music from original songs was as follows.

The correct rate of melody cognition:  $A > D > B > C$

The difficulty of aha music:  $B > C > D > A$

### BRAIN WAVES' MEASUREMENTS ON THE AHA EXPERIENCE

The changes in brain activity with electroencephalogram (EEG) during the aha experience were examined by measuring a momentary brain wave at the time of flashing.

#### Expeimental environment and experimental method

The paste-less electrode helmet was used for the brain wave measurement. The electrode was arranged by 10-20 electrode arrangement method (shown in Figure 2). Six areas of Fp1, Fp2, F3, F4, and F7 and F8 in the frontal lobe were mainly examined.

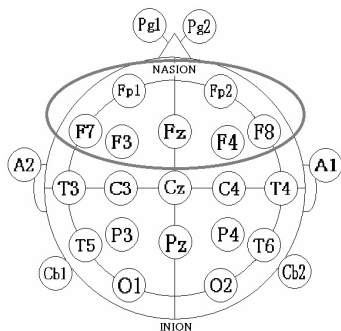


Figure 2. Arrangement of electrode

The aha music was reproduced by the volume of  $L_c=60\text{dB}$  at the listening position by a loud speaker. Figure 3 shows an example of the score of the aha music used to experiment.



Figure 3. An example of score of aha music

Eight university students (4 males and 4 females aged 21 to 22) agreed to participate in this experiment.

The procedure of the experiment is shown as follows.

- The electrode is arranged.
- Silent.
- Aha music is reproduced. The subject pushes the trigger when the melody is understood.
- Silent.
- The answer is confirmed.

The brain waves during the test were measured on the condition of the sampling frequency 200Hz, the high-pass filter 1.6 Hz, the low-pas filter 100Hz, and the hum-filter 60 Hz, and these data were used for the frequency analysis.

#### Method for analyzing

The frequency analysis on the brain wave was done. The moment when the subject pushed the trigger is provided as a reference point. The power of  $\theta(4\sim 8\text{Hz})$ ,  $\alpha(8\sim 13\text{Hz})$ , and  $\beta(13\sim 30\text{Hz})$  wave before and behind the reference point was calculated every five seconds. In addition, the power ratio of  $\alpha$  wave defined as follows was calculated every five seconds.

$$\text{Power ratio of } \alpha \text{ wave} = \frac{\text{Power of } \alpha \text{ wave}}{\text{Total power of } \theta, \alpha \text{ and } \beta \text{ wave}}$$

### RESULTS AND DISCUSSION

#### Results

Sixteen data by the brain waves' measurements were obtained from eight subjects. Figure 4, 5 and 6 show three typical examples that the power ratio of  $\alpha$  wave in the frontal lobe is calculated. A horizontal axis shows the section of every five seconds before and behind the reference point in six areas of frontal lobe. The reference point is arrowed.

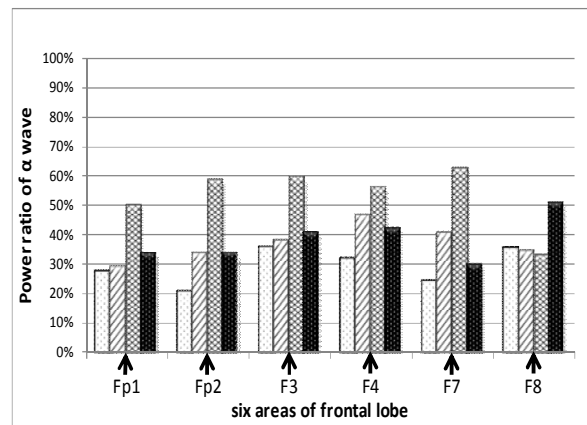


Figure 4. The power ratio of  $\alpha$  wave by subject M (song D)

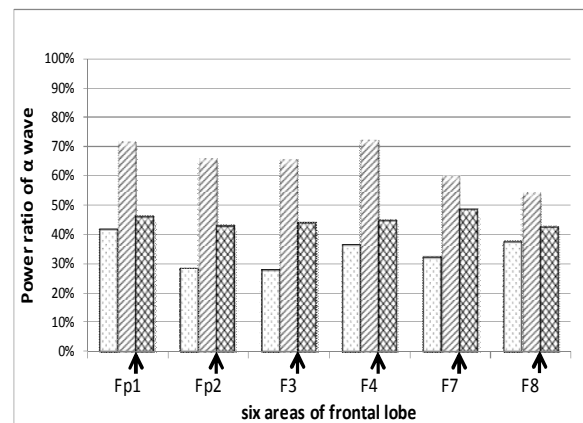


Figure 5. The power ratio of  $\alpha$  wave by subject Y (song B)

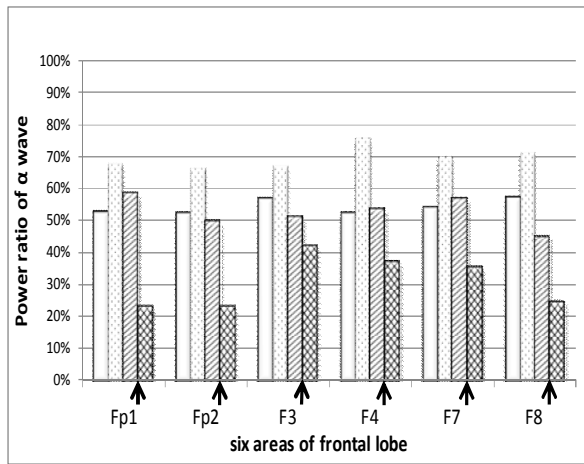


Figure 6. The power ratio of  $\alpha$  wave by subject O (song C)

## Discussions

The power ratios of  $\alpha$  wave in the section before and behind the reference point are compared for every five seconds, and the section that becomes the peak of the value is examined.

The peak of  $\alpha$  power ratio is seen in the section of five seconds behind of the reference point in Figure 4. In Figure 5, the peak of  $\alpha$  power ratio is seen in the section of five seconds before of the reference point. In Figure 6, the peak of  $\alpha$  power ratio is seen in the section of ten seconds before of the reference point.

These results mean the power of  $\alpha$  wave increases in the frontal lobe momentarily at the time of flashing caused by the aha experience. As for this, the generation of dopamine is guessed by flashing the aha experience.

## CONCLUSIONS

All subjects can experience the auditory aha experience when they find an original melody in an aha music with lower difficulty. The changes in brain activity with EEG (electroencephalogram) during the aha experience were examined by measuring a momentary brain wave at the time of flashing. The result shows that the alpha wave in the frontal lobe increases at the moment of the auditory aha experience.

## REFERENCES

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