Analysis of EEG during composition and live music video viewing

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For some time now, we have been considering how to increase the number of artists, singers, composers, and other members of the creative class who are professionally active in music. We have become aware of the fact that professional activities are the activities of only a handful of people. The reasons why their activities are regarded as something that only a handful of people can do are that there is no ecosystem in place to enable many people to make a living from them, and that their activities are not properly evaluated. We wanted to establish an ecosystem to solve these problems. Based on this recognition, we hypothesized that it would be possible to quantitatively evaluate the creative activities of professional artists from a different perspective. This study focused on the process of composition and goosebumps that appear during the emotional experience, and considered the possibility of quantifying the process of composition and the mechanism by which their works generate emotion. The proposal was to measure brain waves.

Introduction

Great music moves people, and the output of that emotion manifests itself in goosebumps and teary eyes. We also still know very little about what kind of brain activity musicians engage in during the process of creating great music.

Creativity as a distinct trainable mental state:An EEG study of musical improvisation (Joel A. Lopata, Elizabeth A. Nowicki, Mark F. Joanisse J (2016)) proposed that the magnitude of right upper frontal α waves is greater during improvisation in more skilled musicians. Several studies have also shown that when in a state of creative concentration, including musical activity, the brain produces more α waves that promote relaxation and brain activity. All of these findings indicate that α waves are involved in the creative process. Thus, we can hypothesize that compositional activity, a similarly creative process, generates many α waves during the lengthy process of its composition. However, it was assumed that simply acquiring and analyzing these α waves during the process of composing would make it difficult to distinguish them from other states of concentration. Therefore, in this study, we attempted to analyze brain activity during the composition process by acquiring and analyzing not only α waves but also δ, θ, and β waves and comparing them. In addition, by analyzing brain activity during goosebumps, which is the ultimate emotional experience of listening to a completed piece of music, we attempted to evaluate not only the process of composition, such as the experience given to the audience by the composer's work, but also the work as a result of the composition activity from the viewpoint of brain waves and goosebumps.

We attached an electroencephalograph (EEG) measuring device that can measure EEG at electrodes A1 and A2 to the subject, and measured EEG each in three states: a state in which the subject did nothing, a state in which the subject was watching a live video of his/her favorite artist, and a state in which the subject was actually composing a piece of music. In order to reduce noise, we started the measurement at the timing when the waveform indicated by the electroencephalograph was stable, and we tried to avoid noise other than goosebumps and compositional activity during the measurement.The goal was to elucidate the brain activity during goosebumps and compositional activity.

Materials and Methods

One healthy volunteer participant (1 male, left-handed, age 20) participated. He had musical experience as an amateur dancer and composer. He had no history of hearing, neurological, or psychiatric disorders.

Experimental design.

Experiment 1, EEG measurements while seated for 5 min. The subjects were asked to identify noise from blinking, slight limb movements, and the structure of normal brain activity and possible noise waveforms, such as when imagining something, staring at a point without thinking, or salivating. From this experiment, subjects perceived the electroencephalograph as stable and showing EEG values with little noise, as well as noise due to blinking, limb movements, and imagining with the brain. Attention was paid to orthostatic movements and body movements in order to measure EEG with high accuracy.

Experiment 2, subjects watched a live video of a musician whose videos had given them goosebumps in the past on their smartphones for 5 minutes and measured their brain waves. Based on the findings from Experiment 1, subjects were kept in a seated posture, with body movements reduced as much as possible to avoid noise.

Experiment 3, subjects composed a piece of music for 10 minutes using a PC logic pro and measured their brain waves while composing. As in Experiment 2, the subjects were kept in a sitting posture, and the motions other than those necessary for composing were suppressed in order to reduce the noise. Note that the composition was the introduction to an R&B style song.

The subjects were in good health during the experiment.

Figure 1. An electroencephalograph (EEG) from View Zone

EEG measurements. An electroencephalograph (EEG) from View Zone was used to measure EEG, which can measure data from channels A1 and A2. The window was 1 sec/0.6 Hz. The frequency range acquired was 0-49.8 Hz. It was important to note that the frequency bands representing δ, θ, α, and β waves were included and that the respective values were recorded on the same time stamp.

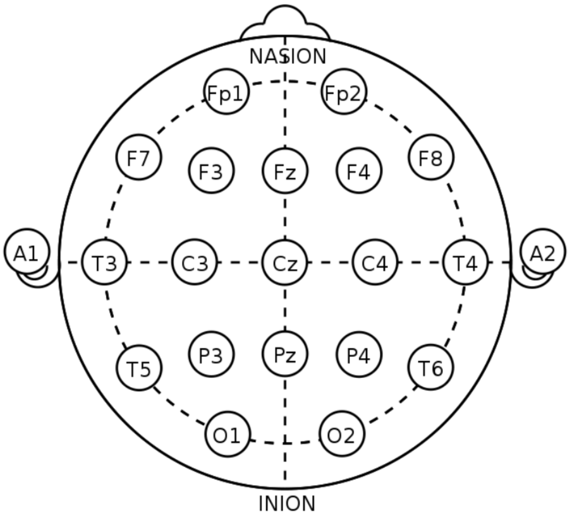


Figure 2. Location of channels during EEG measurement

The live sound was listened to through earphones attached to the electroencephalograph, and the sound source used in the composition process was the sound output from the PC speakers.

Results

The acquired data were first cleaned, as shown in Fig.

As a cleaning step, the data were first cleaned with a smoothing factor of 0.25 in order to smooth the data.

Next, the standard deviation of the data was determined, and the data was thereby normalized. Then, outliers were removed to reduce noise. Outliers were defined by setting the detection method as the moving median and the threshold coefficient as 3. In addition, linear interpolation was used to embed the outliers when dropping them into the graph.

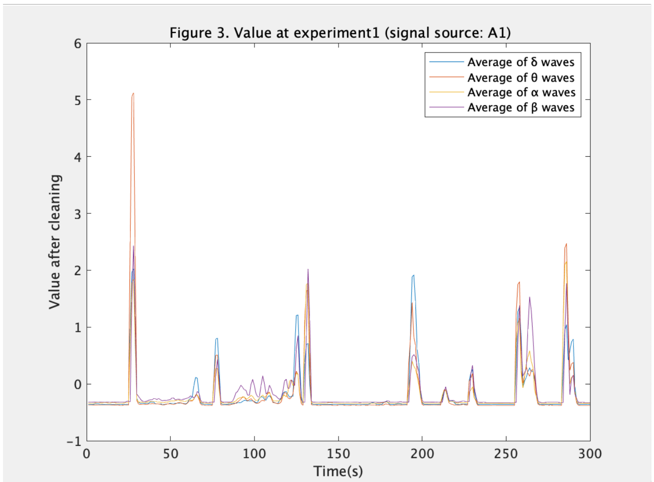
Through these processes, the cleaned data were categorized into the following conditions.

δ waves: 0.6, 1.2, 1.8, 2.3, 2.9 Hz
θ waves: 4.1, 4.7, 5.5, 5.9, 6.4 7.0 Hz
α waves: 8.2, 8.8, 9.4, 10.0, 10.5, 11.1, 11.7, 12.3, 12.9 Hz
β waves: 14.1, 14.6, 15.2, 15.8, 16.4, 17.0, 17.6, 18.2, 18.8, 19.3, 19.9, 20.5, 21.1, 21.7, 22.3, 22.9, 23.4, 24.0, 24.6, 25.2, 25.8, 26.4, 27.0, 27.5, 28.1, 28.7, 29.3, 29.9 Hz

The average value for each wave was then calculated and dropped into a graph for each experiment.

Experiment 1, In both A1 and A2 channels, the β wave, shown in purple, represented the largest waveform and was dominant except during conditions of characteristically large amplitude waves. β waves appear during states of arousal, worry, and frustration, so when β waves are large, they are generally present during general arousal or psychological. The β waves are also found to be dominant during periods of general arousal or psychological noise. In addition, the large amplitude waves that characteristically appear on both sides are mostly dominated by δ or θ waves, both of which are known to appear during shallow or deep sleep, so when these large waves appear, we can consider that the subjects were in a micro-sleep or drowsy state. Therefore, we can assume that the subjects were in a micro-sleep or drowsy state when these large waves appeared. In both cases, α waves were not the most dominant.

Although there were some discrepancies between the data acquired in A1 and A2, a correlation was observed.



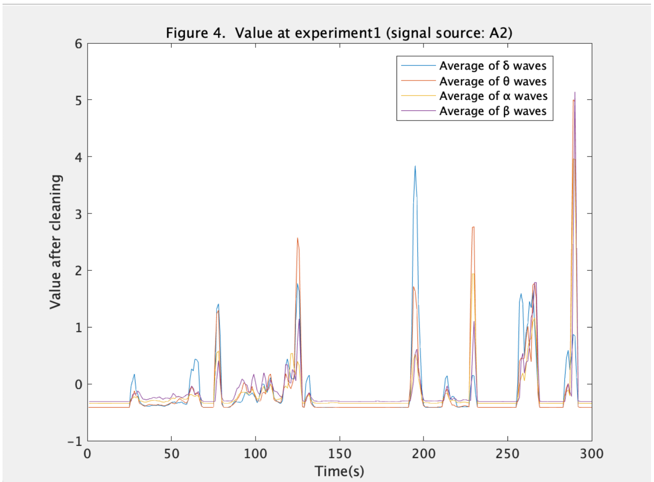


Figure 4. Value at experiment1 (signal source: A2)

Experiment 2, In Experiment 1, β waves were often dominant, with occasional dominance of δ and θ waves, but in Experiment 2, δ waves were often dominant. In addition, when β waves were dominant in Experiment 1, they were dominant while maintaining a gentle wave shape, but during the period when δ waves were dominant in Experiment 2, waves of characteristic amplitude were detected, suggesting that the influence of watching live video and this This result can be attributed to the influence of watching the live video. In addition, a characteristic wave with a large amplitude, in which the α wave was dominant, was detected in Experiment 2, whereas it was not detected in Experiment 1. Since the period during which this wave was generated coincided with the period when subjects felt goosebumps, it was found that α waves were at their highest level when subjects were moved by watching live video and felt goosebumps. The large amplitude wave with the highest α wave frequency in A1 and the very characteristic large amplitude wave with the highest δ wave frequency in A2 indicate that the δ wave frequency is often dominant when watching a favorite live video, while the α wave frequency is rarely dominant when the subject is moved to the point of goosebumps. The results showed that α waves were most dominant when the subject was moved to the point of goosebumps.

It is said that α waves appear during immersion, meditation, and other states of arousal, but when one is not very conscious.

As with the experimental position, there was a correlation between the data obtained from A1 and A2, although there were some differences.

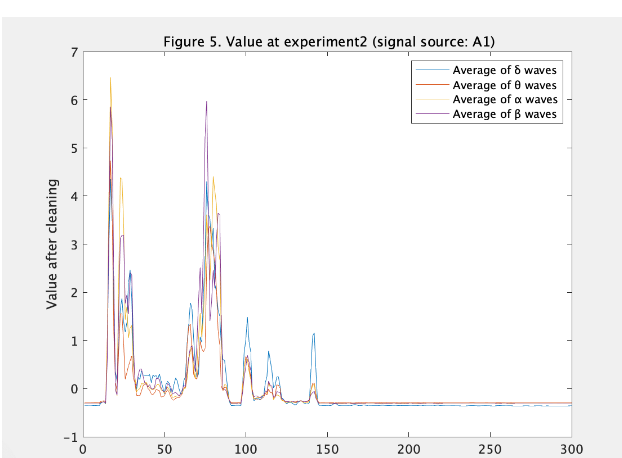


Figure 5. Value at experiment2 (signal source: A1)

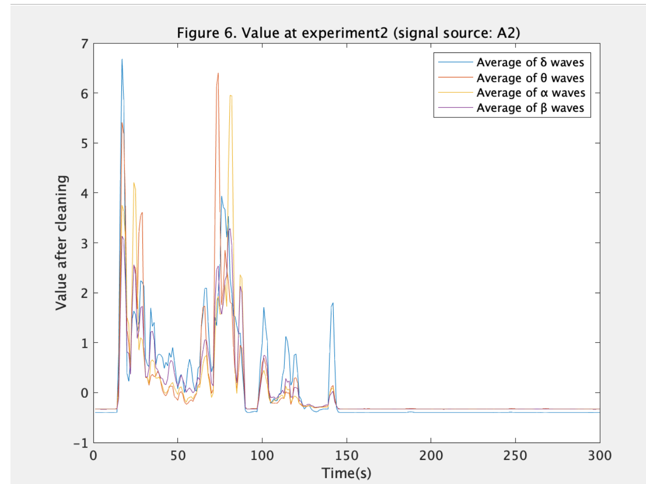


Figure 6. Value at experiment2 (signal source: A2)

Experiment 3, As in Experiment 1, the β wave, shown in purple, was dominant when the wave was stable except when a wave with a characteristically large amplitude appeared. On the other hand, in Experiment 3, a characteristic wave period appeared. That is, the δ wave, θ wave, and the β wave are replaced in a short period of time, and after a period in which many waves with large amplitudes occur, the yellow α wave with a very characteristic size appears. A wave appears. These waves indicate that, in the process of composing, the group of waves with large amplitudes is the result of trial and error until the subject finds a satisfactory sound composition or selects a satisfactory sound. After that process, it is conceivable that α waves are remarkably generated when a convincing sound configuration is found or when a convincing sound is found. I was able to think that the periodicity of this wave represents the process of composing, and that it might lead to the evaluation of the process of composing from brain waves.

As in Experiments 1and 2, although there were some differences, there was a correlation between the data obtained in A1 and A2.

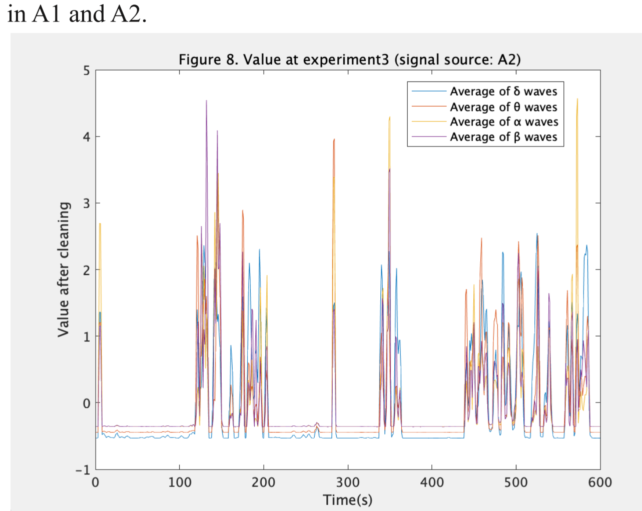
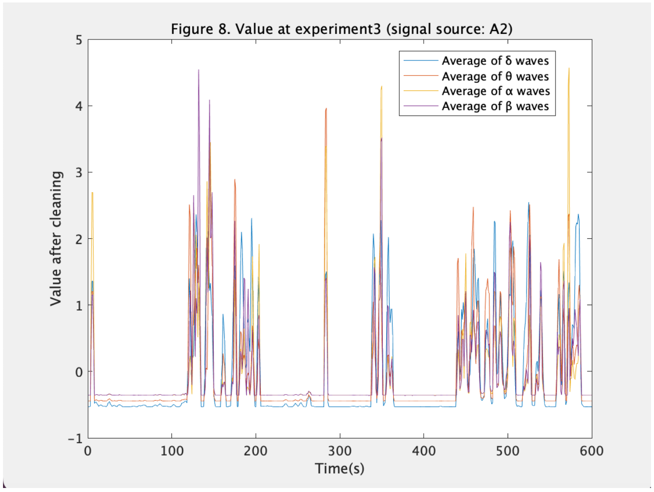


Figure 8. Value at experiment3 (signal source: A2)



A wave that has a characteristic magnitude of amplitude and is dominant

As shown in each figure, in Experiment 1, the dominant waves with characteristic amplitudes are θ and β waves with values slightly above 5, and δ waves with values around 4. was detected. In Experiment 2, α and δ waves with values over 6, θ waves, β waves with values around 6, and α waves with values around 4.5 were detected. In Experiment 3, α waves and β waves with values around 4.5 and θ waves with values around 4 were detected.

Discussion

The results of this experiment show that, compared to normal times, α waves begin to occur predominantly in the brain when listening to music by watching live music videos or composing music.

In addition, when goosebumps occur, α and δ waves with characteristically large amplitudes are generated. It shows that there is a period in which the waves are dominant. These indicate the possibility of evaluating the process of composing and the musical experience itself from the perspective of EEG by investigating the appearance of α waves and the characteristic EEG cycles during composition. If these are proven, it will be possible to make an important step in the music industry from the perspective of neuroscience.

Insufficiency of experiments and considerations

About γ waves and other brain waves, γ waves were not analyzed in this experiment. The frequency band is from 30 Hz, which is a hertz higher than β waves, and was also measured by the electroencephalograph used this time. Many experiments have shown that γ waves are myoelectric activity and artifacts caused by blinking, but they are also said to be related to higher mental activity. In order to analyze it, careful separation analysis is necessary, and if possible, We would like to explore a method and analyze it.

The relationship between α waves and goosebumps and the prediction function of the brain, We sometimes get goosebumps when listening to music and having a moving experience. However, the timing that gives us goosebumps is not because the music is new to us, but because we have already heard it, in other words, it is music whose emotional experience is predictable. In other words, it indicates that memory-related brain activity is involved in getting goosebumps. From this, it can be said that artists who can provide people with a memorable emotional experience can make music after that experience, can provide people with a feeling that gives them goosebumps, and can fascinate people. In other words, by analyzing whether music made by a certain composer resonates with the part of the brain that controls people's memories and is settled in people's memories, it is possible to determine that the composer who makes that music is an excellent composer. It shows that it is possible to evaluate. I thought that the research process should include clarifying what music resonates with the part of the brain that controls memory, and what is happening in the brain of the composer who composes the music.

About left and right handedness, Different EEG brain activity in right and left handers during visually induced self-motion perception (Michaela McAssey, James Dowsett, Valerie. Kirsch, Thomas Brandt, Marianne Dieterich (2020)) found that decreased α output resulting from exposure to vector-compatible stimuli was observed in different terrain regions for left-handers and right-handers. Left-handers exhibit lateralized responses to vectonic stimuli in the left centro-parietal region, whereas right-handers, in contrast, exhibit bilateral responses in the midline centro-parietal region. From this, it can be considered that it is essential to mention and study the difference between left-handed and right-handed people when analyzing α waves.

Differences between professional and amateur, Differences in brain activity during improvisation between professionals and amateurs have been clarified, as shown in the research presented in the introduction. Then, it can be hypothesized that the difference in brain activity between professionals and amateurs may also appear in the process of composition. We also show that if we create a machine learning model that can identify the characteristics of the brain activity of professionals and amateurs, we will be able to draw a clear line between professional and amateur composition from the perspective of electroencephalograms. This means that it is possible to establish a new evaluation method for composers, and it is considered to have an important meaning in the music world.

Comparison between composing and another process, The characteristic brain wave cycle in the composition process detected in experiment 3 is not limited to the composition process, but may apply to other processes that create something through trial and error. be. In order to avoid confusion with them, it is considered necessary to compare it with creative processes other than composition and to analyze the characteristics of the composition process.

Consideration with data transformed to Fourier, When the amount of data increases and periodicity is recognized in the waveform data appearing as a result, analysis by Fourier transform can be performed correctly. Therefore, it may be necessary to analyze the characteristics and periodicity of EEGs using a Fourier transform and a different approach from the current analysis method to prevent omissions in research. For this reason, we obtained the results from waveform analysis this time, but in order to further corroborate the results, it is necessary to incorporate data analysis using Fourier transform into the research process.

Data analysis method

Preprocessed using EEGlab,

- Downsampling
- Filtering
- Reduction of power supply noise
- Registration of electrode information
- Exclusion of noisy electrodes
- Epoching
- Epoch rejection
- Independent component analysis
- Dipole estimation
- Recalibration of electrodes
- Conditioning

Concerning, at the time of electroencephalogram measurement, the channels are already limited to A1 and A2, and the noise frequency band has not been recorded.

- Filter by EEG type
- Data smoothing
- Data normalization
- Data outlier removal and noise removal
- Derivation of average value for each type of EEG
- Graphing average values
- Extract features by comparing graphs

took such steps. Regarding the averaging of the data, we decided to calculate the average value and consider it because there was a large correlation between the types of electroencephalograms in each experiment, even if the Hz was different for each type.

Moreover, it is thought that it is important to use machine learning as an experiment from now on. This time, there was only one subject, but when data from multiple subjects were collected, I wondered if their correlations and characteristic waveforms were general enough to apply to any person. In order to do so, it is necessary to have a model that learns the characteristic phenomena found in this study. If this happens, the amount of data will gradually increase, so downsampling or limiting the data to be acquired will be required. In addition, in order to more clearly clarify the phenomena indicated by the characteristics of the waves, we would like to investigate methods for grasping the subject's movements in detail during the experiment.

Conclusion

The results of this study show that characteristic α and δ waves are involved when you get goosebumps. In addition, it was discovered that there is a characteristic electroencephalogram cycle in which characteristic α waves are detected. However, in order to verify this result, further research is required, and from the perspective of ensuring diversity such as the number of subjects and listeners, analysis using Fourier transform, and other electroencephalogram phenomena by machine learning Comparative analysis, analysis of the relationship between the part of the brain that controls memory and goosebumps, and analysis of γ waves were mentioned.

Utilizing the research results supported by these, we will establish new evaluation methods for composers, evaluation of the composition process, and new evaluation methods for produced music, create an ecosystem for new composers, and promote music.

We aim to lay an important foundation for the world.

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