The Effects of Visual and Auditory Stimulation on EEG Power Spectra during the Viewing of Disgust-Eliciting Videos

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Abstract: Disgust is an affect produced in response to something that is offensive or unpleasant. This emotion is associated with feelings of dizziness and vomiting and, in severe cases, mental illnesses, such as obsessive compulsive disorder and depression. Most experimental electroencephalography (EEG) studies on disgust have identified activated brain areas or disgust elicitors or examined the effects of unimodal stimulation, such as visual, auditory, olfactory, or haptic stimulation. This EEG study examined the effects of disguste liciting visual stimuli that were presented with different auditory stimuli in relative power spectrum analyses of the delta-, theta-, alpha-, beta-, and gamma-wave bands. The EEG data were collected while the participants watched disgust-eliciting videos of body mutilation and disgusting creatures with the original soundtrack or auditory stimuli. Two types of auditory stimuli were used: relaxing music or exciting music. The EEG power spectra of all of the frequency bands were lower in response to videos with auditory stimuli compared with videos with the original soundtracks. Additionally, the mood of the music aroused different responses depending on the type of disgust elicitor, and the types of music that reduced disgust differed according to the different types of disgust elicitors.

1 INTRODUCTION

An emotion is a feeling or mood that arises in reaction to a situation or an event. A wide variety of factors, including physiological, physical, and psychological, cause emotional reactions to cultural elicitors as diverse as arts, science, and religion. Affect is an intense emotion that does not last long. Several studies have suggested different ways to classify the basic types of affect. Of these, a categorical model of 6 types of affect (happiness, surprise, fear, anger, disgust, and sadness) has been recognized as the basic theory of affect (Lin, 2010). Previous studies have largely been devoted to examining the 4 following affects: happiness, fear, anger, and sadness. These studies, however, have not investigated elicitors of disgust, which is a type of negative emotion and which is a recent topic of interest due to the sharing of internet contents, such as movies, games, and social networking sites.

From an evolutionary perspective, disgust is a feeling that is generated in response to things that might be harmful to us, and it is considered an oral defense mechanism for excreting or vomiting what is harmful. In psychiatry, disgust is thought to be related to obsessive-compulsive disorder or specific phobias, such as aichmophobia, trypophobia, and thalassophobia, as well as mental illnesses like depression and anxiety disorder. There are a variety of disgust elicitors, and Jonathan Haidt et al. have classified the 7 main domains of disgust elicitors (food, specific organisms, sex, body mutilation, death, hygiene, and body products) into core disgust and animal reminder disgust. Various studies have investigated the effects of disgust (Haidt, 1994).

Electroencephalography (EEG) is a methodology that is used to record changes in the electrical potentials or brain currents in the cerebral cortex through the scalp of a human or animal (MIT Press, 2014). Recently, EEG studies have been actively conducted in diverse research areas, including the classification of affects; addiction to the internet, games, or smartphones; and mental illnesses (Gasser, 1982; Schaefer, 2011; Gotlib, 1998).

In this study, we recorded EEGs while subjects viewed disgust-eliciting video clips and compared the brain wave data that were collected when the original video was presented with those collected when the video was presented with music for auditory stimulation. For the disgust-eliciting

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stimuli, we used videos about body mutilation and disgusting organisms, which are the disgust elicitors that show disgust most clearly. The music presented as the auditory stimuli consisted of relaxing music and exciting music, and we examined the differences in the EEGs that resulted from the different moods of music. The brain wave data were compared with relative power spectrum analyses across the following bands: delta (0.5–3 Hz), theta (3–8 Hz), alpha (8–12 Hz), beta (12–30 Hz), and gamma (30–70 Hz). Additionally, a survey was administered after the EEGs were recorded for further data validation. Previous EEG studies of disgust stimulation have mostly dealt with disgust elicitors or changes in brain activity that was related to disgust. Those studies mainly used unimodal sensory stimulation, such as visual, olfactory, or haptic stimulation. However, unlike previous studies, we aimed to investigate the effects of visual and auditory stimuli that were presented at the same time.

This paper is organized as follows. In Section 2, we introduce the existing literature that is relevant to EEG studies on emotion recognition and the disgust affect and explain how the current study fills a gap in the field. In Section 3, the experimental methods, procedures, and analytical methods are presented. In Section 4, we analyze the results and further discuss some notable findings.

2 RELATED WORKS

Many studies have been conducted on emotion recognition by using EEG, functional magnetic resonance imaging, and electrocardiography methods (Lewis, 2010; Palomba, 2000; Köchel, 2013). Human beings feel emotions that are aroused through vision, audition, olfaction, and touch, and all of these types of stimuli have been studied through diverse research efforts in order to understand the elicitation of emotions (Wheaton, 2013; Utama, 2009). The majority of studies of a single stimulation modality have used visual or auditory stimulation, which are the primary sensory types. Lin et al. used auditory stimuli and classified the 4 emotions of joy, anger, sadness, and pleasure that occur during music listening with 12 symmetric electrode pairs (DASM12) (Lin, 2010). Dan Nie et al. used visual stimuli and EEG recordings and identified the emotions that occurred while subjects watched movies (Nie, 2011).

Murugappan et al. have analyzed EEG signals and identified 6 affects (Murugappan, 2008). Of these, we focused on disgust and compared it to the results of previous studies. Michela Sarlo classified disgust elicitors into body mutilation and contamination with an EEG alpha power analysis and compared the levels of activation induced by each elicitor type (Sarlo, 2005). Syed Syahril et al. measured the subgamma band of EEG signals in subjects while disgust-eliciting stimuli were presented (Syahril, 2011).

The existing studies on emotion recognition and disgust are limited because they examined only single stimulation modalities. In addition, most EEG studies on disgust distinguished regions of activation instead of showing clear differences. This study was meaningful because we examined the effects of auditory stimuli on disgust-eliciting visual stimulation. Additionally, in the EEG analysis, we analyzed data on the regions of activation and the impact of the videos and music. Finally, we showed video clips to the participants of a short story that strongly elicited the disgust affect instead of visual images that were unidirectional and similar.

3 METHODS

3.1 Experimental Environment

Figure 1: Experimental environment.

As shown in Figure 1, the experiment was conducted in a dark and isolated room in which the participants could be tested comfortably away from any non-experimental stimulation. By placing only experiment-related equipment in the room, we tried to provide an experimental environment in which the participants could focus on the experiment. The participants were forbidden to drink alcohol before the study, and they were asked to get enough sleep on the day prior to the experiment.

Table 1: The list and categories of the videos and the music used in the study.

		Video and music			
Category	Type	A_Original	A_Sound	B_Original	B_Sound
Body Mutilation	Video	The dentist <Final Destination5>	The dentist <Final Destination5>	The gymnast <Final Destination5>	The gymnast <Final Destination5>
	Music		Yumeji's Theme <In the Mood for Love>		Give it up <Kings man>
Category	Type	C_Original	C_Sound	D_Original	D_Sound
Disgusting Organisms	Video	The alien <Slither>	The alien <Slither>	The worm <Slither>	The disgust worm <Slither>
	Music		Yumeji's Theme <In the Mood for Love>		Give it up <Kings man>

3.2 Procedure

In a separate experimental room, the participants watched 4 disgust-eliciting video clips of body mutilation and organisms. They watched each video twice for a total of 8 viewings. After watching the video clips with the soundtrack on, the participants watched them again while they were accompanied with either relaxing music or exciting music and with the original soundtrack removed. The length of the video clips was 40 s. There was a 30-s break between the videos, during which the screen was black so that the participants could rest and eliminate any previously experienced emotions. In order to collect the data as accurately as possible, the participants were told to sit upright during the experiment and try not to move while watching the video. The video clips and the music were taken from movies. Table 1 lists the videos and music used in the study. After watching the videos for a total of 5 min, the participants rated their level of disgust for each video on a 5-point scale.

3.3 Analytical Methods

For the brain wave measurements, we used a NeuroScan EEG device and Curry 7 software program. We examined 12 participants, including 6 males and 6 females, and their average age was 22.7 years. The average ages of the males and females were 23.25 years and 22 years, respectively. The data from 10 of the 12 participants were included in the final analysis after the data of 2 participants were excluded due to errors resulting from large body movements and the participants' falling asleep during the experiment. The brain waves were recorded with 64-channel electrodes that were placed according to the 10-20 system. The EEG signals were recorded with a 1-kHz sampling rate and later downsampled to 500 Hz. Impedance was maintained below 10 kΩ during the experiment.

All of the EEG data were divided into 4 segments according to the type of video and mood of the music and then extracted for 40 s, after which a baseline correction was performed by matching the baselines of the raw data to a constant with Curry 7. To remove signal noise from eye blinks, the data in the area outside of the amplitude threshold were replaced with the covariance of the area 200 ms before and the area 800 ms after the affected data area. Band-pass filters were applied. To compare power spectra, the delta (0.5–3 Hz), theta (3–8 Hz), alpha (8–12 Hz), beta (12–30 Hz), and gamma (30–70 Hz) bands, as well as the full frequency range (0.5–70 Hz), were extracted. In the analysis, we compared the peak relative power, which was the ratio of a frequency band power to the total frequency band power.

4 RESULTS

For the body mutilation category of disgusteliciting stimuli, we used the following labels: AO to indicate the first video with the original soundtrack, AS to indicate the first video but with relaxing music,

BO to indicate the second video with the original soundtrack, and, finally, BS to indicate the second video with exciting music. For the disgusting organism category, we used CO to indicate the first video with the original soundtrack, CS to indicate the first video with relaxing music, DO to indicate the second video with the original soundtrack, and, finally, DS to indicate the second video with exciting music. The data from 4 electrodes (FZ, CZ, PZ, and OZ) were used to analyze the relative power spectra. The relative power spectrum values were expressed by category. The relative power spectra data are expressed in µV.

4.1 Body Mutilation

4.1.1 FZ

Table 2: The relative power spectra at the FZ electrode.

	Delta/ Total	Theta/ Total	Alpha/ Total	Beta/ Total	Gamma / Total
AO	2.710951	-1.44074	-0.6693	-0.06018	-0.00096
AS	2.71096	-1.44076	-0.66931	-0.06018	-0.00096
BO	2.13304	-1.13358	-0.52662	-0.04735	-0.00075
BS	2.02069	-1.13372	-0.52667	-0.04735	-0.00075

Table 2 shows the values for the relative power spectra recorded at the FZ electrode during AO, AS, BO, and BS. For the first video, the relative power spectrum of the theta- and alpha-frequency bands was higher during AO compared to that during AS. For the second video, the relative power spectrum of the delta-, theta-, and alpha-frequency bands was higher during BO than that during BS. The relative power spectra of the beta- and gamma-frequency bands were similar during AO, AS, BO, and BS.

4.1.2 CZ

Table 3: The relative power spectra at the CZ electrode.

	Delta/ Total	Theta/ Total	Alpha/ Total	Beta/ Total	Gamma / Total
AO	1.555454	-0.82667	-0.38404	-0.03453	-0.00055
AS	1.555407	-0.82665	-0.38402	-0.03453	-0.00055
BO	2.711577	-1.44115	-0.55665	-0.17304	-0.00096
BS	2.598958	-1.44109	-0.66947	-0.06019	-0.00096

Table 3 shows the values for the relative power spectra recorded at the CZ electrode during AO, AS, BO, and BS. For the first video, the relative power spectrum of the delta- and alpha-frequency bands was higher during AO compared to that during AS. Likewise, for the second video, the relative power spectrum for the delta-, alpha-, and beta-frequency bands was higher during BO than that during BS. In addition, the relative power spectra of the gammafrequency bands were similar during AO, AS, BO, and BS.

4.1.3 PZ

Table 4: The relative power spectra at the PZ electrode.

	Delta/ Total	Theta/ Total	Alpha/ Total	Beta/ Total	Gamma / Total
AO	1.811968	-0.96294	-0.44734	-0.04022	-0.00064
AS	2.133065	-1.13363	-0.52663	-0.04735	-0.00075
BO	2.132629	-1.13336	-0.52648	-0.04734	-0.00075
BS	2.020075	-1.13335	-0.52649	-0.04734	-0.00075

Table 4 shows the values of the relative power spectra recorded at the PZ electrode during AO, AS, BO, and BS. For the first video, the relative power spectrum of the theta-, alpha-, beta-, and gammafrequency bands was higher during AO compared to that during AS. Likewise, for the second video, the relative power spectrum of the delta- and alphafrequency bands was higher during BO than that during BS. In addition, the relative power spectra of the beta- and gamma-frequency bands were similar during BO and BS.

4.1.4 Oz

Table 5: The relative power spectra at OZ electrode.

	Delta/ Total	Theta/ Total	Alpha/ Total	Beta/ Total	Gamma / Total
AO	0.977283	-0.51938	-0.24128	-0.02169	-0.00035
AS	0.977522	-0.51954	-0.24134	-0.0217	-0.00035
BO	-2.28066	-0.13037	-0.01172	-0.00019	-0.00055
BS	-0.28055	-0.13032	-0.01172	-0.00019	-0.00055

Table 5 shows the values of the relative power spectra recorded at the OZ electrode during AO, AS, BO, and BS. For the first video, the relative power spectrum of the theta-, alpha-, and beta-frequency bands was higher during AO compared to that during

AS. Likewise, for the second video, the relative power spectrum of the delta- and thetafrequency bands was higher during BO than that during BS. In addition, the relative power spectra of the gamma-frequency bands were similar during AO and AS, and that of the alpha-, beta-, and gammafrequency bands were similar during BO and BS.

4.2 Disgusting Organisms

4.2.1 FZ

Table 6: The relative power spectra at the FZ electrode.

	Delta/ Total	Theta/ Total	Alpha/ Total	Beta/ Total	Gamma / Total
AO	3.288796	-1.74784	-0.81197	-0.073	-0.00116
AS	3.288853	-1.74794	-0.81199	-0.073	-0.00116
BO	2.711133	-1.44084	-0.66934	-0.06018	-0.00096
BS	2.711128	-1.44083	-0.66935	-0.06018	-0.00096

Table 6 shows the values of the relative power spectra recorded at the FZ electrode during CO, CS, DO, and DS. For the third video, the relative power spectrum of the theta- and alpha-frequency bands was higher during CO compared to that during CS. Likewise, for the fourth video, the relative power spectrum of the delta-frequency band was higher during DO than that during DS. In addition, the relative power spectra of the beta- and gammafrequency bands were similar during CO, CS, DO, and DS.

4.2.2 CZ

Table 7: The relative power spectra at the CZ electrode.

	Delta/ Total	Theta/ Total	Alpha/ Total	Beta/ Total	Gamma / Total
AO	2.712979	-1.44205	-0.66993	-0.06023	-0.00096
AS	2.708993	-1.43947	-0.66866	-0.06012	-0.00096
BO	2.709902	-1.44009	-0.66897	-0.06015	-0.00096
BS	2.710961	-1.44074	-0.6693	-0.06018	-0.00096

Table 7 shows the values of the relative power spectra recorded at the CZ electrode during CO, CS DO, and DS. For the third video, the relative power spectrum of the delta-frequency bands was higher during CO compared to that during CS. For the fourth video, the relative power spectrum of the theta-, alpha-, and beta-frequency bands was higher during DO than that during DS. In addition, the relative power spectra of the gamma-frequency bands were similar during CO, CS, DO, and DS.

4.2.3 PZ

Table 8: The relative power spectra at the PZ electrode.

	Delta/ Total	Theta/ Total	Alpha/ Total	Beta/ Total	Gamma / Total
AO	0.977341	-0.63517	-0.25877	-0.02169	-0.00035
AS	0.977569	-0.51954	-0.24134	-0.0217	-0.00035
BO	-1.30416	-0.60587	-0.05447	-0.00087	-0.00075
BS	-1.30421	-0.60588	-0.05447	-0.00087	-0.00075

Table 8 shows the values of the relative power spectra recorded at the PZ electrode during CO, CS, DO, and DS. For the third video, the relative power spectrum of the beta-frequency bands was higher during CO compared to that during CS. For the fourth video, the relative power spectrum of the delta-frequency bands was higher during DO than that during DS. The relative power spectra of the gamma-frequency bands were similar during CO and CS, and those of the alpha-, beta-, and gammafrequency bands were similar during DO and DS.

4.2.4 OZ

Table 9: The relative power spectra at the OZ electrode.

	Delta/ Total	Theta/ Total	Alpha/ Total	Beta/ Total	Gamma / Total
AO	-0.28066	-0.13037	-0.01172	-0.00019	-0.00075
AS	-0.28055	-0.13032	-0.01172	-0.00019	-0.00075
BO	-0.62189	-0.28889	-0.02597	-0.00041	-0.00096
BS	-0.62174	-0.28882	-0.02597	-0.00041	-0.00096

Table 9 shows the values of the relative power spectra recorded at the OZ electrode during CO, CS, DO, and DS. For the third video, the relative power spectrum of the delta-frequency bands was higher during CO compared to that during CS. For the fourth video, the relative power spectrum of the theta-, alpha, and beta-frequency bands was higher during DO than that during DS. In addition, the relative power spectra of the beta- and gammafrequency bands were similar during CO and CS, and those of the alpha-, beta-, and gamma-frequency bands were similar during DO and DS.

4.3 Survey

After watching the videos, the participants rated their level of disgust for each video on a 5-point scale. The survey results for 7 participants were used in the final analysis. For body mutilation, all of the participants responded that the first and second original videos (AO and BO) were more disgusting than the same videos with easy listening and exciting music (AS and BS). In addition, for the disgusting organisms, all of the participants responded that the third and fourth original videos (CO and DO) were more disgusting than the same videos with easy listening and exciting music (CS and DS).

4.4 Overall Results

In this study, we investigated the differences in the relative power spectra of the brain waves while the participants watched disgust-eliciting videos with auditory stimuli for different moods. The results of the experiment showed that the relative power spectra of the delta-, theta-, and alphafrequency bands were mostly higher for the disgusteliciting videos with the original soundtracks compared to the same videos with extraneous auditory stimuli and that the relative power spectra of the beta- and gamma-frequency bands were almost similar for the disgust-eliciting videos with the original soundtracks compared to the same videos with extraneous auditory stimuli. These results were consistent with the results of the survey that was administered following the experiment. These findings suggest that the participants may have felt less disgust when they watched the disgusteliciting videos with background music compared to when they watched them with the original soundtracks.

5 CONCLUSIONS

This study was conducted to examine the effects of auditory stimulation on disgust-eliciting visual stimulation. We selected videos of two categories of disgust elicitors, added auditory stimulation to them with music, and then examined the changes in brain waves. The categories of the disgust elicitors were body mutilation and disgusting organisms. For the auditory stimuli, easy listening and exciting music were used to provide contrasting moods of music.

The relative power spectra of the brain waves were lower when the videos were shown with auditory stimulation compared with its original soundtrack. That is, the participants experienced less disgust while they watched disgust-eliciting videos with auditory stimulation. Additionally, we found differences between the stimulation of body mutilation videos and that of disgusting organism videos, which suggests that the responses to the mood of music may differ depending on the type of disgust elicitors. The significance of this study was that that it utilized visual and auditory stimulation together to study a specific type of affect.

The study materials were limited to the disgust elicitors of body mutilation and disgusting organisms. Thus, future research of a variety of disgust elicitors is needed. Furthermore, future research needs to investigate other stimulation modalities other than auditory stimuli.

In the present study, we investigated disgust elicitors, which were limited to body mutilation and disgusting organisms. In our follow-up studies, we plan to examine a wider range of disgust elicitors and investigate different kinds of auditory stimulation that may arouse different responses depending on the type of disgust elicitor.

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REFERENCES

Haidt, J., Cauley, C., Rozin, P., 1994. Individual differences in sensitivity to disgust: A scale sampling seven domains of disgust elicitors. *Personality and Individual Differences*. Pages 701-713.

MIT Press., 2014. *Analyzing Neural Time Series Data*. MIT Press.

Lin, Y. P., Wang, C. H., Jung, T. P., Wu, T. L., Jeng, S. K.,

Duann, J. R., Chen, J. H., 2010. IEEE TRANSACTIONS ON BIOMEDICAL.

ENGINEERING. Pages 1798-1806.

Nie, D., Shi, L. C., Lu, B. L., 2011. EEG-based emotion recognition during watching movies. Proceedings of the 5th International IEEE EMBS Conference on Neural Engineering Cancun. Pages 667-670.

Murugappan, M., Rizon, M., Nagarajan, R., Yaacob, S., Hazry, D., Zunaidi, I., 2008. Time-frequency analysis of EEG signals for human emotion detection. *In 4th Kuala Lumpur International Conference on Biomedical Engineering 2008. Pages 262-265.*

Sarlo, M., Buodo, G., Poli, S., Palomba, D., 2005. Changes in EEG alpha power to different disgust elicitors: the specificity of mutilations. *Neuroscience Letters.* Pages 291-296.

Syahril, S., Subari, K. S., 2011. Detection of disgust in the EEG sub-gamma band. *In TENCON 2011-2011 IEEE Region 10 Conference*. Pages 293-297.

Wheaton, M. G., Holman, A., Rabinak, C. A., MacNamara, A., Proudfit, G. H., Phan, K. L., 2013. Danger and disease: Electrocortical responses to threat-and disgust-eliciting images. *International Journal of Psychophysiology*. Pages 235-239.

Lewis, M., M.Haviland-Jones, J., Barrett, L. F., 2010.
Handbook of Emotion.

Gasser, T., Bächer, P., Möcks, J., 1982. Transformations towards the normal distribution of broad band spectral parameters of the EEG. *Electroencephalography and clinical neurophysiology*, Pages 119-124.

Utama, N. P., Takemoto, A., Nakamura, K., Koike, Y., 2009. Single-trial EEG data to classify type and intensity of facial emotion from P100 and N170. In *Neural Networks, 2009. IJCNN 2009. International Joint Conference in IEEE.* Pages 3156-3163.

Schaefer, R. S., Vlek, R. J., Desain, P., 2011. Music perception and imagery in EEG: Alpha band effects of task and stimulus. *International Journal of Psychophysiology*. Pages 254-259.

Gotlib, I. H., 1998. EEG alpha asymmetry, depression, and cognitive functioning. *Cognition & Emotion*. Pages 449-478.

Palomba, D., Sarlo, M., Angrilli, A., Mini, A., Stegagno, L., 2000. Cardiac responses associated with affective processing of unpleasant film stimuli. *International Journal of Psychophysiology*, Pages 45-57.

Köchel, A., Schöngassner, F., Schienle, A., 2013. Cortical activation during auditory elicitation of fear and disgust: a near-infrared spectroscopy (NIRS) study. *Neuroscience letters*, *549*, Pages 197-200.