

What influence does music in visual content have on human reaction/behavior?

A qualitative research using EEG

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ICC, Spring 2011**

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Introduction

Today, neuroscientists are only just beginning to understand how music affects the brain. Music encompasses great potential and that it can elicit hundreds of shades of emotion very quickly. Additionally, numerous researches have demonstrated that music is closely aligned to a person's memory-enhanced patterns and concentration. Yet, with great difficulty can one perceive something auditory to have a stronger impact on an individual than a visual representation that though intangible may penetrate deeper into a person's understanding. In today's growing global society, seldom are individuals exposed to images that are not accompanied by some sort of sound or melody; this can be in part due to the fact that individuals are being increasingly influenced by the media, as they become the targets of propaganda from merchandising to television and politics.

The experiment that will take place will seek to bind both aural and visual stimuli and measure its impact on a human's brain. The aim of the experiment will be to find connections, deviations, and ambiguities formed after an individual is exposed to visual content while music plays in the background. A sequence of images high in graphic content will make up the visual dynamic, while instrumental music will constitute the aural aspect of the scene. The content of the photographs will be chosen on a basis of "graphic violence." In order to avoid ambiguities, a definition will be instituted to establish what is implied by "violent". Furthermore, the images chosen should aim at having no existing propagandized ties to the media or societal institutions (no famous photographs that the individual may already have preconceived notions about). The music that will play should be non-verbal so as to avoid any linguistic attachments that may already pre-exist, and also to limit the potential of ambiguities in the case research to permit more accurate test outcomes.

The procedure of the experiment shall consist of: a (control) group of individuals who watch the image sequence without being exposed to the music in the background, and 2 (case) groups of individuals who will be exposed to the same image sequence while listening to a type of music simultaneously (the types of music will be different in each case group). The aim is to have at least 6 subjects (persons) per test group, equally balanced in gender within each group. Said subjects will be tested in isolation from one another at different times. The primary objective of the experiment is to enable the delving into human behavior with the aim to understand the potential of sound's influence on humans' perception.

Predictions: the results are expected to show that the individuals, when exposed to playful music that sharply contrasts the content of the images, will be less impacted by the powerful violent visual content, whereas the more melodious melody should enhance concentration by the viewer in the images, as it adds to the sentimental value of the viewing experience.

Literary Review

In our research, the aim is to investigate whether two different sensory inputs have an influence on one's perception and emotional state. We suspect to find that indeed these two inputs coincide and are able to collectively create a certain perception. According to Jon Driver and Charles Spence (1998), we have reason to believe this interplay between senses (p. 245). In their article "cross-modal attention" they propose that even with selective attention people's perception is not based upon one single sensory modality, but rather as a composition of multiple modalities. It is therefore not unreasonable to think that, as with our research, perception by vision (watching graphically violent pictures) can be influenced by the additional sensory input of hearing (listening to emotionally-hinted music) (Driver & Spence 1998, p. 245). We should not suspect that subject would not notice the change in music, because, as Driver and Spence suggest, selective attention to one sensory modality in the presence of multiple is in general not possible.

Edelman's approach in his article, "Arousal and visual perception in drosophila", reflects the belief that research on music has the potential to illuminate fundamental aspects of human brain function, including language, the active nature of perception, and the processing of complex sequences that unfold in time (Edelman, 2005). This article establishes a connection between visual perception and cognitive science, that although asserted is not yet wholly understood, even by today's scientists. The article states that hearing and optical systems may have fundamentally different mechanisms for selective attention, suggesting that attention disorders in the two domains might need to be treated with different approaches (Edelman 2005). Furthermore, it presents an outline of the complexity of the human brain, enabling us to re-evaluate our tactics for approaching the problem.

In their research titled, "Intensely pleasurable responses to music correlate with activity in brain regions implicated with reward and emotion," Blood & Zatorre (2001) mention the difficulties of uniting music with emotions together, due to the limited amount of existing research conducted on the topic. The article gives a summary of the difficulties, and possibilities related to brain and music. Additionally, the source refers to a recent experiment measured the activity in the brain while subjects were played previously-chosen musical pieces which created feelings of intense pleasure for them, where "musical pieces had an fundamental emotional value for the subjects, and no memories or other associations attached to them". Activity was seen in the reward/motivation, emotion, and arousal areas of the brain. The results outlined by this source

provide background for the association between the pleasure induced by food, sex, and images, and pleasure induced by music.

David Kahneman is the author of “Well-being: the foundations of hedonic psychology,” where he discusses “brain-based measures of emotion” stating that in the last decade or so researchers have begun to refine neurophysiological measures of emotion. Scalp-recorded brain electrical activity, (EEG), can index patterns of anterior asymmetries that distinguish specific emotion states as well as individual differences in affective style (2005, 54). This source affirms the current research in development that seeks to find a way to measure human emotion by what is referred to as “Behavioral activations;” Similar to Kahneman’s research, our experiment will aim, not at disproving any previous music and cognition theory, but instead, building on their research with the goal of establishing a new foundation that will enable future research to shed light on the complexity of behavior as targeted by sound and image.

Jean Baudrillard’s famous “Simulacra and simulation” (1997) is a source that puts our experiment into the relevancy of society today, attributing the violent content of images to a society at risk of desensitization, bringing into testimony some of the historic events that have shaped modern society. Baudrillard was the late post-modern theorist and photographer. This source will not only enable the content of the images that will be used in the experiment to be measured with greater objectivity, but also places its larger significance into perspective as a way to understand how humans makes sense of the world around them, in a world infiltrated with violence.

Methodology of Experiment

In the experiment, there will be two test groups who will watch a sequence of negative images (e.g. from war, violence). One group of subject will view a video sequence of violent images while *sad* music plays in the background. The other test group will be exposed to the same sequence of images but accompanied by what is considered *happy* or *playful* music. The distinction between the two types of music is based on the beat, rhythm, harmony (major vs. minor key) and the pace of the music. All video sequences will last approximately 4 minutes with a compilation of about 120 images, without any repetitions of images in each test sequence.

Additionally, the procedure will include a control group of individuals who will observe the image sequence without being exposed to any background music/sound. Currently, the aim is to have at least 4 subjects for the control group, and 4 test subjects for one test group (sad music) and 4 different test subjects for the other test group (happy music). An aim to keep in mind is that the subjects per test group should be equally balanced in gender: for example, with a total of 6 test subjects in a group, 3 should be female, and 3 should be male, thus, there is only the possibility of having groups of even numbers.

The subjects will be tested in isolation from one another at different times. Every subject will see the same order of pictures, yet accompanied by either the happy or sad song. The requirements for the subjects are that they do not have a history of epilepsy, for –although improbable– the sequence of pictures might trigger an epileptic seizure.

Clint Mansell’s calm and melodious “Death is the Road to Awe” will be used as the *sad* music to accompany the one test group’s sequence of violent images. This song has a much lower pace and uses lower (minor) chords, which is associated more with sadness. Mansell is famous for making film music (e.g. Requiem for a Dream) that strongly provokes human emotion; this song fits well within the experiment as the song will be used to enhance the *sad* perception of certain film scenes. In contrast, the fast-paced, unmelodious music from the Animaniac’s theme song (without words), which has a higher pace and higher (major) chords, will play in the video sequence viewed by the other test group. The primary objective of the experiment is to enable the delving into human behavior with the aim to understand the potential of sound’s influence on humans’ perception.

Data Collection

In order to carry out the experiments so that data could be recorded according to the video sequence, the EEG (Electroencephalography) technology, which measures the human brain’s electrical vibrations, was used. The resulting EEG patterns contained the frequency elements that were triggered by the 14 electrodes placed on the scalp and the signals were transformed and produced as data measured in Hertz, which then can be divided into various brain waves (alpha, beta, delta, and theta) along their frequency. While using the EEG, some technical difficulties were experienced, which negatively affected the experimenting process as some data of test subjects was lost or unable to be used for analysis.

The control group watched the video sequence without any external noise or music. The first case study group of individuals tested watched the video sequence with *happy* music. The second case study group viewed the same video sequence while listening to *sad* music. The groups were consequently only exposed to one type of stimulus in addition to the picture sequence rather than to an abrupt change of music which might have lead to a blurry overload of emotional response. This was a necessary step to ensure adequate measurements for significant comparison between purely visual input and visual input with supplementary auditory input, especially as the overall length of the video sequence would not have allowed for more incorporations in its short span. In addition, the *happy* music used was the Animaniacs theme song, whose lyrics had to be removed before being added to the video sequence, and was chosen as it seemed to be a better and more unbiased option for a happy song.

Deviating from the original plan, where a larger output of test subjects per test group were expected, the control group consisted of eight individuals (equally divided between males and

females), while the happy-music and sad-music groups consisted of four test subjects each (also equally divided by gender). The unfortunate decrease in the number of test subjects occurred due to time restrictions. Furthermore, problems with the set-up of the equipment further delayed research and antagonized some potential participants, leading to an additional loss in data. Difficulties were experienced with the raw EEG signals, as trying to test two test subjects at once lead to an interference in the signals, thus the subjects' results were not able to be utilized in the experiment.

Since the test subjects were required to wear headphones for the experiment, whether listening to music or not, it was important that these would not interfere with the EEG measurements. Thus the headphones used for the test subjects were plug-in headphones and there is no indication in the data that any interference occurred.

As the pictures were viewed for three seconds before changing, the measurement interval was placed at the same rate. This led to a tremendous amount of results per individual, since the sequence consisted of 120 pictures. Visible emotional responses varied in amplitude. Some test subjects closed their eyes or looked away from the screen when shown a very violent picture, demonstrating the emotional intensity with which some images were perceived. These strong responses are apparent as very high peaks in brain activity. Other test subjects remained calm and (visibly) unresponsive but reported jokingly that the picture sequence was not a good start into the day.

Data Interpretation

The process of analyzing involved several steps and modifications of methods. First to modify were the subjects per test group, as the number of subjects in the control group far exceeded those in each of the two case study groups. Thus, the number of subjects in the control group also had to be reduced to four, as in the case study groups. This was not intentionally but occurred as a consequence of the difficulties in finding test subjects, which in turn provided less data to work with, and less accurate results. The data that was collected followed the same procedure, where the mean and standard deviation for each subjects separate wavelengths were calculated. These results were again used to find the mean of the mean and the standard deviation for the groups in total. By using these data the first histogram (figure 1) could be constructed, which indicated some deviating results. Firstly, the values on the x-scale were considerably high ranging up till 36000 Hz. Compared to the majority of the data which centered around 5000 -10000 Hz, this indicated a number of outliers. Furthermore, the subjects in the control group had large considerably large standard deviations. These findings asked for a review and reconsideration of the raw data previously obtained, and resulted in the removal of the outliers. The outliers were detected by calculating the mean plus three times the standard deviation of each group. This

changed our results significantly. The values on the x-axis were halved, and the standard deviations went down.

The removal of the outliers, however, did not change the general trend in our data, and might still contradict the initial hypothesis that the brain wave activity in the subjects exposed to music would increase. Yet, lower values in the measured brain waves (Alpha, Beta, Delta, and Theta) could be explained due to the very *presence* of the music, which, although emotionally provoking, might have a relaxing effect (see also Walker, 1977). Moreover, looking at the raw data, we should take the large standard deviations in consideration, which might indicate the insignificance of the higher values in the control group compared to the groups with music. Indeed, t-distribution tests on the seemingly largest differences in values between the control group and the groups with music (such as most theta waves and certain delta waves) show that most differences are insignificant (F7 theta: $P > 0.1$; P8 theta: $P > 0.1$; FC6 theta: $P > 0.1$; F3 delta: $P > 0.1$; P7 delta: $P > 0.1$). The fact that this variance between groups is trivial might be explained by the highly deviating values, possibly caused by background noise that managed to survive the process of filtering outliers, such as the mean F7 theta wave of subject 8 in the control group (43.4922) that greatly increases the standard deviation of the control group.

Furthermore, it is apparent that not all data contradict our prediction of elicitation of stronger brain activity; looking at the data derived from the AF3-electrode (corresponding to the dorsolateral prefrontal cortex), the average of the control group is *lower* in all waves than the average of the group with happy music. Since the AF3-electrode refers to Brodmann Area 9, known for its motor control function and inhibition of somatosensory responses (SKIL, 2007), the higher values of brain waves found in the group with happy music might point towards the dissociation between violent pictures and happy music, which might make subject repress emotional responses such as laughter or grinning. However, one should note that these explanations, though tentative at most, also point out that our hypothesis still has potential and is worth investigating further. The following graphs (figure 1 and figure 2) depict the data collected in the experiment with each case study:

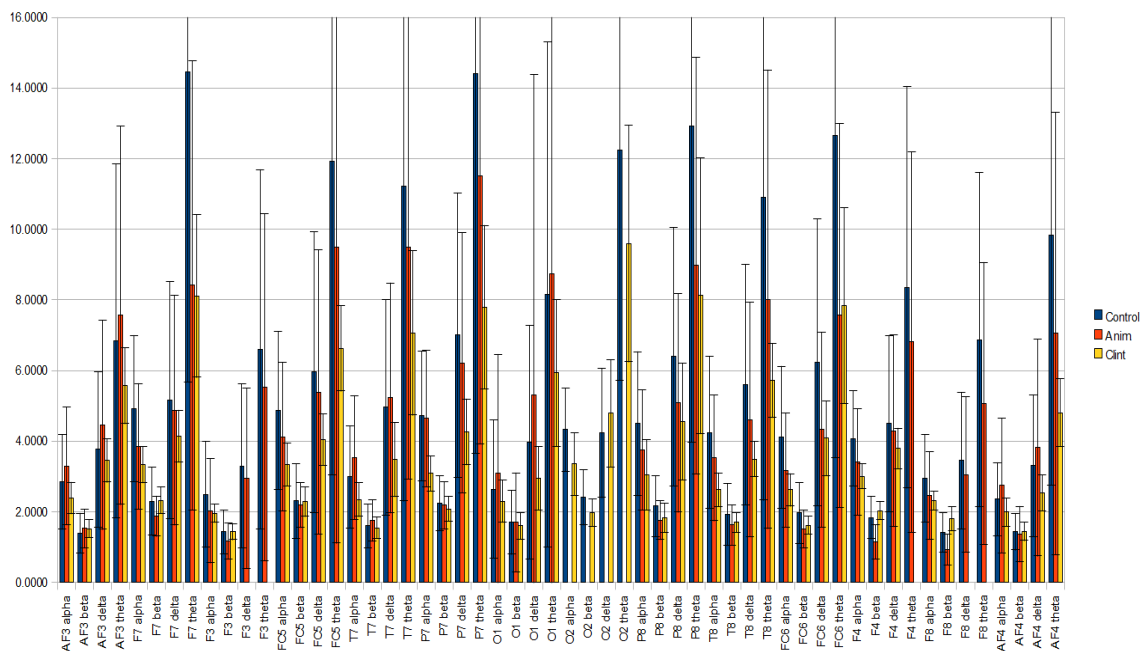


Figure 1: modified data, without outliers

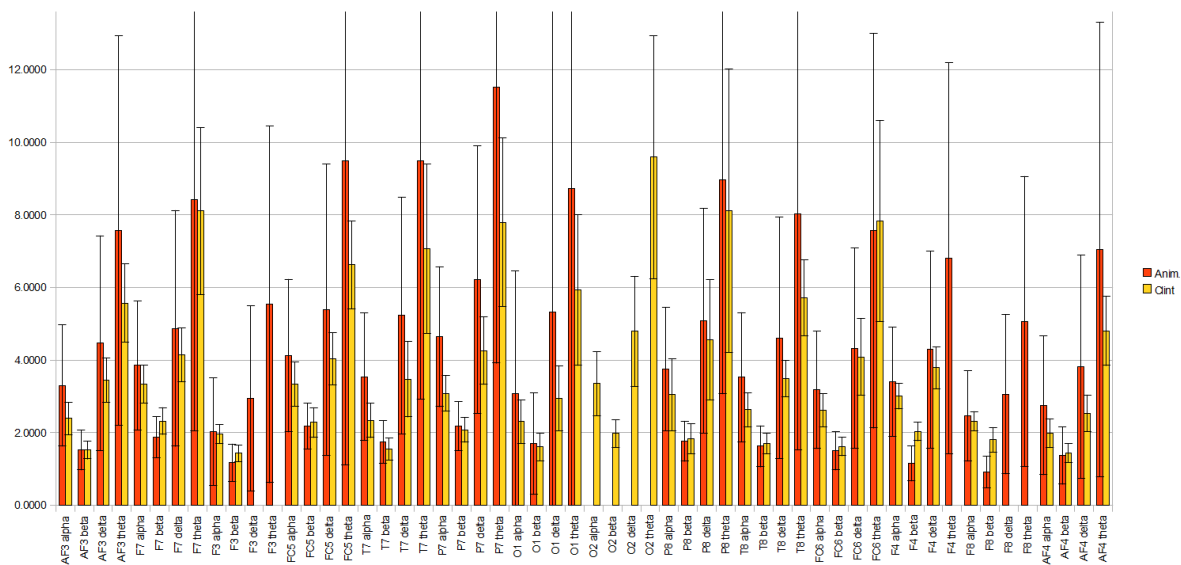


Figure 2: comparison between the two groups exposed to music

More thorough statistical analysis using the WEKA-tool, however, yielded more subtle yet compelling results in favor of the hypothesis. Merging the data of the three groups (control, happy music, and sad music) allowed WEKA to conduct an inverse classification analysis, which provided an indication of how well fragments of data (in clips of 5 seconds) can be predicted

from values of brain waves to rightly fit a certain group. The first classification analysis (figure 3) gave a surprisingly accurate prediction rate (84%), using an algorithm mainly based upon the F4-Beta wave.

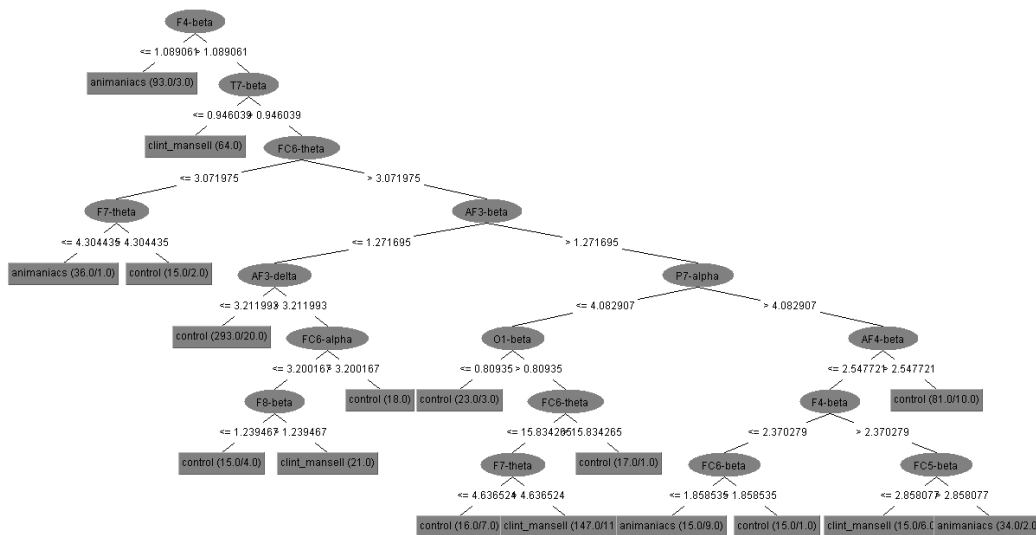


Figure 3: J48-classification analysis of three groups

This analysis indicates that there are, although it may seem otherwise from the data represented in figure 1-2, indeed cues that allow accurate statistical predictions in which brain waves correspond with the particular categories.

Even stronger patterns emerge when comparing just the data from the two types of music, happy versus sad. As depicted in figure 4, an even better prediction follows from a J48-test, resulting in a 93% success rate in the classification analysis. In this differentiation of categories, the brain wave of F4-Beta plays an important role again, since it yields a rather short (especially in comparison with figure 3) classification tree. In retrospect, a t-distribution test on the difference between the values of this wave among the two categories (happy vs. sad) indicates that the variance of F4-Beta between both groups is significant (P<0.05).

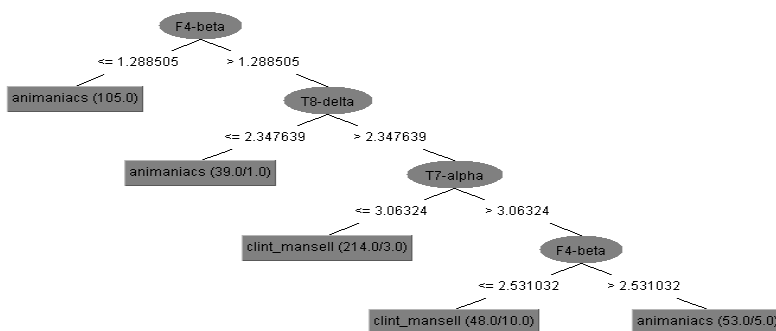


Figure 4: J48-classification analysis of happy vs. sad

Interpreting this importance of the most significant waves –being F4-Beta, T8-Delta, and T7-Delta (figure 4) leads to the Brodmann Areas corresponding with these measured waves. Firstly, the F4-Beta waves refer to a part on the frontal cortex of the brain (BA08), associated with eye movement, but, as recent research on autism and “theory of mind” has indicated, also with higher-order mental states involved in emotion recognition (Fletcher et al., 1995; Happé et al., 1996). This finding might tentatively support our hypothesis by suggesting that higher activation in BA8 indicates a more intense emotional experience (see figure 4).

As one would assume based on the data outputs in correlation to the signals, the T8 and T7 electrodes of the EEG correspond to respectively to BA41, BA21, BA22, which all are located on the temporal lobe, specifically on the auditory processing cortex. Therefore, it could be that the control group and both groups with music are differentiated in terms of brain waves by the activation of these areas, as, for example, can be seen in figure 3 (the outer left node labels T8-Theta waves smaller than a particular value as “control”). In figure 4, the classification due to the T7 and T8-related waves hint at a cue regarding the nature of the music. These T7 and T8 electrodes correspond with Brodmann Area 22, of which the T8 electrode is involved in processing melody, pitch, and sound intensity (Campbell & Reece, 2007). An interesting interpretation, then, could be that the brain emits different brain waves around BA22 when hearing happy music (upbeat, major key, fast pace melody) versus sad music (slow pace, minor key, slow melody progression).

Discussion and conclusion

a) Discussion

The experiment along with the data analysis turned out to be more difficult than thought beforehand. Not only did practical difficulties arise during the testing phase of the experiment, such as technical problems with the EEG headsets (no connection, interference with multiple EEG headsets working at the same time), but also methodological issues appeared while conducting this research. The major issue regarded the specific aim of the experiment. Although it was decided on that the focus should lie on the effect of music (auditory) on one’s emotional experience altogether (auditory and visual), it was much harder to determine what would be the best approach and methodology in order to prove this through analysis of EEG data. After carefully considering the possibilities, we decided to stick with three groups consisting of one control group, one with playful music, and one with sad music.

In the process of preprocessing and analysis of the data there appeared to be major inconsistencies (possibly caused by background noise and/or fidgeting of the subjects) in the EEG data, resulting in highly varying values (outliers) accompanied with extremely high standard deviations, that would make statistical testing practically impossible. After eliminating all the outliers ($3 \cdot \sigma < X < 3 \cdot \sigma$), however, brain waves from certain electrodes (e.g. the O2

electrode) or time fractions were forced to be left out completely. Although we realize that we could not include all the data in our analysis, this does not mean that we were left with insufficient data to work with and conduct statistical analysis on.

b) Conclusion

In retrospect, it seems that our data is not consistent with our initial hypothesis, i.e., that visual content supplemented with certain music types would yield stronger brain waves than with visual content alone. Additionally, we predicted that sad music would add more to the emotional experience than playful music would. Our data, however, showed that brain activity in most regions (as divided by electrode placement) was lower when tested *with* music than tested without music. Although this might seem contradictory to our hypothesis, it does not necessarily invalidate our findings. As mentioned before, it could be that music in general has a reducing influence on the measurements of brain waves (especially alpha and beta waves), independent of emotional experience. Nonetheless, inverse statistical analysis indicated that there are indeed cues in brain activity that successfully (in 84% percent of the instances) predict the corresponding group. It appeared that activation in the Brodmann Areas located at the temporal lobe (specifically on the auditory cortex) differentiated the control group from the groups with music. This suggests that there are indeed, yet subtle, significant differences and patterns in the specific brain waves emitted from each group.

Further comparison between the group with playful music versus the group with sad music gave us relatively more interesting results. Though we did not intend to explicitly investigate the relation between the two groups with contrasting musical accompaniment, predictive classification analysis (J48) gave evidence that sad music, as opposed to playful music, elicited stronger beta waves in BA8, which might indicate a more emotional experience. In fact, this finding supports our hypothesis that sad music triggers a more intense emotional experience, to the extent that this is measurable with EEG testing.

Thus, in having a hypothesis not wholly upheld by the results, once analyzed, the data collected from the experiment not only depicted the parallels between the expected results but also elucidated new findings that open grounds for further research in the area of human cognition and perception as related to aural and visual stimuli. Much is left to be uncovered but this experiment provided a small building block for future analysis that can use this data to better understand human behavior.

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Acknowledgement

As a group, we would like to express our gratitude to David de Bos and Jeroen Kools for their valuable help and endless patience. The data analysis and interpretation would have been impossible without them!