NeuroClick

# Analyzing Brainwave Signals to Understand What Clicks

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# 1. Introduction

## 1.1. Why?

Advances in EEG (electro-encephalogram) biosensor technologies over the past few years have opened up brainwave research and application development at an unprecedented level. Brainwave data collection traditionally used expensive research equipment, but similar data can now be collected using consumer-grade sensors built into simple headsets, such as Neurosky devices, and many more.

The increased interest in Brain Computer Interfaces as a topic of research and the availability of consumer-grade sensors means that there is an increased potential for the use of such technology in fields that conventionally make use of other techniques such as gaming, marketing and user research. Even though there has been some usage of such technology in some areas, there has not been too many software platforms that enable a seamless pipeline for data collection, analysis and visualization for other purposes.

## 1.2 What?

Our project, **NeuroClick,** aims to explore the relationship between brainwave signals and "interest" that users develop to various external stimuli. Does an interesting photo pique our attention more than a usual photo? Does an attention catching video actually induce a significant brainwave signal? Can the brain wave signal analysis allow us to predict what goes viral on social media?

Apart from judging cute cat photos, this technology could also find applications in design, advertising, marketing, A/B testing and various other fields, which might benefit from the knowledge of user attention/interest.

## 1.3 How?

In pursuit of our goal, we designed and developed a platform consisting of various tools to interface with the Neurosky device and performed semi automated experiments with users and archive data anonymously. In our research, the proposed human subject experiment are run on various volunteered subjects whose brain wave signals are collected when they are presented various stimuli like text, pictures, videos. We analyzed the data using standard correlation techniques to see whether there is any correlation between features of brainwave signals and stimuli presented to the human subjects.

We recruited 30 participants from different gender, ethnicity, and age groups. This number is based on the level of statistical significance we wished to attain for our analysis, as well as to account for the possibility that some participants may fail to complete the single session requirement for the study.

# 2. Background Research

## 2.1. The Technology

The device to collect brainwave is a headset with a built-in non-invasive EEG sensor manufactured by Neurosky. It is a consumer-grade EEG sensor that has a direct connection to a dry electrode and operates on a single channel (as opposed to a wet sensor operating on multiple channels that is commonly available). It has a sampling rate of 512 Hz and can collect signals within the frequency range from 3-100 Hz and operates at a voltage of 2.97 ~3.63V. It is connected to a laptop through bluetooth and streams packets that contain various information that includes the raw spectrum sampled at 512Hz, information about the quality of the signal and other such information.

Fig. 1. Neurosky MindWave headset

## 2.2. The Terminology

Electroencephalography (EEG) is the recording of electrical activity along the scalp. EEG measures voltage fluctuations resulting from ionic current flows within the neurons of the brain. The EEG signal is represented by the presence of rhythmic activity that is divided into preset bands based on the frequency. Scientifically the activity within a certain frequency band has been observed to have some biological significance.

| Name | Frequency Band | Indicates |
|---|---|---|
| Delta | <4 | slow-wave sleep, continuous attention tasks |
| Theta | 4 -7 | drowsiness, idling |
| Alpha | 8 - 15 | relaxed |
| Beta | 16-31 | active thinking, high alert |
| Gamma | 32 + | familiarity |

| | | |
|---|---|---|
| Mu | 8 – 12 | rest-state motor neurons |

Table 1. EEG frequency bands (Data from Wikipedia)

Of these frequency bands, the neurosky hardware provided information about alpha, beta, gamma, delta and theta bands.

# 3. Implementation

## 3.1. Experimental Design

### 3.1.1. Stimulus Selection

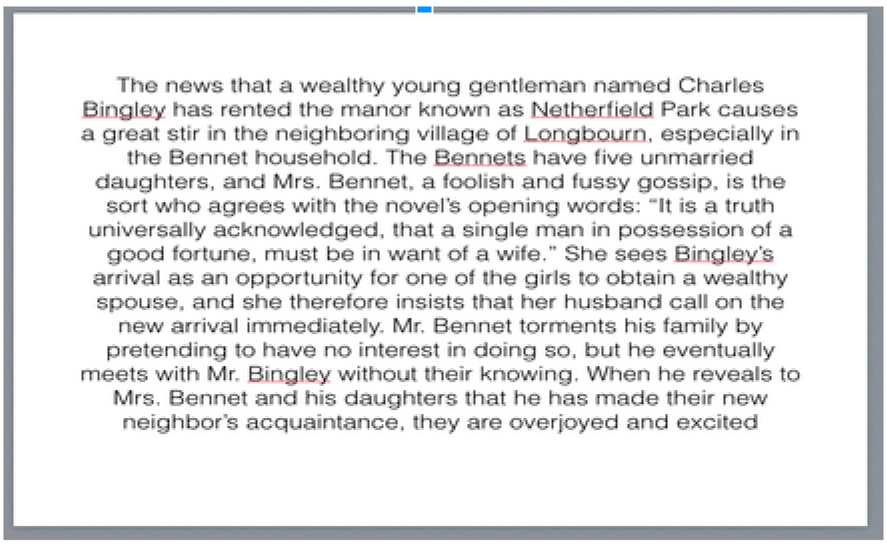
We chose stimuli that are diverse (text, pic, video) and could evoke different responses from the users. Along with the stimulus type, we also experimented with the time-duration of the stimulus and see how it affects participants' response. We selected stimuli from various social media on the internet like youtube, twitter, vine and amazon kindle highlights. Each of these stimuli have specific properties associated with them such as the duration, how many people liked it/favorited it, highlighted it based on which we decided the measure of popularity of the stimulus.

| Tag | Meta | data-time | data-transperiod | url | Likes | views | Dislikes | Revines |
|---|---|---|---|---|---|---|---|---|
| vid1 | P | 7 | 2 | <iframe class="vine-embed" src="https://vine.co/v/htbr9vhq5HB/embed/simple?audio=1" width="600" height="600" frameborder="0"></iframe><script async src="//platform.vine.co/static/scripts/embed.js" charset="utf-8"></script> | 35.9k | | | 28.8k |
| vid2 | P | 70 | 2 | <iframe width="560" height="315" src="//www.youtube.com/embed/w4lnVx2BAYk&start=0&end=70" frameborder="0" allowfullscreen></iframe> | 50498 | 7611819 | 2100 | |
| vid3 | P | 56 | 2 | <iframe width="560" height="315" src="//www.youtube.com/embed/_OBlgSz8sSM" frameborde | 1202489 | 677930244 | 185924 | |
| vid4 | NP | 8 | 2 | <iframe class="vine-embed" src="https://vine.co/v/MbMm9ltnTjF/embed/simple?audio=1" width="600" height="600" frameborder="0"></iframe><script async src="//platform.vine.co/static/scripts/embed.js" charset="utf-8"></script> | 0 | | | 0 |
| vid5 | NP | 7 | 2 | <iframe class="vine-embed" src="https://vine.co/v/hpeAW7W2MbJ/embed/simple?audio=1" width="600" height="600" frameborder="0"></iframe><script async src="//platform.vine.co/static/scripts/embed.js" charset="utf-8"></script> | 2 | | | 0 |
| vid6 | P | 6 | 2 | <iframe class="vine-embed" src="https://vine.co/v/MzqJb9Kei3E/embed/simple?audio=1" width="600" height="600" frameborder="0"></iframe><script async src="//platform.vine.co/static/scripts/embed.js" charset="utf-8"></script> | 22.9k | | | 25.1k |
| vid7 | NP | 111 | 2 | <iframe width="560" height="315" src="//www.youtube.com/embed/ilrJVpsa3k0" frameborder=' | 23 | 1897 | 18 | |
| vid8 | P | 6 | 2 | <iframe class="vine-embed" src="https://vine.co/v/MWd03dtgbBb/embed/simple?audio=1" width="600" height="600" frameborder="0"></iframe><script async src="//platform.vine.co/static/scripts/embed.js" charset="utf-8"></script> | 129.4 | | | 69.4k |
| vid9 | NP | 151 | 2 | <iframe width="420" height="315" src="//www.youtube.com/embed/HhEjpl6L6Qc" frameborder | 10 | 5419 | 1 | |
| vid10 | P | 6 | 2 | <iframe class="vine-embed" src="https://vine.co/v/hlUaFxUKqm6/embed/simple?audio=1" width="600" height="600" frameborder="0"></iframe><script async src="//platform.vine.co/static/scripts/embed.js" charset="utf-8"></script> | 35.8 | | | 41.1 |
| vid11 | NP | 6 | 2 | <iframe class="vine-embed" src="https://vine.co/v/MmPh0PTxjvz/embed/simple?audio=1" width="600" height="600" frameborder="0"></iframe><script async src="//platform.vine.co/static/scripts/embed.js" charset="utf-8"></script> | 143 | | | 102 |
| vid12 | P | 4 | 2 | <iframe class="vine-embed" src="https://vine.co/v/MzwlgwptbaZ/embed/simple?audio=1" width="600" height="600" frameborder="0"></iframe><script async src="//platform.vine.co/static/scripts/embed.js" charset="utf-8"></script> | 9635 | | | 8357 |
| vid13 | P | 103 | 2 | <iframe width="560" height="315" src="//www.youtube.com/embed/Hwt2Jt6mxpE" frameborde | 9 | | | |
| vid14 | P | 6 | 2 | <iframe class="vine-embed" src="https://vine.co/v/MAeD2DK6W9X/embed/simple?audio=1" width="600" height="600" frameborder="0"></iframe><script async src="//platform.vine.co/static/scripts/embed.js" charset="utf-8"></script> | 79.3k | | | 93.4k |
| vid15 | P | 68 | 2 | <iframe width="560" height="315" src="//www.youtube.com/embed/eN6c8aHBIbU" frameborder="0" allowfullscreen></iframe> | 1945 | 675896 | 363 | |
| | | | | <iframe class="vine-embed" src="https://vine.co/v/MmMXrrFZI20/embed/simple?audio=1" | | | | |

Fig 2. Meta data information of stimuli

**Text:**

For text, we chose Amazon Kindle book reviews as our source and shortlisted around 40 text snippets from various books based on number of words in the text and the popularity of the snippet as indicated by the highlight count. We went through a lot of iterations before ending up with a final list of 40 text snippets to choose a representative sample for popular and non-popular text. We also calculated an estimate of the time that would be required by an average user to read the text  based on the number of words in the text.



The news that a wealthy young gentleman named Charles Bingley has rented the manor known as Netherfield Park causes a great stir in the neighboring village of Longbourn, especially in the Bennet household. The Bennets have five unmarried daughters, and Mrs. Bennet, a foolish and fussy gossip, is the sort who agrees with the novel's opening words: "It is a truth universally acknowledged, that a single man in possession of a good fortune, must be in want of a wife." She sees Bingley's arrival as an opportunity for one of the girls to obtain a wealthy spouse, and she therefore insists that her husband call on the new arrival immediately. Mr. Bennet torments his family by pretending to have no interest in doing so, but he eventually meets with Mr. Bingley without their knowing. When he reveals to Mrs. Bennet and his daughters that he has made their new neighbor's acquaintance, they are overjoyed and excited

Fig 3. Sample Long Text

**Images**

Images are selected mainly from twitter and meta-data such as favourites and retweets associated  with the tweet formed the basis of our categorization into popular and non-popular stimulus type.

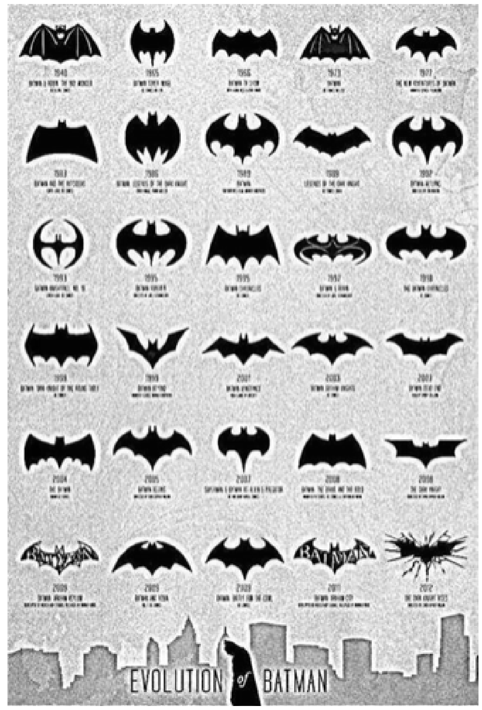



Fig 4. Sample Image Stimuli

### Video

Various youtube videos and vines are chosen for variety in length of time-duration and availability of rich meta-data in terms of likes, views, downvotes, retweets, favourites, etc. For short video stimulus type, vines of about 4-6 sec and for long video stimulus type, 1-3 min youtube videos were selected.

### Summary of Stimulus Information:

| Stimulus type | Stimulus SubType | Total |
| --- | --- | --- |
| Text | Long | 20 |
| Text | Short | 20 |
| Pic | - | 25 |

| | | |
|---|---|---|
| Vid | Long | 10 |
| Video | Short | 25 |

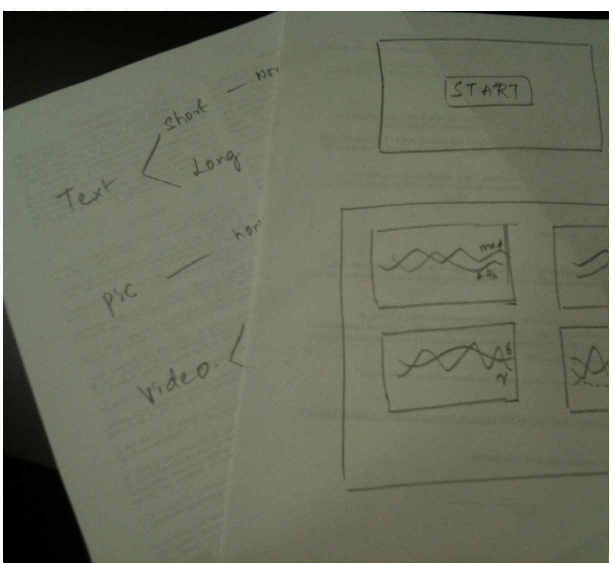
Appendix A shows the details of the stimuli metadata

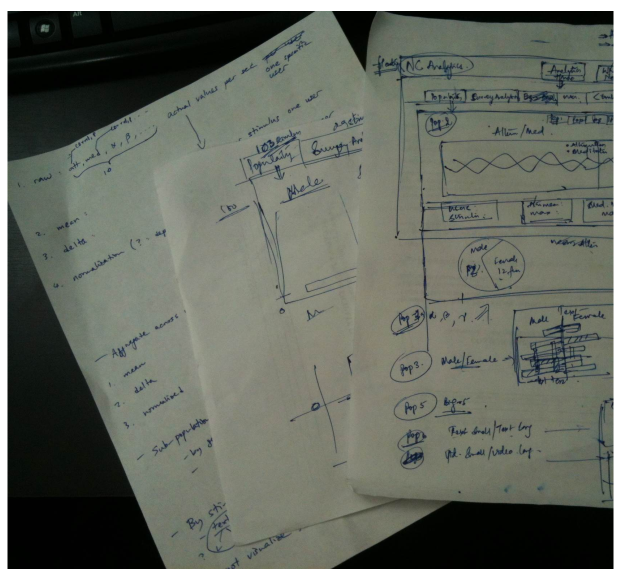
## 3.2. Data Collection

### 3.2.1. Initial Prototype

During the initial prototype, we combined Neuroview, a proprietary software of Neurosky Co. and Keynote presentation, to collect brainwave signals in response to the stimuli presented in the keynote.

We also configured appropriate transition times between various type of stimulus to help with easy control of brain wave signal analysis and to avoid overlap of brain wave signal response of one stimulus into the next stimulus.



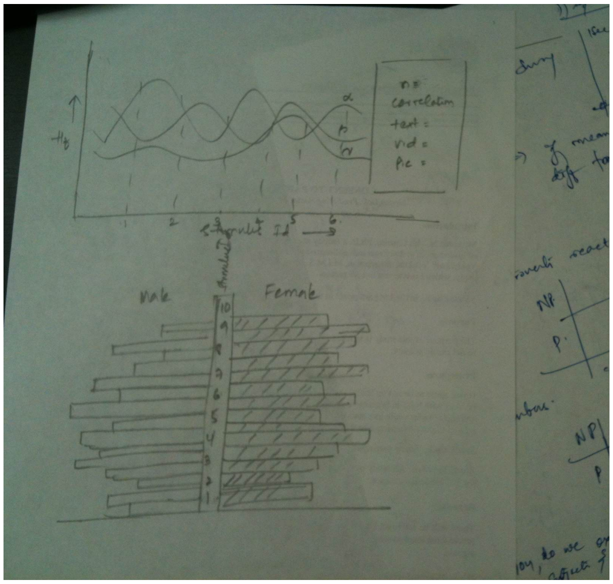




Fig. 7. Initial Prototype for dashboard

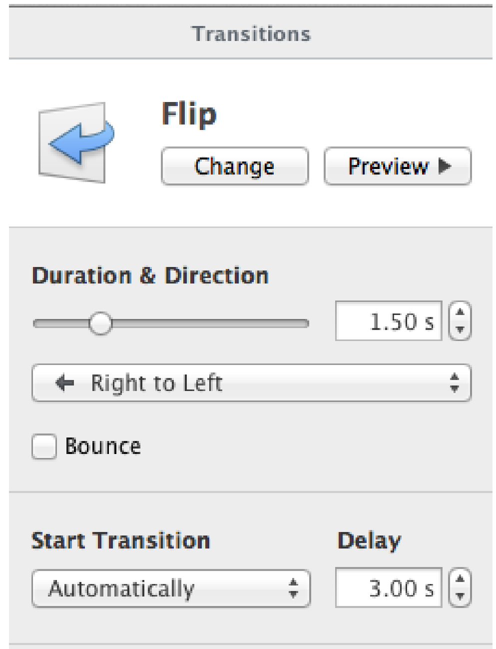




Fig. 8 Initial Prototype configuring time

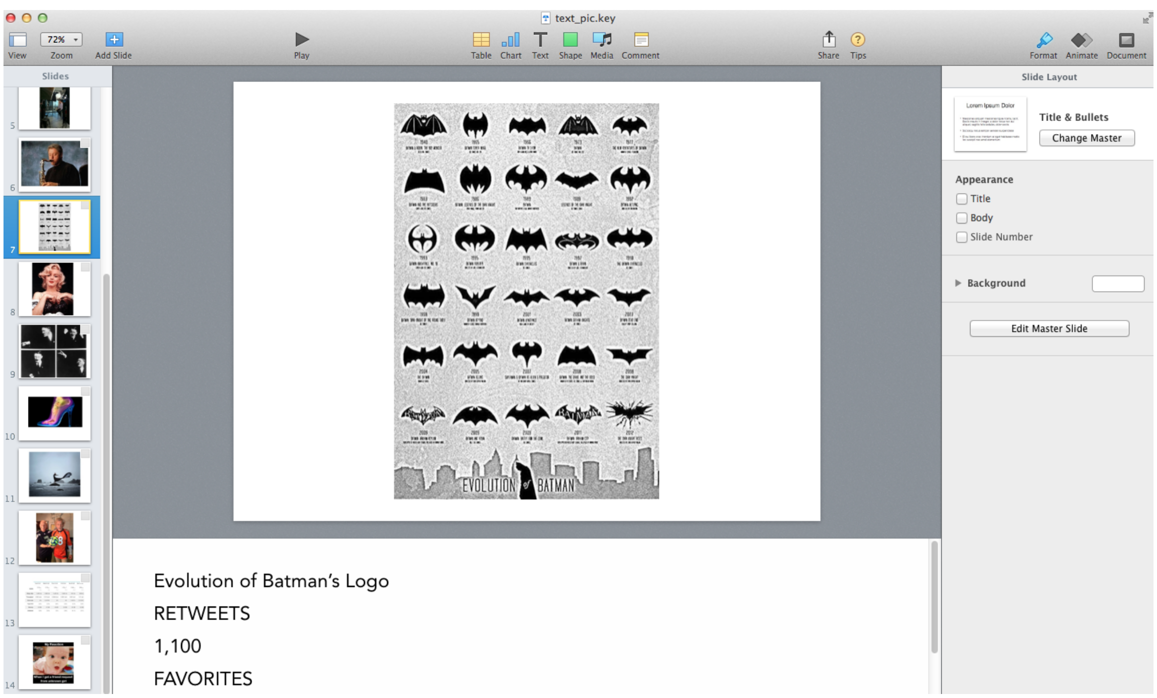




Fig. 9. Initial Prototype for experiment framework

Though we could collect stream of brain wave signals for the duration of the experiment, there was difficulty in the synchronization of both the applications and get exact time snapshots of the signals. Since the signal stream data is collected every sec, it caused errors during analysis.

### 3.2.2. Final Prototype

**System Architecture**

The system is designed to be a fully integrated seamless pipeline that can be configured to load the various stimuli for the experiment and configure the duration for which each stimulus has to be displayed, record the EEG signals during the experiment and save the data for processing later. The collected and stored is not associated to any user by any kind of personally identifiable information. Each user's data is saved with a system generated number.

There are two important points that we had to focus on with the implementation of the system. One is the component that would be visible to the end user, the subject of the experiment. This is really important because the whole process had to be automated so that the user can remain undisturbed during the course of the experiment. We created a system that is built using HTML, CSS3 and JavaScript that allows the person conducting the experiment to decide what stimuli needs to be inserted and then configure various settings such as the duration for which the stimulus should appear on screen, the time required for transition from one stimulus to the other etc.

The second important part of the system relates to monitoring of the brainwave signals as the experiment progressed. This is necessary in order to make sure that the device is well connected at all times and that the quality of signal was good. For this we integrated this system to a backend that interfaced with the neurosky headset via bluetooth and Socket IO and streamed brainwave signals such as alpha, beta, delta, theta and gamma waves at every second.

For the backend, the most important component was to interact with the hardware to collect the streaming data via bluetooth. The system was designed in such a way that we would be able to monitor the real time streaming data and also synchronize the time stamps for data analysis.

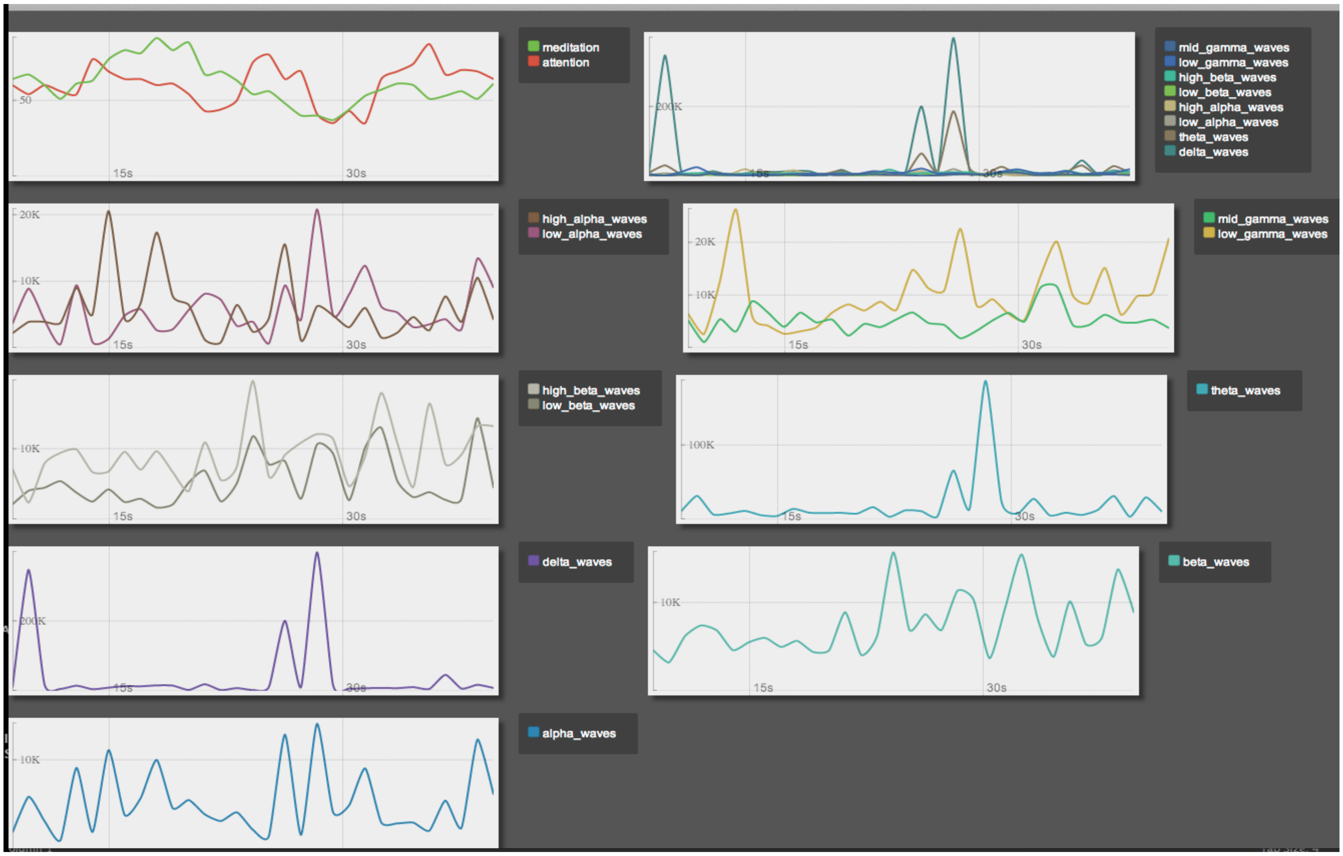



Fig 10. Real time monitor during the experiment.

This is done in two steps - first, to establish a connection with the bluetooth device (neurosky headset) and then streaming this data to the frontend at regular intervals so that this could be monitored in real time. The second, to include information about the signal quality, the raw spectrum, the amplitude at various frequency bands etc. All of this information along with timestamps are saved for the next step ie., processing of signals. Along with the timestamp at which each stimulus showed up on screen, we also collected transition times, raw spectrum and signal quality information as well, in order to identify the data specific to a particular stimulus.

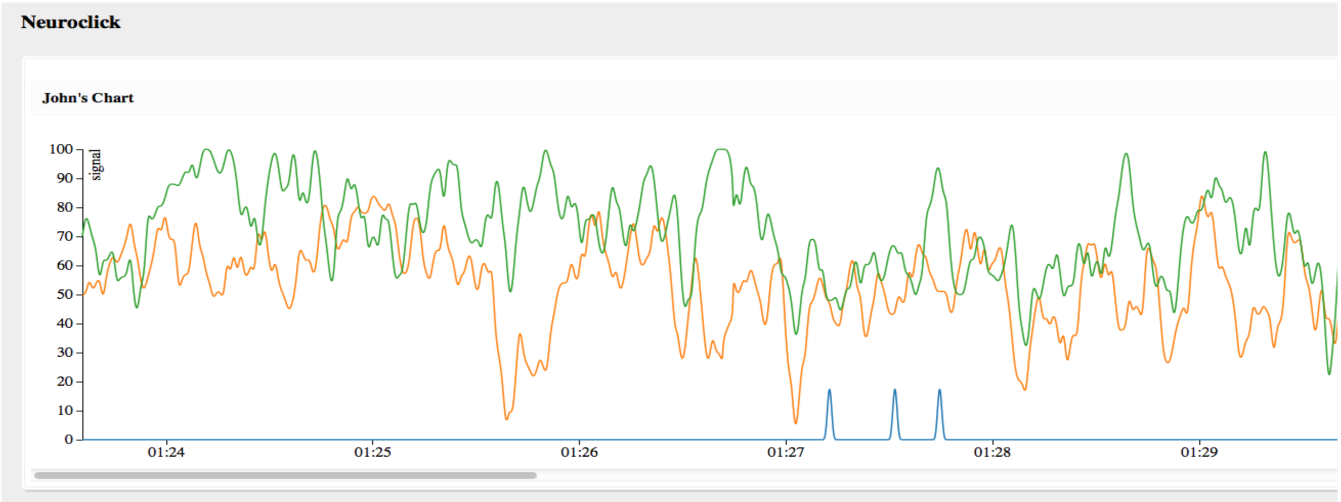



Fig. 11. Time series graph of user data after experiment for analysis

**Software Used**

Python, Flask

Light blue (Bluetooth library for python)

Gevent

Socket IO

HTML, CSS3, JavaScript, JQuery

Numpy, Scipy

HighCharts, D3.js

### 3.2.3. Procedure to collect the data

Each participant will first be briefed on the objective of the study and the procedure of the session. Then, the participant will be instructed to put on the commercially available headset with built-in non-invasive EEG sensors. The experimenter will help adjust the headset to ensure that it is worn properly. Then, the participant will be asked to watch a series of stimuli like text, pictures and videos taken from social media.  EEG data will be recorded in real-time on the researcher's computer while the stimuli are being presented to the participant. An anonymous questionnaire on the participant's evaluation of the level of involvement or enjoyment of the various stimuli will be taken. The metadata collected will include time and date of session, tasks performed, participant ID (not identifiable). No personally identifiable data will be collected.

Each of the project personnel will be responsible for conducting the study procedures. The procedures will take place at a quiet location on or near the UCB campus and at a time that is of mutual convenience to the participant and researcher. The session will last approximately 1 hour.

Fig. 12. Experimental study in progress

After the experiment is done, the participant will answer two surveys. SurveyA contains comparison of two pictures at a time and the participant is asked to choose which one caught his/her attention more. Survey B is a standard personality psychometric test, which we planned to see how  each personality characteristics correlate with his/her responses to the same stimulus. Appendix B contains sample Survey A questions, while Appendix C contains personality test Survey questions.

## 3.4. Data Processing

### 3.4.1. Data Cleaning

The data saved during the experiment could not be used directly for the analysis since there was a lot of noise associated with the raw data.So the second part of our system had to deal with this before we could perform any kind of analysis on the collected data. Since the data that was recorded included data during the transition of slides in addition to the actual data that was collected when the stimulus was being shown, we had to do some kind of slicing of the data to only include the relevant data for analysis.

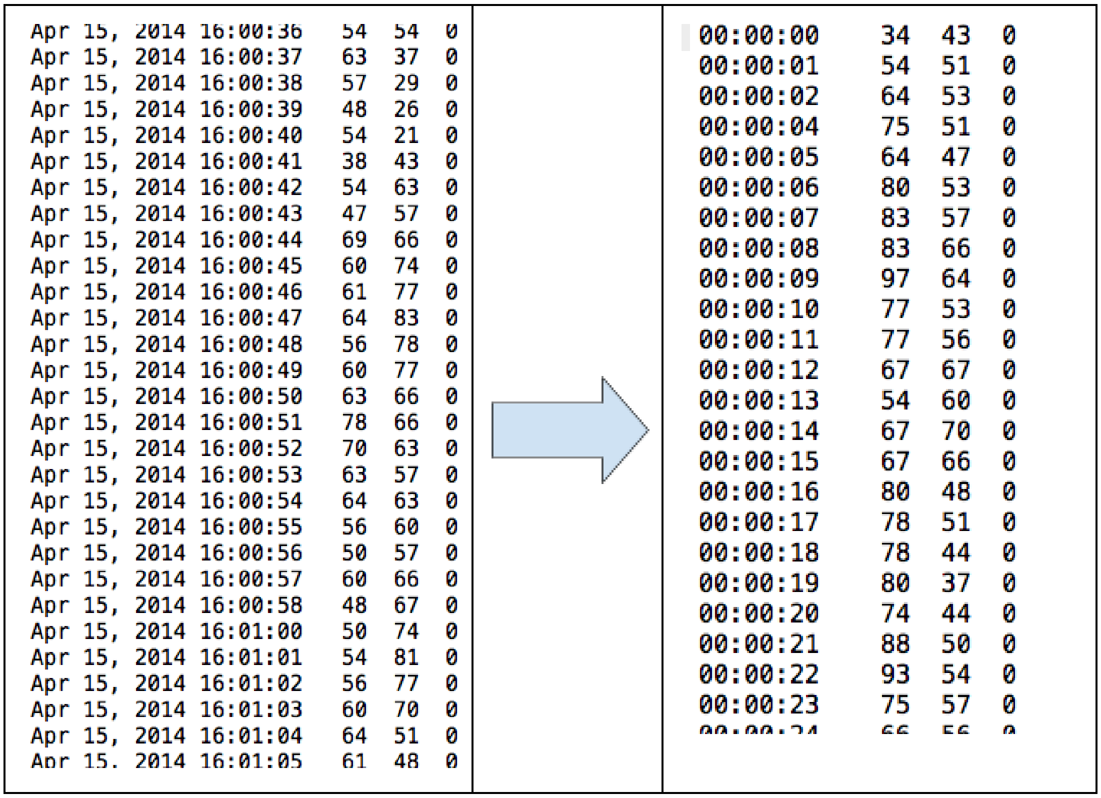
### 3.4.3. Data Formatting

**Time Synchronization**

Since all of the data that we had were recorded with different time stamps, the first step of data preprocessing that we had to do was to reorganize the data so that it would be possible to isolate the timestamps that were associated with a particular stimuli among all users. This was required so that we could use this information for all of our statistical analysis and models.

**MetaData Information**

Since most of our analysis was centered on using the meta data of the stimuli and the users, such as the gender of the user and the popularity of the stimulus, the category of the stimulus (short, long etc.) we had to build a data structure that would enable us to access all of this information with ease. This was especially important since we required to use this information quite frequently with each iteration of analysis.



| | | | |
|---|---|---|---|
| Apr 15, 2014 16:00:36 | 54 | 54 | 0 |
| Apr 15, 2014 16:00:37 | 63 | 37 | 0 |
| Apr 15, 2014 16:00:38 | 57 | 29 | 0 |
| Apr 15, 2014 16:00:39 | 48 | 26 | 0 |
| Apr 15, 2014 16:00:40 | 54 | 21 | 0 |
| Apr 15, 2014 16:00:41 | 38 | 43 | 0 |
| Apr 15, 2014 16:00:42 | 54 | 63 | 0 |
| Apr 15, 2014 16:00:43 | 47 | 57 | 0 |
| Apr 15, 2014 16:00:44 | 69 | 66 | 0 |
| Apr 15, 2014 16:00:45 | 60 | 74 | 0 |
| Apr 15, 2014 16:00:46 | 61 | 77 | 0 |
| Apr 15, 2014 16:00:47 | 64 | 83 | 0 |
| Apr 15, 2014 16:00:48 | 56 | 78 | 0 |
| Apr 15, 2014 16:00:49 | 60 | 77 | 0 |
| Apr 15, 2014 16:00:50 | 63 | 66 | 0 |
| Apr 15, 2014 16:00:51 | 78 | 66 | 0 |
| Apr 15, 2014 16:00:52 | 70 | 63 | 0 |
| Apr 15, 2014 16:00:53 | 63 | 57 | 0 |
| Apr 15, 2014 16:00:54 | 64 | 63 | 0 |
| Apr 15, 2014 16:00:55 | 56 | 60 | 0 |
| Apr 15, 2014 16:00:56 | 50 | 57 | 0 |
| Apr 15, 2014 16:00:57 | 60 | 66 | 0 |
| Apr 15, 2014 16:00:58 | 48 | 67 | 0 |
| Apr 15, 2014 16:01:00 | 50 | 74 | 0 |
| Apr 15, 2014 16:01:01 | 54 | 81 | 0 |
| Apr 15, 2014 16:01:02 | 56 | 77 | 0 |
| Apr 15, 2014 16:01:03 | 60 | 70 | 0 |
| Apr 15, 2014 16:01:04 | 64 | 51 | 0 |
| Apr 15, 2014 16:01:05 | 61 | 48 | 0 |

| | | | |
|---|---|---|---|
| 00:00:00 | 34 | 43 | 0 |
| 00:00:01 | 54 | 51 | 0 |
| 00:00:02 | 64 | 53 | 0 |
| 00:00:04 | 75 | 51 | 0 |
| 00:00:05 | 64 | 47 | 0 |
| 00:00:06 | 80 | 53 | 0 |
| 00:00:07 | 83 | 57 | 0 |
| 00:00:08 | 83 | 66 | 0 |
| 00:00:09 | 97 | 64 | 0 |
| 00:00:10 | 77 | 53 | 0 |
| 00:00:11 | 77 | 56 | 0 |
| 00:00:12 | 67 | 67 | 0 |
| 00:00:13 | 54 | 60 | 0 |
| 00:00:14 | 67 | 70 | 0 |
| 00:00:15 | 67 | 66 | 0 |
| 00:00:16 | 80 | 48 | 0 |
| 00:00:17 | 78 | 51 | 0 |
| 00:00:18 | 78 | 44 | 0 |
| 00:00:19 | 80 | 37 | 0 |
| 00:00:20 | 74 | 44 | 0 |
| 00:00:21 | 88 | 50 | 0 |
| 00:00:22 | 93 | 54 | 0 |
| 00:00:23 | 75 | 57 | 0 |

Fig. 13. Formatted data from raw data

## 3.5 Data Analysis

### 3.5.1. Frequency Data Analysis

We started with the most basic analysis - how different users responded to each of the stimulus that were presented to them. Apart from raw signal frequencies of various brainwave signals such a delta, theta, low alpha, high alpha, low beta, high beta,low gamma and mid gamma, Neurosky headset also provides attention and meditation values. These two are calculated by Neurosky using their proprietary algorithm. Initially, we chose these two metrics - attention and meditation to look at how the user's response was to various stimuli.

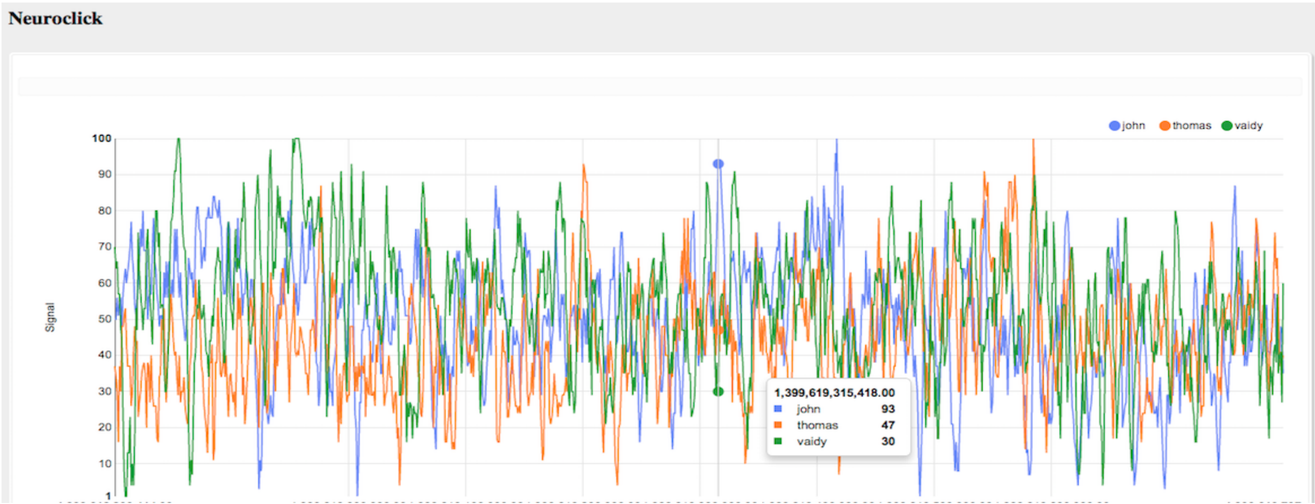



Fig. 14. Frequency data analysis

It was quite interesting to start the analysis this way and notice patterns in the responses.We noticed that the average attention of all users was relatively higher in the beginning and that there was a gradual decrease in the attention level with time.

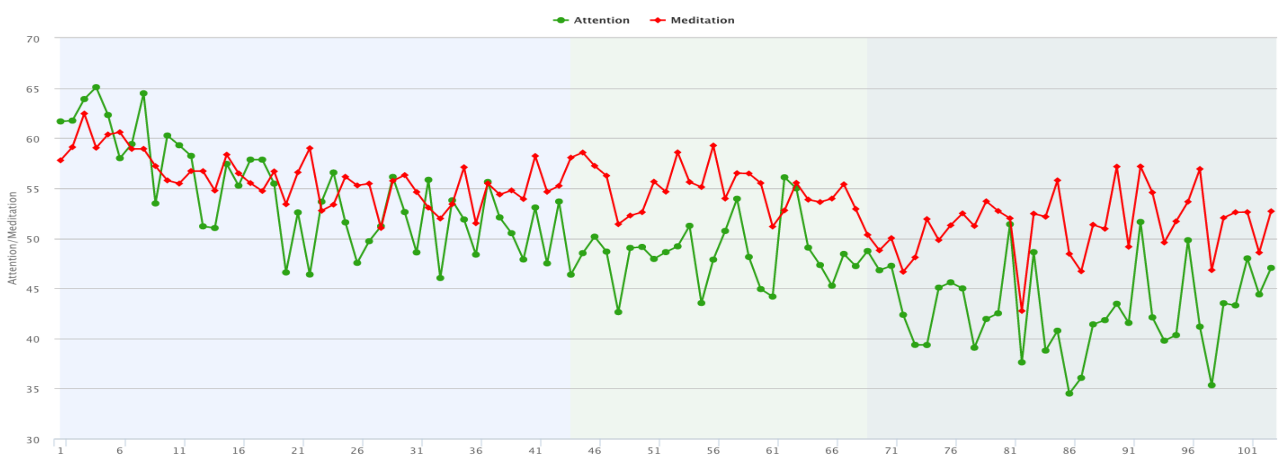



Fig. 15. Average Signal data analysis

### 3.5.2. Stimulus Type Analysis

We also analyzed the data to see if the effect remained the same even for specific portions of certain stimuli. We also analyzed how users reacted to certain stimuli that we hypothesized would evoke a strong response in the user. We found mild positive correlation between Alpha &

Beta signal data and popularity of the stimulus. See Appendix D for Average signal data correlations.

### 3.5.3. Time Slice/Blink Effect Analysis

Further, we also analyzed if there is any significant impact on the response in the first few seconds when a stimulus is presented to the user. For this, we computed values that reflect the user's reaction to specific time slices for each stimuli. We observed that the users stopped paying attention (relatively) to a stimulus as the experiment progressed. We could see a dip of almost 50%in the attention level of users from the beginning to the end of the experiment.

We also repeated this analysis through various iterations over different time slices and by looking at the longest sequences of spikes/decrease in activity for a particular sequence. This was with the hypothesis that all users have a similar response to a specific slice of a specific stimuli. Appendix E shows popularity correlations for Blink Effect data.

### 3.5.4. Survey Feedback Data Analysis

We also carried out the above analysis with the data that we collected from the post-experiment surveys that served as a ground truth for us in terms of assessing the interest of the user. With the initial analysis, we took the meta-data of the selected stimuli (popular/not popular) as the label for our statistical models. But towards the later stages of analysis, we looked at these results to determine if the stimuli is popular or not popular (specific to a user). Appendix F shows Average signal data correlations for Survey data.

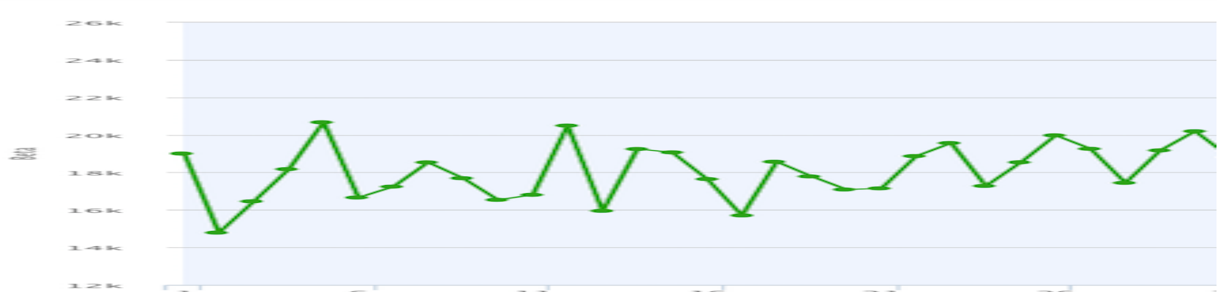



Fig 16. Beta Waves

### 3.5.5. Gender Analysis

We also ended up getting some really interesting insights on how the responses were different among the male and the female sections of the population. Our participants' sample has almost equal split in male and female population.

**Observations from Average Signal Data**

- attention level was higher among the female population than the male population for text , whereas it is vice-versa for videos.
- Average attention decreased for both male and female population. It could be either due to fatigue or inconvenience caused by the headset as the time progressed

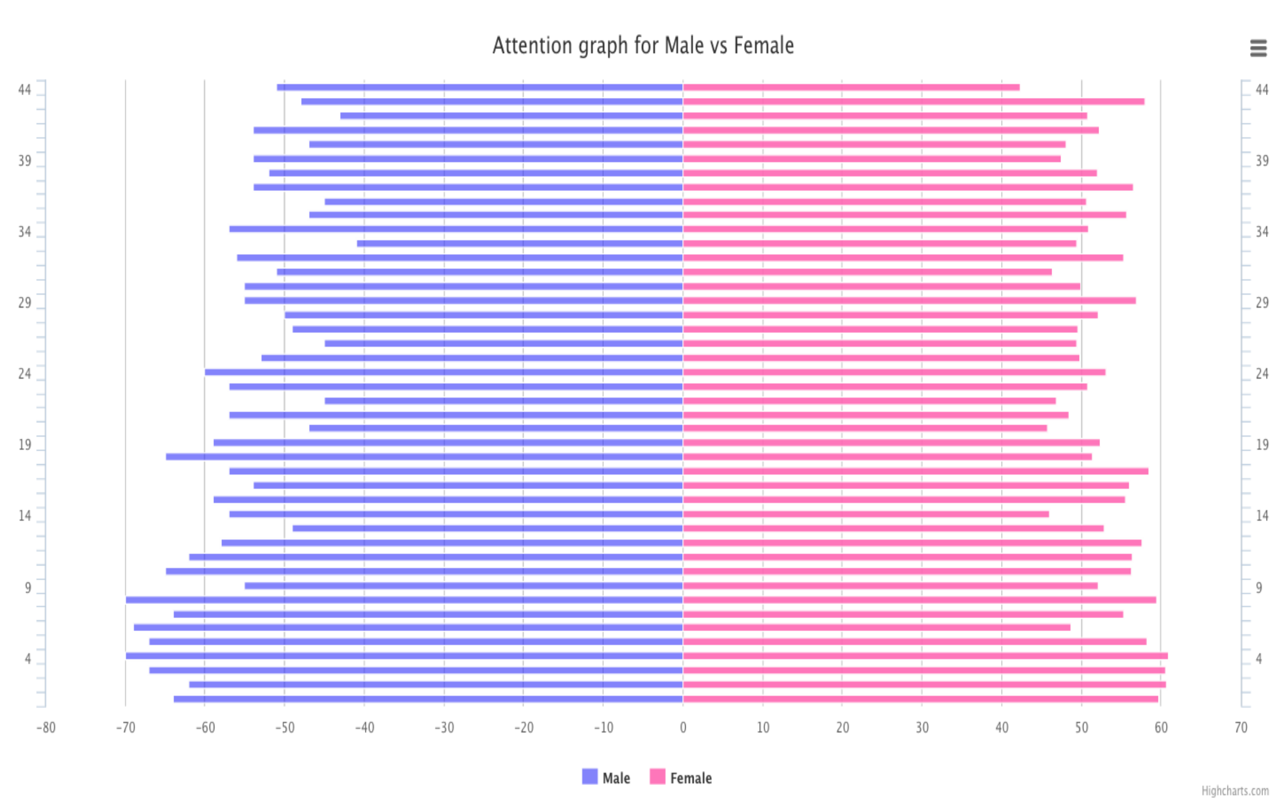



Fig. 16. Gender data analysis

**Observations from Time Slice/Blink Effect Data**

- attention level for the first few seconds in each stimulus was fairly higher among the male population than the female population, which was quite interesting.

-there was no visible difference in the attention levels between male and female population for videos.

- for most images, men and women and diametrically opposite responses in terms of attention.

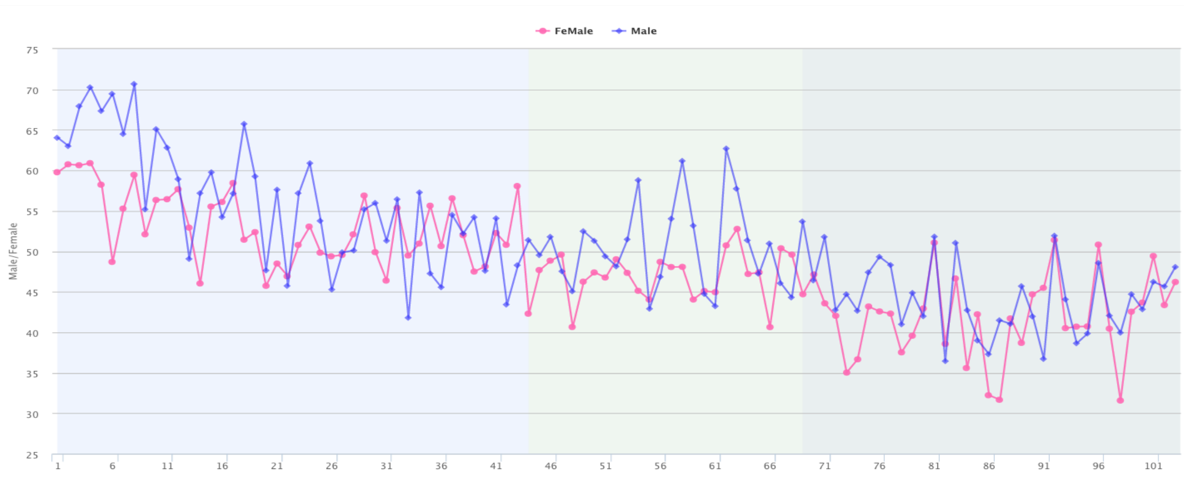



Fig. 17. Gender data analysis

### 3.5.6. Normalized Data Analysis

During our initial exploration, we observed that signal ranges differ from user to user. For instance, user A's max attention is 90 and minimum attention is 60, whereas for user B maximum attention is 70 and minimum attention is 30. Similar observations are found among alpha, beta, gamma waves as well. Therefore, we normalized the data for each user and calculated correlations with respect to popularity.

# 4. Conclusions

Being in the nascent stages of research, this technology has lots of avenues in terms of research. There were a lot of decisions that we had to make with respect to the experiment due to paucity of time, but as a full fledged research a lot of variations could be done with the experiments, both in terms of the stimuli that are chosen for the experiment as well as the variations with the experimental setup.

There were a few information that we had collected during the post-experiment survey that gives an indication of the behavior of the users in group settings and it would be interesting to look at the various kinds of analysis that we can run with that information - how does the brain wave response differ among introverts and extroverts, for instance.

In Conclusion, we find that attention is always required even to parse mundane stimulus. We need to capture “interest” which seems to be a tricky combination of one or more signal data. Though we observe positive correlations between signal data and popularity of the stimulus, we did not find statistical significance so as to draw any strong conclusions.

# Appendices

## Appendix A: Stimulus Metadata

| Tag | Meta | data-time | data-transperiod | url | Likes | views | Dislikes | Revines |
|---|---|---|---|---|---|---|---|---|
| vid1 | P | 7 | 2 | <iframe class="vine-embed" src="https://vine.co/v/htbr9vhq5HB/embed/simple?audio=1" width="600" height="600" frameborder="0"></iframe><script async src="//platform.vine.co/static/scripts/embed.js" charset="utf-8"></script> | 35.9k | | | 28.8k |
| vid2 | P | 70 | 2 | <iframe width="560" height="315" src="//www.youtube.com/embed/w4lnVx2BAYk&start=0&end=70" frameborder="0" allowfullscreen></iframe> | 50498 | 7611819 | 2100 | |
| vid3 | P | 56 | 2 | <iframe width="560" height="315" src="//www.youtube.com/embed/_OBlgSz8sSM" framebord | 1202489 | 677930244 | 185924 | |
| vid4 | NP | 8 | 2 | <iframe class="vine-embed" src="https://vine.co/v/MbMm9ltnTjF/embed/simple?audio=1" width="600" height="600" frameborder="0"></iframe><script async src="//platform.vine.co/static/scripts/embed.js" charset="utf-8"></script> | 0 | | | 0 |
| vid5 | NP | 7 | 2 | <iframe class="vine-embed" src="https://vine.co/v/hpeAW7W2MbJ/embed/simple?audio=1" width="600" height="600" frameborder="0"></iframe><script async src="//platform.vine.co/static/scripts/embed.js" charset="utf-8"></script> | 2 | | | 0 |
| vid6 | P | 6 | 2 | <iframe class="vine-embed" src="https://vine.co/v/MzqJb9Kei3E/embed/simple?audio=1" width="600" height="600" frameborder="0"></iframe><script async src="//platform.vine.co/static/scripts/embed.js" charset="utf-8"></script> | 22.9k | | | 25.1k |
| vid7 | NP | 111 | 2 | <iframe width="560" height="315" src="//www.youtube.com/embed/ilrJVpsa3k0" frameborder=' | 23 | 1897 | 18 | |
| vid8 | P | 6 | 2 | <iframe class="vine-embed" src="https://vine.co/v/MWd03dtgbBb/embed/simple?audio=1" width="600" height="600" frameborder="0"></iframe><script async src="//platform.vine.co/static/scripts/embed.js" charset="utf-8"></script> | 129.4 | | | 69.4k |
| vid9 | NP | 151 | 2 | <iframe width="420" height="315" src="//www.youtube.com/embed/HhEjpl6L6Qc" frameborder | 10 | 5419 | 1 | |
| vid10 | P | 6 | 2 | <iframe class="vine-embed" src="https://vine.co/v/hlUaFxUKqm6/embed/simple?audio=1" width="600" height="600" frameborder="0"></iframe><script async src="//platform.vine.co/static/scripts/embed.js" charset="utf-8"></script> | 35.8 | | | 41.1 |
| vid11 | NP | 6 | 2 | <iframe class="vine-embed" src="https://vine.co/v/MmPh0PTxjvz/embed/simple?audio=1" width="600" height="600" frameborder="0"></iframe><script async src="//platform.vine.co/static/scripts/embed.js" charset="utf-8"></script> | 143 | | | 102 |
| vid12 | P | 4 | 2 | <iframe class="vine-embed" src="https://vine.co/v/MzwlgwptbaZ/embed/simple?audio=1" width="600" height="600" frameborder="0"></iframe><script async src="//platform.vine.co/static/scripts/embed.js" charset="utf-8"></script> | 9635 | | | 8357 |
| vid13 | P | 103 | 2 | <iframe width="560" height="315" src="//www.youtube.com/embed/Hwt2Jt6mxpE" framebordе | 9 | | | |
| vid14 | P | 6 | 2 | <iframe class="vine-embed" src="https://vine.co/v/MAeD2DK6W9X/embed/simple?audio=1" width="600" height="600" frameborder="0"></iframe><script async src="//platform.vine.co/static/scripts/embed.js" charset="utf-8"></script> | 79.3k | | | 93.4k |
| vid15 | P | 68 | 2 | <iframe width="560" height="315" src="//www.youtube.com/embed/eN6c8aHBIbU" frameborder="0" allowfullscreen></iframe> | 1945 | 675896 | 363 | |
| | | | | <iframe class="vine-embed" src="https://vine.co/v/MmMXrrFZI20/embed/simple?audio=1" | | | | |

| Stimulus Id | Stimulus Time | P/NP | Stimulus Type | Stimulus SubType |
|---|---|---|---|---|
| 1 | 25 | 1 | text0 | Long |
| 2 | 7 | 1 | baseline1 | baseline |
| 3 | 21 | 1 | text1 | Long |
| 4 | 27 | 1 | text2 | Long |
| 5 | 37 | -1 | text3 | Long |
| 6 | 26 | 1 | text4 | Long |
| 7 | 11 | -1 | text5 | Short |
| 8 | 40 | -1 | text6 | Long |
| 9 | 9 | -1 | text7 | Short |
| 10 | 13 | -1 | text8 | Long |

| | | | | |
|---|---|---|---|---|
| 11 | 27 | -1 | text9 | Long |
| 12 | 52 | -1 | text10 | Long |
| 13 | 4 | 1 | text11 | Short |
| 14 | 9 | -1 | text12 | Short |
| 15 | 22 | 1 | text13 | Long |
| 16 | 13 | -1 | text14 | Long |
| 17 | 15 | -1 | text15 | Long |
| 18 | 6 | -1 | text16 | Short |
| 19 | 9 | -1 | text17 | Short |
| 20 | 7 | 1 | text18 | Short |
| 21 | 6 | 1 | text19 | Short |
| 22 | 10 | -1 | text20 | Short |
| 23 | 7 | 1 | baseline2 | baseline |
| 24 | 36 | 1 | text21 | Long |
| 25 | 5 | 1 | text22 | Short |
| 26 | 6 | -1 | text23 | Short |
| 27 | 4 | 1 | text24 | Short |
| 28 | 15 | 1 | text25 | Long |
| 29 | 21 | 1 | text26 | Long |
| 30 | 6 | 1 | text27 | Short |
| 31 | 6 | 1 | text28 | Short |
| 32 | 11 | 1 | text29 | Short |
| 33 | 6 | -1 | text30 | Short |
| 34 | 13 | 1 | text31 | Long |
| 35 | 35 | -1 | text32 | Long |
| 36 | 6 | -1 | text33 | Short |
| 37 | 45 | 1 | text34 | Long |
| 38 | 17 | -1 | text35 | Long |
| 39 | 6 | 1 | text36 | Short |
| 40 | 6 | -1 | text37 | Short |
| 41 | 18 | 1 | text38 | Long |
| 42 | 6 | 1 | text39 | Short |
| 43 | 21 | -1 | text40 | Long |
| 44 | 3 | -1 | pic1 | pic |
| 45 | 3 | 1 | pic2 | pic |
| 46 | 3 | 1 | pic3 | pic |
| 47 | 3 | 1 | pic4 | pic |

| | | | | |
|---|---|---|---|---|
| 48 | 3 | -1 | pic5 | pic |
| 49 | 3 | 1 | pic6 | pic |
| 50 | 3 | -1 | pic7 | pic |
| 51 | 3 | 1 | pic8 | pic |
| 52 | 3 | -1 | pic9 | pic |
| 53 | 3 | 1 | pic10 | pic |
| 54 | 3 | -1 | pic11 | pic |
| 55 | 3 | -1 | pic12 | pic |
| 56 | 3 | 1 | pic13 | pic |
| 57 | 3 | -1 | pic14 | pic |
| 58 | 3 | -1 | pic15 | pic |
| 59 | 3 | 1 | pic16 | pic |
| 60 | 3 | -1 | pic17 | pic |
| 61 | 3 | 1 | pic18 | pic |
| 62 | 3 | -1 | pic19 | pic |
| 63 | 3 | 1 | pic20 | pic |
| 64 | 3 | -1 | pic21 | pic |
| 65 | 3 | 1 | pic22 | pic |
| 66 | 3 | -1 | pic23 | pic |
| 67 | 3 | 1 | pic24 | pic |
| 68 | 3 | 1 | pic25 | pic |
| 69 | 7 | 1 | vid1 | Short |
| 70 | 70 | 1 | vid2 | Long |
| 71 | 56 | 1 | vid3 | Long |
| 72 | 8 | -1 | vid4 | Short |
| 73 | 7 | -1 | vid5 | Short |
| 74 | 6 | 1 | vid6 | Short |
| 75 | 111 | -1 | vid7 | Long |
| 76 | 6 | 1 | vid8 | Short |
| 77 | 151 | -1 | vid9 | Long |
| 78 | 6 | 1 | vid10 | Short |
| 79 | 6 | -1 | vid11 | Short |
| 80 | 4 | 1 | vid12 | Short |
| 81 | 103 | 1 | vid13 | Long |
| 82 | 6 | 1 | vid14 | Short |
| 83 | 68 | 1 | vid15 | Long |
| 84 | 6 | 1 | vid16 | Short |

| | | | | |
|---|---|---|---|---|
| **85** | **5** | **1** | **vid17** | **Short** |
| **86** | **6** | **1** | **vid18** | **Short** |
| **87** | **6** | **-1** | **vid19** | **Short** |
| **88** | **85** | **-1** | **vid20** | **Long** |
| **89** | **4** | **1** | **vid21** | **Short** |
| **90** | **6** | **1** | **vid22** | **Short** |
| **91** | **6** | **-1** | **vid23** | **Short** |
| **92** | **51** | **1** | **vid24** | **Long** |
| **93** | **7** | **-1** | **vid25** | **Short** |
| **94** | **6** | **-1** | **vid26** | **Short** |
| **95** | **6** | **-1** | **vid27** | **Short** |
| **96** | **104** | **-1** | **vid28** | **Long** |
| **97** | **7** | **1** | **vid29** | **Short** |
| **98** | **7** | **-1** | **vid30** | **Short** |
| **99** | **7** | **1** | **vid31** | **Short** |
| **100** | **6** | **1** | **vid32** | **Short** |
| **101** | **6** | **-1** | **vid33** | **Short** |
| **102** | **7** | **1** | **vid34** | **Short** |
| **103** | **59** | **1** | **vid35** | **Long** |

# Appendix B: Sample Survey A Questions

| Q.No | Image1 | Image2 |
|---|---|---|
| Q1 | pic4 | pic1 |
| Q2 | pic2 | pic9 |
| Q3 | pic25 | pic7 |
| Q4 | pic15 | pic10 |
| Q5 | pic23 | pic22 |
| Q6 | pic8 | pic19 |
| Q7 | pic24 | pic17 |
| Q8 | pic11 | pic20 |
| Q9 | pic5 | pic3 |
| Q10 | pic12 | pic16 |

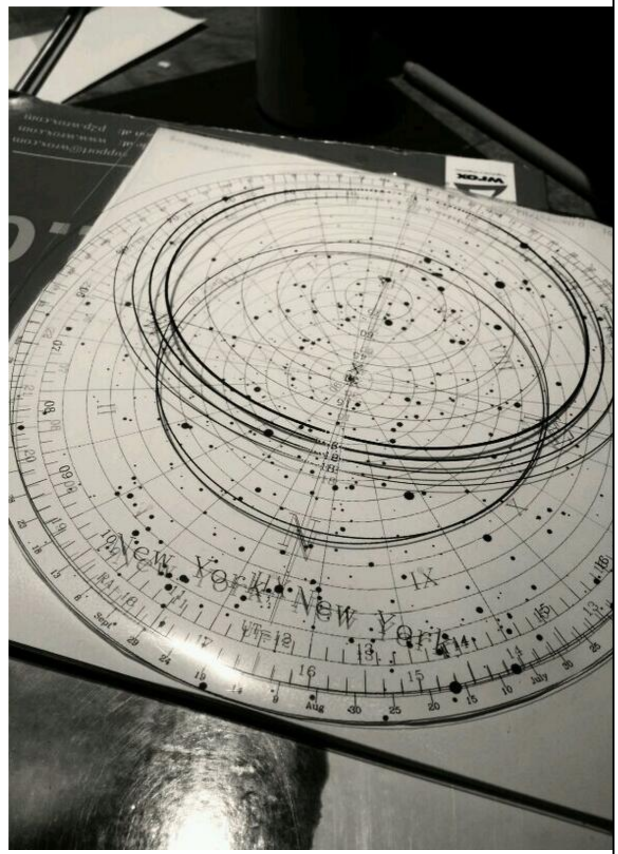
**Gender*** Required

- **F**
- **M**

**Please take a few minutes to fill this survey. This would help us with getting to know your preferences about some of the images and videos that you watched during the experiment.**

**Which of the two pictures caught your attention?*** Required

- **pic1**
- **pic2**
- **Both**
- **I dont remember seeing these images**

| | |
|---|---|
|  |  |





**Which of the two pictures caught your attention?*** Required

- **pic1**
- **pic2**
- **Both**
- **I dont remember seeing these images**

| | |
|---|---|
|  |  |

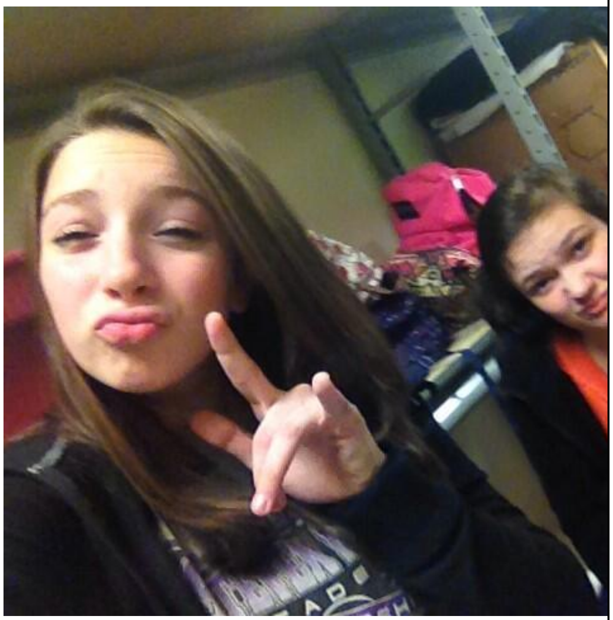
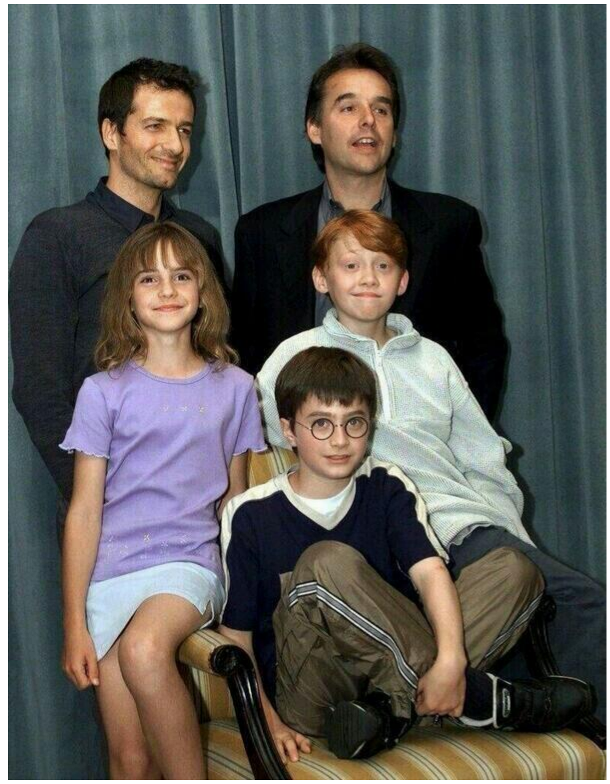
**Which of the two pictures caught your attention?*** Required

- **pic1**
- **pic2**
- **Both**
- **I dont remember seeing these images**

| | |
|---|---|
|  |  |

**Which of the two pictures caught your attention?*** Required

- **pic1**
- **pic2**
- **Both**
- **I dont remember seeing these images**

**Rate these videos from a scale of 1(Lowest) to 5(Highest) based on how much detail you remember each of these. Please choose NA if you do not remember watching the video*Required**

| | 1 | 2 | 3 | 4 | 5 | NA |
|---|---|---|---|---|---|---|
| **Arnold Crushing objects with a tank** | | | | | | |
| **Psychology experiment for persuasion** | | | | | | |
| **Horticulture video of a guy explaining how to divide iris** | | | | | | |

# Appendix C: SurveyB Questions

**Enter User ID***

**In the table below, for each statement 1-50 mark how much you agree with on the scale 1-5, where 1=disagree, 2=slightly disagree, 3=neutral, 4=slightly agree and 5=agree**

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **1. Am the life of the party.** | | | | | |
| **2. Feel little concern for others.** | | | | | |
| **3. Am always prepared.** | | | | | |
| **4. Get stressed out easily.** | | | | | |
| **5. Have a rich vocabulary.** | | | | | |
| **6. Don't talk a lot.** | | | | | |
| **7. Am interested in people.** | | | | | |
| **8. Leave my belongings around.** | | | | | |
| **9. Am relaxed most of the time.** | | | | | |
| **10. Have difficulty understanding abstract ideas.** | | | | | |

**Continue to next page**

**In the table below, for each statement 1-50 mark how much you agree with on the scale 1-5, where 1=disagree, 2=slightly disagree, 3=neutral, 4=slightly agree and 5=agree**

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **11. Feel comfortable around people.** | | | | | |
| **12. Insult people.** | | | | | |
| **13. Pay attention to details.** | | | | | |
| **14. Worry about things.** | | | | | |
| **15. Have a vivid imagination.** | | | | | |
| **16. Keep in the background.** | | | | | |
| **17. Sympathize with others' feelings.** | | | | | |
| **18. Make a mess of things.** | | | | | |
| **19. Seldom feel blue.** | | | | | |
| **20. Am not interested in abstract ideas.** | | | | | |

**Continue to next page**

**In the table below, for each statement 1-50 mark how much you agree with on the scale 1-5, where 1=disagree, 2=slightly disagree, 3=neutral, 4=slightly agree and 5=agree**

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **21. Start conversations.** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **22. Am not interested in other people's problems.** | | | | | |
| **23. Get chores done right away.** | | | | | |
| **24. Am easily disturbed.** | | | | | |
| **25. Have excellent ideas.** | | | | | |
| **26. Have little to say.** | | | | | |
| **27. Have a soft heart.** | | | | | |
| **28. Often forget to put things back in their proper place.** | | | | | |
| **29. Get upset easily.** | | | | | |
| **30. Do not have a good imagination.** | | | | | |

**Continue to next page**

**In the table below, for each statement 1-50 mark how much you agree with on the scale 1-5, where 1=disagree, 2=slightly disagree, 3=neutral, 4=slightly agree and 5=agree**

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **31. Talk to a lot of different people at parties.** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 32. Am not really interested in others. | | | | | |
| 33. Like order. | | | | | |
| 34. Change my mood a lot. | | | | | |
| 35. Am quick to understand things. | | | | | |
| 36. Don't like to draw attention to myself. | | | | | |
| 37. Take time out for others. | | | | | |
| 38. Shirk my duties. | | | | | |
| 39. Have frequent mood swings. | | | | | |
| 40. Use difficult words. | | | | | |

**Continue to next page**

**In the table below, for each statement 1-50 mark how much you agree with on the scale 1-5, where 1=disagree, 2=slightly disagree, 3=neutral, 4=slightly agree and 5=agree**

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 41. Don't mind being the center of attention. | | | | | |
| 42. Feel others' emotions. | | | | | |

| | |
|---|---|
| **43. Follow a schedule.** | |
| **44. Get irritated easily.** | |
| **45. Spend time reflecting on things.** | |
| **46. Am quiet around strangers.** | |
| **47. Make people feel at ease.** | |
| **48. Am exacting in my work.** | |
| **49. Often feel blue.** | |
| **50. Am full of ideas.** | |

## Appendix D: Average Signal Data Correlations

AVERAGES DATA for =============================================== attn
Stimulus type: VID_LONG Corr: 0.103716118887 p_val: 0.077841116637

Stimulus type: TEX_SHORT Corr: -0.0460241270992 p_val: 0.29391891168

Stimulus type: PIC_PIC Corr: -0.018929734523 p_val: 0.610846988962

Stimulus type: TEX_LONG Corr: -0.000152368166058 p_val: 0.996866131702

Stimulus type: VID_SHORT Corr: 0.0144309255818 p_val: 0.69807946167

No. of feature values=== 103
(-0.04033800059621654, 0.68580502156522383)

****************************
AVERAGES DATA for =============================================== med
Stimulus type: VID_LONG Corr: -0.00785692623255 p_val: 0.894017161367

Stimulus type: TEX_SHORT Corr: 0.0136083409136 p_val: 0.756421701716

Stimulus type: PIC_PIC Corr: 0.0210002827738 p_val: 0.572389075336

Stimulus type: TEX_LONG Corr: 0.0232551127921 p_val: 0.548806790752

Stimulus type: VID_SHORT Corr: 0.0608684000343 p_val: 0.101500468639

No. of feature values=== 103
(0.082026311556203754, 0.41010678728818795)
****************************

AVERAGES DATA for =============================================== delta
Stimulus type: VID_LONG Corr: 0.00762687364842p_val: 0.897102932518

Stimulus type: BAS_BASELINE Corr: nan p_val: 1.0

Stimulus type: TEX_SHORT Corr: -0.0291531606272 p_val: 0.506296079371

Stimulus type: PIC_PIC Corr: 0.0130516354235 p_val: 0.725712442654

Stimulus type: TEX_LONG Corr: 0.00461319238295p_val: 0.905339489102

Stimulus type: VID_SHORT Corr: -0.0240702527441 p_val: 0.517575753357

No. of feature values=== 103
(0.008095535630290562, 0.9353152464033947)
****************************
BLINK DATA for ============================================= theta
Stimulus type: VID_LONG Corr: 0.0245277969927 p_val: 0.677445173927

Stimulus type: TEX_SHORT Corr: -0.00854381414479 p_val: 0.845597397955

Stimulus type: PIC_PIC Corr: 0.010677356992 p_val: 0.774105628572

Stimulus type: TEX_LONG Corr: -0.0110484170276 p_val: 0.775786879412

Stimulus type: VID_SHORT Corr: 0.00858610590592p_val: 0.817475375369

No. of feature values=== 103
(0.045694794922040295, 0.64671442291433889)

****************************
BLINK DATA forr ============================================= low_alpha
Stimulus type: VID_LONG Corr: 0.0292603979472 p_val: 0.619724503647

Stimulus type: TEX_SHORT Corr: 0.00407987009607p_val: 0.925910693964

Stimulus type: PIC_PIC Corr: 0.0609326255057 p_val: 0.101139629078

Stimulus type: TEX_LONG Corr: 0.011698780836 p_val: 0.762971999699

Stimulus type: VID_SHORT Corr: 0.0192681277715 p_val: 0.604484020164

No. of feature values=== 103
(0.15607844790475608, 0.11540510010287176)
****************************

BLINK DATA for============================================= high_alpha
Stimulus type: VID_LONG Corr: 0.019622082878 p_val: 0.739329876675

Stimulus type: TEX_SHORT Corr: 0.0239092364089 p_val: 0.585732655105

Stimulus type: PIC_PIC Corr: 0.0265259056506 p_val: 0.475768448687

Stimulus type: TEX_LONG Corr: 0.00449559654832p_val: 0.907741600198

Stimulus type: VID_SHORT Corr: 0.0281566759662 p_val: 0.449059682284

No. of feature values=== 103

(0.12119177630893202, 0.22267267732884227)
****************************

BLINK DATA for============================================= low_beta
Stimulus type: VID_LONG Corr: 0.0643411098758 p_val: 0.274793821612

Stimulus type: TEX_SHORT Corr: 0.00892498204734p_val: 0.838801194294

Stimulus type: PIC_PIC Corr: 0.0249775231761 p_val: 0.501911814162

Stimulus type: TEX_LONG Corr: 0.0123430883472 p_val: 0.750340034438

Stimulus type: VID_SHORT Corr: -0.00769111269742 p_val: 0.836216610692

No. of feature values=== 103
(0.06590514124125732, 0.50834248972767937)
****************************

AVERAGES DATA for ===========================high_beta
Stimulus type: VID_LONG Corr: 0.0276338720628 p_val: 0.639323430741

Stimulus type: TEX_SHORT Corr: -0.0226551922627 p_val: 0.60555003805

Stimulus type: PIC_PIC Corr: 0.0277764913152 p_val: 0.455209357328

Stimulus type: TEX_LONG Corr: -0.00635505729871 p_val: 0.869871513703

Stimulus type: VID_SHORT Corr: 0.0262499682731 p_val: 0.480372207234

No. of feature values=== 103
(0.061014551658822525, 0.5403765542295953)
****************************

AVERAGES DATA for ===========================low_gamma
Stimulus type: VID_LONG Corr: 0.113301584573 p_val: 0.0539380410466

Stimulus type: TEX_SHORT Corr: -0.00896892414188 p_val: 0.838018469057

Stimulus type: PIC_PIC Corr: 0.0166454515187 p_val: 0.65455008102

Stimulus type: TEX_LONG Corr: 0.0179725973296 p_val: 0.643125507827

Stimulus type: VID_SHORT Corr: -0.0160650995075 p_val: 0.665852242613

No. of feature values=== 103

(0.065412100336874168, 0.51152691387053983)
****************************

AVERAGES DATA for ================================================ mid_gamma
Stimulus type: VID_LONG Corr: 0.170090280091 p_val: 0.0036699273659

Stimulus type: TEX_SHORT Corr: 0.0272550906611 p_val: 0.534383577665

Stimulus type: PIC_PIC Corr: 0.038867924334 p_val: 0.295958266029

Stimulus type: TEX_LONG Corr: 0.000686850352527 p_val: 0.985873743042

Stimulus type: VID_SHORT Corr: -0.00140102859238 p_val: 0.969959745407

No. of feature values=== 103
(0.1582015489079665, 0.11047897608159028)
****************************

## Appendix E: Blink Effect Data Correlations

For all the stimulus:
START_TIME =1
END_TIME =5

BLINK DATA for ============================================== attn
Number of Values= 290
Stimulus type: VID_LONG Corr: -0.0311561879047 p_val: 0.597216481902

Number of Values= 522
Stimulus type: TEX_SHORT Corr: -0.00937671550535 p_val: 0.830762344252

Number of Values= 725
Stimulus type: PIC_PIC Corr: -0.00101318397682 p_val: 0.97827329929

Number of Values= 667
Stimulus type: TEX_LONG Corr: -0.0220753852595 p_val: 0.569270326345

Number of Values= 725
Stimulus type: VID_SHORT Corr: 0.0327382458837 p_val: 0.378740595909

No. of feature values=== 103
(-0.043316127573833914, 0.66396199770464281)
****************************

BLINK DATA for ============================================== med
Number of Values= 290
Stimulus type: VID_LONG Corr: -0.013175094619 p_val: 0.823220729424

Number of Values= 522
Stimulus type: TEX_SHORT Corr: 0.011679756969 p_val: 0.790069394712

Number of Values= 725
Stimulus type: PIC_PIC Corr: 0.016307181787 p_val: 0.661128373215

Number of Values= 667
Stimulus type: TEX_LONG Corr: 0.0295527363377 p_val: 0.446075552048

Number of Values= 725
Stimulus type: VID_SHORT Corr: 0.0631853704951 p_val: 0.0891155863692

No. of feature values=== 103
(0.07794964532702868, 0.4338388042191148)

****************************

AVERAGES DATA for ============================================== delta
Stimulus type: VID_LONG Corr: -0.0371449892164 p_val: 0.528667179295

Stimulus type: TEX_SHORT Corr: -0.0608921295593 p_val: 0.164779208158

Stimulus type: PIC_PIC Corr: 0.0172107798553 p_val: 0.643615928152

Stimulus type: TEX_LONG Corr: 0.0242848528314 p_val: 0.531246154626

Stimulus type: VID_SHORT Corr: -0.0415832874608 p_val: 0.263474757429

No. of feature values=== 103
(-0.009352786625878115, 0.92529660821843107)

****************************
AVERAGES DATA for ============================================== theta
Stimulus type: VID_LONG Corr: -0.0142266215794 p_val: 0.809371824519

Stimulus type: TEX_SHORT Corr: -0.0305886588559 p_val: 0.485579613162

Stimulus type: PIC_PIC Corr: 0.0181214252846 p_val: 0.626164525059

Stimulus type: TEX_LONG Corr: -0.0321445947823 p_val: 0.407198129992

Stimulus type: VID_SHORT Corr: -0.0118921129703 p_val: 0.749223258247

No. of feature values=== 103
(-0.013338754405278397, 0.89361815506162534)
****************************

AVERAGES DATA for ============================================== low_alpha
Stimulus type: VID_LONG Corr: -0.00809206520098 p_val: 0.890864813362

Stimulus type: TEX_SHORT Corr: -0.0241432972869 p_val: 0.582067342889

Stimulus type: PIC_PIC Corr: 0.0508965305525 p_val: 0.17101375945

Stimulus type: TEX_LONG Corr: 0.0187999748226 p_val: 0.627912771971

Stimulus type: VID_SHORT Corr: -0.00317645370194 p_val: 0.931958284309

No. of feature values=== 103
(0.078225936932565715, 0.43220610464656561)
****************************

AVERAGES DATA for ============================================== high_alpha
Stimulus type: VID_LONG Corr: 0.0164775549276 p_val: 0.779930411794

Stimulus type: TEX_SHORT Corr: 0.0064087574446 p_val: 0.883863435959

Stimulus type: PIC_PIC Corr: 0.00932928009476p_val: 0.801991499075

Stimulus type: TEX_LONG Corr: -0.00564581652192 p_val: 0.884285752159

Stimulus type: VID_SHORT Corr: 0.0236948849119 p_val: 0.524129497599

No. of feature values=== 103
(0.069862053935277682, 0.48316148813817827)
****************************

AVERAGES DATA for ============================================== low_beta
Stimulus type: VID_LONG Corr: 0.0429536601817 p_val: 0.466214765623

Stimulus type: TEX_SHORT Corr: 0.00313049687266p_val: 0.943117471506

Stimulus type: PIC_PIC Corr: 0.00332536581667p_val: 0.928776768027

Stimulus type: TEX_LONG Corr: -0.00190792918709 p_val: 0.960773893413

Stimulus type: VID_SHORT Corr: -0.0038451350437 p_val: 0.91768109548

No. of feature values=== 103
(0.03314300794004308, 0.73962419554647396)
****************************

AVERAGES DATA for ============================================== high_beta
Stimulus type: VID_LONG Corr: 0.0118014596358 p_val: 0.841394079513

Stimulus type: TEX_SHORT Corr: -0.0248397087649 p_val: 0.571225457406

Stimulus type: PIC_PIC Corr: 0.0268740335802 p_val: 0.469994867519

Stimulus type: TEX_LONG Corr: -0.00513308222565 p_val: 0.894730431057

Stimulus type: VID_SHORT Corr: 0.0427089845125 p_val: 0.250756275773

No. of feature values=== 103
(0.084499374047810757, 0.39608827186362927)
****************************

AVERAGES DATA for =============================================== low_gamma
Stimulus type: VID_LONG Corr: -0.00833625560139 p_val: 0.887592935057

Stimulus type: TEX_SHORT Corr: 0.0156424565234 p_val: 0.721426276637

Stimulus type: PIC_PIC Corr: 0.020114932987 p_val: 0.588692800359

Stimulus type: TEX_LONG Corr: 0.000675058480033 p_val: 0.986116238512

Stimulus type: VID_SHORT Corr: -0.00753595683265 p_val: 0.83947536295

No. of feature values=== 103
(0.042667464380236823, 0.66869649417614085)
*****************************

AVERAGES DATA for =============================================== mid_gamma
Stimulus type: VID_LONG Corr: 0.014624155371 p_val: 0.804151375096

Stimulus type: TEX_SHORT Corr: 0.0268414057088 p_val: 0.540607707543

Stimulus type: PIC_PIC Corr: 0.0376023376281 p_val: 0.311975994958

Stimulus type: TEX_LONG Corr: -0.00952740640472 p_val: 0.805990251955

Stimulus type: VID_SHORT Corr: 0.00743015176779p_val: 0.84169917554

No. of feature values=== 103
(0.090569379963017421, 0.36291076790548293)
*****************************

## Appendix F: Average Signal data vs Survey responses correlations

AVERAGES STIMULUS DATA for
================================================ attn
/System/Library/Frameworks/Python.framework/Versions/2.7/Extras/lib/python/scipy/stats/stats.py:2273: RuntimeWarning: invalid value encountered in double_scalars
  r = (r_num / r_den)
Combined correlation of all 29 users and all 29 survey stimuli========attn

Stimulus type: VID_LONG Corr: -0.0919113000543 p_val: 0.326457894604

Stimulus type: PIC_PIC Corr: 0.0716296230827 p_val: 0.0847868172133

Stimulus type: VID_SHORT Corr: 0.0427330374628 p_val: 0.609803852792

AVERAGES STIMULUS DATA for
================================================ med
Combined correlation of all 29 users and all 29 survey stimuli========med

Stimulus type: VID_LONG Corr: 0.0848279461388 p_val: 0.365272616127

Stimulus type: PIC_PIC Corr: 0.0177091528522 p_val: 0.670394839017

Stimulus type: VID_SHORT Corr: 0.0617905220655 p_val: 0.460318522462

AVERAGES STIMULUS DATA for
================================================ delta
Combined correlation of all 29 users and all 29 survey stimuli========delta

Stimulus type: VID_LONG Corr: 0.0938397016138 p_val: 0.316366711094

Stimulus type: PIC_PIC Corr: -0.0336128710394 p_val: 0.419098005543

Stimulus type: VID_SHORT Corr: -0.0273527019409 p_val: 0.743985162025

AVERAGES STIMULUS DATA for
================================================ theta
Combined correlation of all 29 users and all 29 survey stimuli========theta

Stimulus type: VID_LONG Corr: 0.105855925412 p_val: 0.258081571068

Stimulus type: PIC_PIC Corr: -0.0394246664363 p_val: 0.343235404241

Stimulus type: VID_SHORT Corr: -0.022308099945 p_val: 0.789982550613

AVERAGES STIMULUS DATA for
============================================== low_alpha
Combined correlation of all 29 users and all 29 survey stimuli========low_alpha

Stimulus type: VID_LONG Corr: 0.115912153776 p_val: 0.215318269022

Stimulus type: PIC_PIC Corr: 0.0547594133028 p_val: 0.187863925657

Stimulus type: VID_SHORT Corr: -0.0495634298698 p_val: 0.553836385949

AVERAGES STIMULUS DATA for
============================================== high_alpha
Combined correlation of all 29 users and all 29 survey stimuli========high_alpha

Stimulus type: VID_LONG Corr: 0.0807970518735 p_val: 0.388578804853

Stimulus type: PIC_PIC Corr: -0.0109765848092 p_val: 0.791942644337

Stimulus type: VID_SHORT Corr: 0.0674164892379 p_val: 0.420419884004

AVERAGES STIMULUS DATA for
============================================== low_beta
Combined correlation of all 29 users and all 29 survey stimuli========low_beta

Stimulus type: VID_LONG Corr: 0.0429797521533 p_val: 0.64687717507

Stimulus type: PIC_PIC Corr: 0.00966402898403 p_val: 0.816348530321

Stimulus type: VID_SHORT Corr: 0.114406437258 p_val: 0.170619538439

AVERAGES STIMULUS DATA for
============================================== high_beta
Combined correlation of all 29 users and all 29 survey stimuli========high_beta

Stimulus type: VID_LONG Corr: 0.0288581579068 p_val: 0.758455257326

Stimulus type: PIC_PIC Corr: 0.0502444064068 p_val: 0.226970998062

Stimulus type: VID_SHORT Corr: 0.0333871051707 p_val: 0.690139668908

AVERAGES STIMULUS DATA for
================================================ low_gamma
Combined correlation of all 29 users and all 29 survey stimuli========low_gamma

Stimulus type: VID_LONG Corr: 0.11634784559 p_val: 0.213586868689

Stimulus type: PIC_PIC Corr: -1.37559527523e-05 p_val: 0.999736241325

Stimulus type: VID_SHORT Corr: 0.0799609720615 p_val: 0.339043987767

AVERAGES STIMULUS DATA for
================================================ mid_gamma
Combined correlation of all 29 users and all 29 survey stimuli========mid_gamma

Stimulus type: VID_LONG Corr: 0.139676901927 p_val: 0.134806056202

Stimulus type: PIC_PIC Corr: 0.0133169976156 p_val: 0.748939463609

Stimulus type: VID_SHORT Corr: 0.0896998421585 p_val: 0.283295757058

## Appendix H: Attention and Meditation Correlations for Survey Data

*************** AVERAGE FREQUENCY DATA ********************
*Combined correlation of all 29 users and all 29 survey stimuli*

*Attention*

*Combined correlation of all 29 users and all 29 survey stimuli*

*Meditation*

*Stimulus type: VID_LONG Corr: 0.0848279461388 p_val: 0.365272616127*

*Stimulus type: IMAGE Corr: 0.0177091528522 p_val: 0.670394839017*

*Stimulus type: VID_SHORT Corr: 0.0617905220655 p_val: 0.460318522462*

***************BLINK EFFECT DATA ********************

*Combined correlation of all 29 users and all 29 survey stimuli*

*Attention*

*Stimulus type: VID_LONG Corr: -0.136980973553 p_val: 0.142573633532*

*Stimulus type: IMAGE Corr: 0.0780988625422 p_val: 0.0601511797546*

*Stimulus type: VID_SHORT Corr: 0.0449157208661 p_val: 0.59164993473*

*Combined correlation of all 29 users and all 29 survey stimuli*
*Meditation*

*Stimulus type: VID_LONG Corr: 0.0217437117229 p_val: 0.816787993974*

*Stimulus type: IMAGE Corr: 0.0271734291736 p_val: 0.513671409084*

*Stimulus type: VID_SHORT Corr: 0.0832717427047 p_val: 0.319358700574*

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