Multimodal Perception and Cognition - Mini Project

Andrea Keiser, Ann-Marie H. B. Bech, Frederik S. V. Bærentsen and Nicky M. Kjærgaard

***Abstract*—Visual search tasks require a search for a target object within a cluttered, changing environment while being guided by an auditory beep. This research is based on a visual search task with 36 lines, 35 skewed and only one vertical, while the task consists of searching through this setup is combined with a brain recording technique. The EEG is implemented to show whether the task elicits an ERP when the target object is found. The ERP focus in this study is P300 and it is proposed that the participants will show a potential 300ms after the target was found. The results recorded do not show any clear P300 potential within 1000ms after the target stimuli, however some possible artefacts that could disrupt the results are presented. The paper ends with a short discussion on how EEG and brainwaves related interfaces can contribute to the Medialogy study.**

***Keywords*—EEG, pip and pop, P300, simulink, visual search, unity, MATLAB.**

I. Introduction

The goal of a visual search is to find a target object surrounded by multiple distractors, the set size representing the amount of items displayed on the screen can make the process of finding the target object harder. This study focuses on a visual search task which uses an auditory pip to guide attention toward the target amongst a number of distractors. The set size used for this study is 36 with only a single target object while the rest 35 objects being skewed. During the visual search task the objects change color continuously, either in groups or alone. In the present study it is researched whether an experiment that involves this task will provide an event related potential when the target stimulus is found. Since the visual search is a task related stimuli, this study focuses directly on whether the task elicits an ERP, more specifically a P300 potential. The implementation made it possible to record the brainwaves elicited during the visual search task performed, which resulted into 8 graphs of 30 trials of recorded brainwaves performing the same task.

II. Research

A. Electroencephalography(EEG) (Andrea Keiser)

Electroencephalography, also known as EEG, is an imaging technique that focuses on reading brain activity. An EEG provides the researcher with an electroencephalogram (electric potentials in humans), which is picked up by using electrodes and a conductive media such as water based gel [12]. This study focuses on using EEG as a non-invasive procedure, where the data is gathered from the scalp of the participants. The EEG measures the currents that flow when neurons are activated, however, large populations of neurons in a certain area of the scalp have a higher chance of causing a large signal to be detected by the electrodes. The number of neurons in a normal adults head decreases with age, therefore also decreasing the amount of synapses that can be detected by the electrodes. The EEG can be measured in voltage on the y axis and time on the x axis, a representation of a brainwave or EEG can be seen in Figure 1.

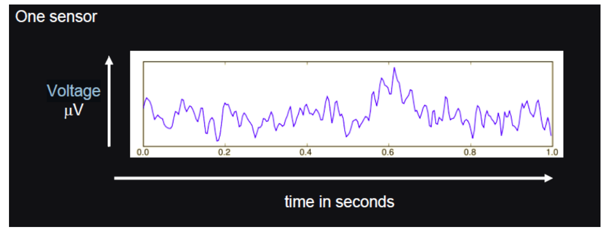

Fig. 1. Example of brainwave, with voltage and time representation. [10, slide 10].

The brain can be divided into 3 areas; cerebrum, with left and right hemisphere and a surface layer cerebral cortex. This area contains areas that control movement initiation, consciousness, complex analysis and expression of emotions and behaviour. The cerebellum controls involuntary movements and balance while the brain stem is in charge of respiration, heart regulation, hormone secretion and biorhythm. The highest influence on the EEG comes from the cerebral cortex due to its surface size and position.

1) Brain waves classification: Brain patterns usually form sinusoidal waves, there are 4 basic categories of the brain rhythm: alpha, beta, theta and delta.

The alpha waves occur with a rate of change taking place between 8 and 13 Hz and amplitudes of 30-50 μV. These type of waves are the most studied brainwaves and are achieved during normal state of awareness by closing the eyes and relaxing and account for an empty mind and a passive state. The alpha waves also account for 70% of the activity that is recoded by the EEG and are obvious when looking at the recorded brainwaves. [9].

The beta waves are dominant, with a rate of change 13 and 30 Hz and a rather low voltage of 5-30 μV and are associated with active thinking, focus and intense mental activity. [9].

Theta waves lie within a range of 4 and 7 Hz and an amplitude greater than 20 uV, and occurs during emotional stress, frustration or disappointment and deep meditation. [9].

Delta waves range between 0.5 to 4 Hz and associated with deep sleep, physical defects in the brain. These types of waves are difficult to achieve information from, mainly because the area that create these type of states is placed deep inside the brain. [9].

When working with EEG, there is also a risk of encountering artefacts which can distort the signal recorded and influence the data. The artefact can either be technical or participant related, these must be considered when looking at the results, some of these artefacts will be quickly described below:

- Minor body movements during the test execution or sweating
- Eye movements, such as blinking
- Any muscle movements such as chewing or moving head even just slightly
- Cable movements
- Too much or not enough gel

Brainwaves from different people differ from each other and persons that may regard themselves as rational, may demonstrate higher brain activity in the frontal left and right hemisphere. The most useful application of the EEG brain-waves recordings is the ERP also known as the event related potential technique.

B. Event related potentials (ERP) (Andrea Keiser)

The ERP are voltage fluctuations in the brainwaves recordings which evoke from the neural activity. An ERP is initiated by a stimuli which can be either internal or external, in the cases of perceptive operations such as attention, memory, etc. proceed over time of milliseconds. These type of potentials started out by being used to measure the speed and accuracy of responses and can be defined as peaks having characteristics, polarities and latency ranges, therefore measurement operations involve assessment of peak amplitudes (microvolts) and peak latency (milliseconds). [2, p. 59].

The amplitude of ERPs are usually not visible on raw EEG data, therefore they are extracted by a set of epochs which are averaged together, this involves EEG data associated with the stimulus provided to the participant while performing the same task multiple times. There are different ways to measure ERPs, one of them is to measure the mean amplitude of the ERP. This is done by defining an epoch and finding the mean voltage for each of the trials in which waveforms were recorded. In order to measure the mean amplitude, the local peak amplitudes of the waveforms can be used. Local peak amplitude or latency is considered a peak if the 3-5 points around it that have smaller values than the peak [6, p. 237]. Latency is the time interval between stimulation and response. ERP latency is defined as peak latencies that find the maximum amplitude within a recorded brain wave and an epoch and the latency of this peak is the latency of the component tested. When measuring peak latency, it is necessary to filter out the high frequency noise, use a local peak measure and to make sure that, when comparing peaks, they show similar noise levels. [6, p. 237].

Overall, the ERP reflects the patterns of neuronal activity evoked by a stimulus. The EEG recording device consists of; electrodes and conductive media (e.g. water based gel), amplifiers with filters, A/D converter and a recording device. The idea is that the electrodes read the signal, before being amplified in order to be digitalized accurately. The minimal configuration of mono channel EEG measurements consists of an active electrode placed on the area of the scalp that is being recorded, a reference and a ground electrode. [12].

Electrodes placements are labelled according to the brain areas they will be placed on; F (frontal), C (central), T (temporal), P (posterior) and O (occipital), while these letters are followed by odd numbers on the left side of the head and even numbers on the right side. Each one of these letters and numbers represent specific areas of the brain which involve different functions of the brain, for example F7 is located near centres for rational activity, C3, C4, Cz deal with sensory and motor functions, P3, P4 and Pz are in charge of activities of perception, etc. However, the scalp electrodes may not reflect the exact same areas of the cortex with the active sources due to the skulls properties.

There are different types of ERPs, there are exogenous or sensory evoked potentials whose characteristics refer the physical properties of an external prompted event, and there are endogenous ERPs which determine characteristics resulting from interaction between the subject and event. This study will have a focus on ERPs that are influenced by the recorded time before an elicited stimuli or event. The most studied of these ERPs are MMN, N200, P300 and N400. [2, p. 67].

MMN or mismatch negativity potential is generally stronger at frontal and central electrode positions, this sort of potential is mainly elicited when stimuli are discriminable on any amount of features and is dependent on the ease of distinguishing them, for example the clearer the stimuli the larger the amplitude.

N200 refers to the detection of a mismatch between stimulus features or between stimulus and previous formed templates. N200 differs from MMN in the fact that the attention is generally on the comparison process of the stimuli.

P300 an endogenous potential, focuses on the relationship between memory and ERPs. The P300 is elicited by task relevant stimuli and can be recorded on parietal scalp locations.

N400 reflects linguistic processes, for example a sentence reading task and incongruence, the amplitude of the N400 is proportional to the degree of incongruity [2, p. 74]. The N400 can be recorded on the right hemisphere and parahippocampal gyrus.

Overall, in order to perform an EEG, certain materials are required, some of these objects are acquisition software for EEG, an amplifier, a computer to save the data on, caps, electrodes and electrolyte gel to allow better conduction.

C. P300 (Ann-Marie H. B. Bech)

The P300 is also known as P3 and was a component discovered by a group consisting of researchers Sutton, Braren, Zubin and John in the year 1965. What they discovered was that when a subject was unable to predict if the next stimulus would appear as a visual or an auditory one, the stimulus provoked a large positive P3 component, which would peak about 300ms after the stimulus. The peak would seem to be smaller if the stimulus the person reacts to is predictable. [6, p. 5].

P300 can be recorded on the centro-parietal position on the scalp. When talking about task related P300, it is also known under the name P3b. Another ERP component is named P3a and what sets this apart is that it elicits a positive ERP when a non-task-relevant event takes place, this is however very rare. What sets the two apart here referring to P3a and P300 (P3b) is that for the P3a the peak appears earlier with a latency of 250-300ms. The P3a and the P300 and their relation are still something that can create a debate theoretically. [1, p. 1888].

The oddball paradigm occurs when a sequence of stimuli is represented at random, P300 ERP is often elicited when the oddballs occur occasionally. There are two different groups in which the stimuli can be classified under and the task here is to either classify the stimuli by pressing a button or by counting the members of one of the groups. If it occurs that a stimuli appears frequently within one of the groups, it is known as an oddball and they will elicit a P300. The amplitude of P300 is also affected by the appearance probability of an attended stimulus, the lower the probability is the larger the amplitude. Another thing affecting the P300 amplitude is the time between each stimulus. [1, p. 1888].

P300 amplitude can be affected by global and temporal probability, but also by the stimuli happening before the target stimuli. Observations have shown that decreases in P300 amplitude can be connected to the constant repetition of the stimuli. The P300 amplitude can vary directly according to the length of the test before the stimulus was shown, when a disruption is detected in the repetition pattern. Furthermore, a larger P300 potential was noticed when an alternating sequence was used, followed by the breaking of the pattern. Target stimuli that require the participant to provide a response, generate a larger P300 than non-target objects that are likely to happen at the same time or before the target stimuli. [1, 1888].

P300 is highly affected by the salience of the stimulus presented and the amount of subjective probability and salience are adjusted by the participants focus and attention to the target stimulus. When a stimulus is ignored or not given attention, because the attention is directed elsewhere, the P300 will fail to peak as it usually would have. A theory is that only after a stimulus has been added to a category through evaluation the P300 is elicited. If it happens that a stimuli is harder to categorize, P300 components are elicited with a longer latency. The length of the latency of P300, depends on the difficulty of the task and whether or not a more complex processing of stimulus is necessary. This can differ between 250-1000ms. [1, 1889].

P300 latency is sensitive to variables involved in stimulus evaluation it is however not altered by response execution and selection that are affecting variables. The variance in reaction time can be broken into two parts, the P300 latency of the stimulus and the production of the response. [1, 1889].

D. Pip and Pop (Ann-Marie H. B. Bech)

Studies have shown that a sound can help searching and direct attention to a visual object, however these studies also discovered that this only occurred when the auditory and visual signals would synchronously come from one place and it was the same location for both. For the pip and pop experiment, it was shown that a non-spatial auditory event, the event being a beep, can help direct the attention toward the placement of a visual target, which would, without the auditory beep, be difficult to locate. So the auditory beep makes the targeted visual object pop. [13].

The experiment used for this research is based on an experiment known as the pip and pop effect conducted by the Vrije University. The pip and pop effect is an experiment that works with visual search [13]. Visual search occurs when the goal is to locate a target surrounded by obstacles called distractors. An example of visual search is shown in Figure 2 where the goal is to find the vertical line, the target, between the skew lines, the distractors. The difficulty of the visual search task can be changed depending on the set size which is the amount of total objects in the image. There are different types of searches the following part will go through three of them.

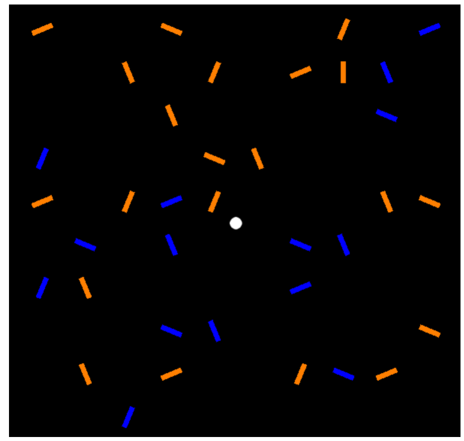

Fig. 2. This figure illustrates an example of a display used for visual search.

When working with visual search, attention should be mentioned since attention is used when searching for the target. Attention is not guaranteed to be aimed at a single point, however most of the time visual selective attention is directed at a single item in a certain location. The theory is that, when referring to selective attention, the attention will mostly be focused on a single place at a time. [15].

Visual search can be used for searching with or without moving the eyes [13]. For the pip and pop effect experiment it is required that the eyes remain still, this prevents scanning the image and taking one item at a time. Since scanning it is not allowed, the participants are told to keep focus on a white fixation point in the center of a grid. The set size for the pip and pop experiment is 24, 36, and 48 that means that there are 24, 36, or 48 objects in this case green and red lines. All the lines are placed in a 10x10 grid with the center containing the white dot. The lines are all placed with the orientation of 22.5 degrees either plus or minus. Only one of the lines is either completely horizontal or vertical,which is the target line. The rule for placing the target is that it is not allowed to be close to the center of the grid, since it needs to be in a certain distance from the fixation point. All the lines, except for the target, change color between red and green at the same time. The target line also changes color but alone in its own cycle. If the auditory beep is tested, the sound takes place at the same time as the target line changes color. [13].

The original pip and pop experiment contains five different experiments, the following section describes the experiment used for this research and the alterations made from the original experiment.

III. Experiment (Nicky M. Kjærgaard)

In this experiment, the participants were asked to find a single vertical line among 35 other slightly rotated lines (as seen in Figure 2). The lines still change colors as in the original pip and pop experiment; the target every 900 ms and the disractors 1, 3, or 5 lines, are chosen at random every 50, 100, or 150 ms.

Each participant were shown 10 different pre-made images 3 times, therefore totaling to 30 images. Between each image there was a 2 second pause for each participant, leaving them time to relax their eyes before the next image. This was mainly done to avoid eye exhaustion, considering it can be tiring to watch numerous random objects changing color constantly.

Throughout the experiment the participants were wearing an EEG cap for measuring brainwaves. This was used in order to check for a P300 spike whenever the participant would find the target object in the visual search setup. Participants were asked to press the space bar as soon as they believed they found the target object and not spend any time on confirming it, this would make sure that there would not be a large delay between finding the target and pressing the trigger.

The experiment required the participants to wear an electrode cap and waterbased gel to create a better connection between the scalp and the electrodes. A demonstration of this setup can be seen in Figure 3.

Fig. 3. Image of electrodes cap

The order of the images shown was the same for each participant, however it was scrambled so there were no images that were shown twice in a row and therefore there were no recognizable patterns. In each image the participant was required to find the vertical line and press space once they believed it was found. The program then logged the time of when the button was pressed in order to calculate a possible P300.

IV. Implementation

In this section the implementation of the experiment will be explained. This includes the implementation of both the visual part and the Simulink patch for the analysis of the brainwaves.

A. *Unity (Nicky M. Kjærgaard)*

The visual program was made using the Unity game engine. It was created following the guidelines found in the original pip and pop Effect experiment, but with the alterations found in section III. Experiment.

Each image is created using a 10x10 grid, with a white dot in the middle. These images are made using 10 2D arrays. An example of one of these arrays can be seen in Code 1.

```
switch(imageNumber) {
case 1:
    return new int[10,10] {
        { 0, 0, 4, 0, 0, 0, 0, 0, 0, 0 },
        { 0, 2, 0, 5, 0, 0, 4, 3, 5, 0 },
        { 0, 0, 0, 3, 2, 0, 0, 0, 0, 3 },
        { 4, 2, 0, 0, 0, 0, 5, 0, 0, 0 },
        { 0, 3, 0, 2, 0, 0, 3, 2, 0, 0 },
        { 5, 0, 4, 5, 4, 0, 0, 0, 2, 3 },
        { 4, 0, 0, 0, 3, 2, 0, 0, 0, 0 },
        { 0, 0, 0, 2, 0, 0, 0, 0, 3, 0 },
        { 0, 0, 2, 0, 4, 0, 5, 1, 2, 0 },
        { 5, 0, 0, 3, 0, 0, 0, 4, 0, 5 } };
    break;
}
```

Code 1. Snippet of code for creating the images.

The 0s are blank spaces in the grid, the 1 is the target, and the 2s, 3s, 4s and 5s are the four different rotations of the distractors. An array named `spawnArray` is set equal to one of the 2D arrays by calling the function `imageType`, which returns one of the images based on the integer `imgNum` (see Code 2 line 1). Using a double `for-loop` and a `switch-statement` to run through the array `spawnArray`, the different objects are placed based on the number in the array.

```
1  spawnArray = imageType(imgOrder[imgNum]);
2  for(int y = 0; y < 10; y++) {
3      for(int x = 0; x < 10; x++) {
4          switch(spawnArray[y,x]) {
5          case 1: // Target
6              GameObject.Instantiate(targetObject, new Vector3(x,y,0),Quaternion.identity);
7              break;
8          case 2: // Distractor 2
9              GameObject.Instantiate(distractorObject2, new Vector3(x,y,0),Quaternion.identity);
10             break;
11         case 3: // Distractor 3
12             GameObject.Instantiate(distractorObject3, new Vector3(x,y,0),Quaternion.identity);
13             break;
14         case 4: // Distractor 4
15             GameObject.Instantiate(distractorObject4, new Vector3(x,y,0),Quaternion.identity);
```

```
                break;
            case 5: // Distractor 5
                GameObject.Instantiate(distractorObject5
                    ↪ , new Vector3(x,y,0),Quaternion.
                    ↪ identity);
                break;
            default: // Nothing
                break;
        }
    }
}
```

Code 2. Snippet of code for placing the lines in the grid based on the array `spawnArray`.

The connection between Unity and the Simulink patch was made using a UDP (User Data Protocol) connection, with Unity acting as the client for sending data (see Code 3). Both programs were running on the same computer, hence the IP address used for the connection was the computer's local address: 127.0.0.1.

```
udpClient = new UdpClient();
address = "127.0.0.1";
ipEndPoint = new IPEndPoint(IPAddress.Parse(address)
    ↪ , 2814);
udpClient.Connect(ipEndPoint);
```

Code 3. Snippet of code for creating the UDP connection.

Data was sent on two different occasions: When the space bar was pressed and whenever there was a beep. When the space bar was pressed, Unity sent a 1 followed by a 0 right after, to a Simulink patch. When the beep was played Unity sent a 2 followed by a 0 again (see Code 4). The data was sent as bytes encoded as ASCII.

```
udpClient.Send(beeps, beeps.Length);
udpClient.Send(zero, zero.Length);
```

Code 4. Snippet of code for sending data using the UDP connection.

B. *Simulink (Frederik S. V. Bærentsen)*

The implementation of the data storage was done in Simulink and a patch to analyze the P300 was used. Simulink is a part of MATLAB and is a block diagram environment for creating model-based simulations [7]. As mentioned before, the application that was used for the test, was made in Unity, but the simulation and recording of the brainwaves was done in Simulink. To allow these two applications to communicate, an UDP connection was set up and Unity sent UDP messages to Simulink, which then recorded these messages.

In Simulink a series of plug-ins from g.tec [4] were used, more specifically the g.USBamp [5] for the EEG data and the g.BSanalyze [3] for analyzing the data.

In Simulink a patch was made, which took input from the g.USBamp and routed it through a downsample filter before logging it in a file. Since 8 channels were used for recording the P300 data, 8 different rows were required in the log file. In that same file, three additional rows were logged. These were the timestamp, the trigger data from each target flash and the trigger data from when the participant pressed the 'space' button on the keyboard. The Simulink patch can be seen in Figure 4.

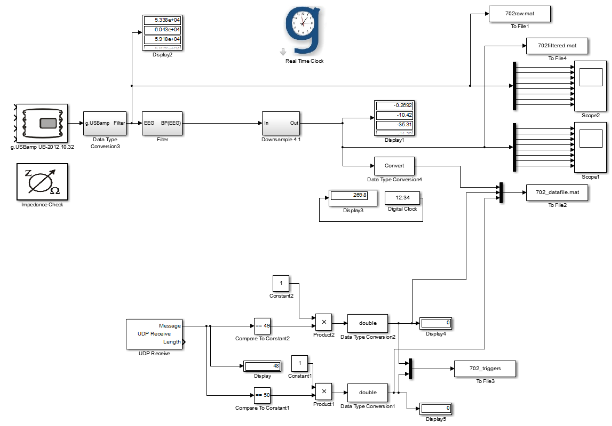

Fig. 4. Simulink patch used for P300 recording.

The UDP Receive block was created to receive the data from Unity and then save it. However, before the data could be used, post processing was conducted. From Unity, two different numbers were sent to Simulink. The number `1` and `2` were both sent as trigger data, but before it was possible to transmit it using UDP, both numbers were firstly converted to ASCII. In ASCII `1` is represented using `49` and `2` is represented using `50`. In Simulink the numbers required to be converted to `1` in both cases, but to distinct them from each other they were saved on two different rows in the datafile. The conversion was done using a simple `if-statement` similar structure. Three blocks were used to create this `if-statement`; a `Compare to Constant` compares the incoming data to a constant, in this case `49` or `50`, and outputs `true` or `false`. If the case was true then the `Product` block was triggered and the `Constant 1` was added to the file.

After the data had been recorded for all five participants, in separate files, g.BSanalyze was used to analyze the data. Each dataset was manually looked through and everytime the participant pressed the `space` button, the closest trigger from the object flash was categorized as the trigger data for the P300. This was done in order to clean up the dataset, before it could be averaged to find out which parts of the datasets needed to be analyzed.

To analyze the data gathered, the MATLAB app g.BSanalyze from g.tec was used. In this app the data from each one of the participant was loaded and the result can be seen in Figure 5.

Channel 1 (C:1) shows the timestamp recorded at 256 Hz, meaning that every 1/256 of a second data is logged. Channel 2-9 (C:2 - C:9) shows the brainwaves from the 8 electrodes.

The areas of the brain to show potentials and can be recorded are: Fz, Cz, P3, P4, Pz, Oz, P07 and P08. These are then mapped to the channel:

- Channel 2 Fz
- Channel 3 Cz
- Channel 4 P3
- Channel 5 Pz

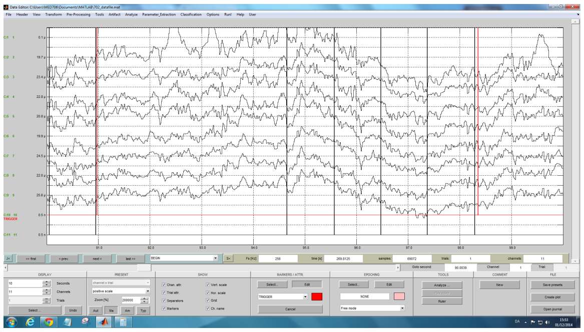

Fig. 5. Example of recording data from P300.

- Channel 6 P4
- Channel 7 PO7
- Channel 8 Oz
- Channel 9 PO8

Channel 10 (C:10) shows the trigger for when the user presses the `space` button and Channel 11 (C:11) shows the trigger for when the object flashes.

Using the Trigger function (see Figure 6) it was possible to assign trial parameters and the trigger attributes to a specific channel. In this case the channel used for the trigger was Channel 11 (CH:11). Channel 11 was originally used to record all the flashes by the target object, however it contained too many triggers. As mentioned earlier, the data was looked through manually and each trigger that was kept or removed was specified. Therefore, new Channel 11 only contained 30 triggers and could be used as the trigger channel. The trial parameters were set to 500ms before the trigger and 1000ms after the trigger.

The data could then be analyzed using the Average function in g.BSanalyze. This function averages the data over each trial and displays it channel-wise. The result for one of the participant can be seen in Figure 7.

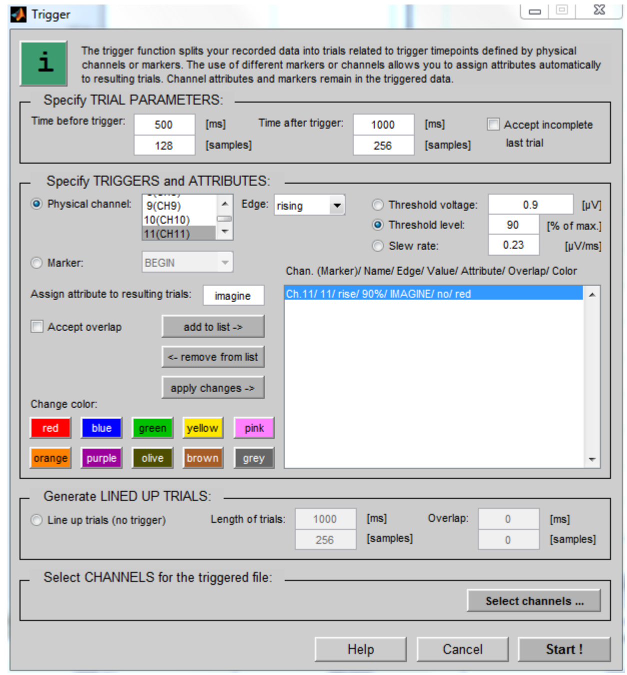

Fig. 6. Example of how the trigger channel is setup.

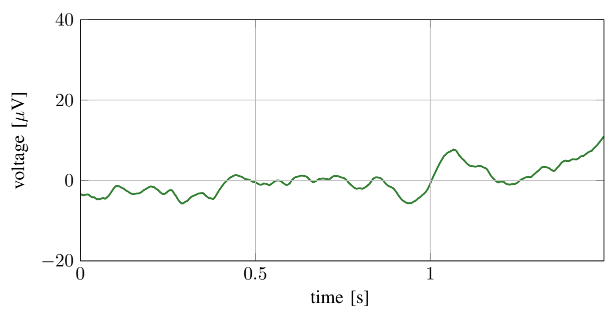

Fig. 7. Example result from Channel 2 (CH:2) from participant 1

V. Results (Andrea Keiser & Frederik S. V. Bærentsen)

The experiment was conducted on 5 participants, with ages ranging between 24 and 31, with 2 female and 3 male participants, each of these participants were introduced to the idea of the experiment and the task they had to fulfill.

The experiment was performed in order to see whether participants show an ERP when they believe they found the vertical line, this being the trigger. In the case of this experiment, the trigger is the target's last color change before the moment the participant presses the space bar when the target object has been located.

As mentioned in the experiment section, they were asked to wear a cap with the 8 electrodes from which the data was gathered and averaged while performing the 30 visual search tasks. Each of the trials gave brainwaves information of the neuronal responses to the task given on screen, the average of each of these brainwaves resulted into a single brainwave for each electrode and each participant, meaning the results for one participant show 8 graphs; one for each electrode. The graph, however, focuses only on the brain activity taking place 500ms before the trigger was activated, in this case the trigger being the pressing of the space bar, and 1000ms after the trigger. The original graphs for all 5 participants, each with the 8 electrodes can be seen in the appendix.

The hypothesis tested within this experiment:

Participants will show a P300 after finding the target object.

The brainwaves recorded during the experiment were averaged in order to show if P300 occured when finding the target object, therefore to see whether any big change occurs after the participant has found the target object.

Looking at Figure 8, the three graphs show different channels (P3, P4, P08) with all 5 participants overlayed to see the difference between the brainwaves. As seen in the graphs, there does not seem to be any correlation between the five participants. All the participants, except Participant 5 (▬) in the P3 graph seem very stable without any big spikes. Even

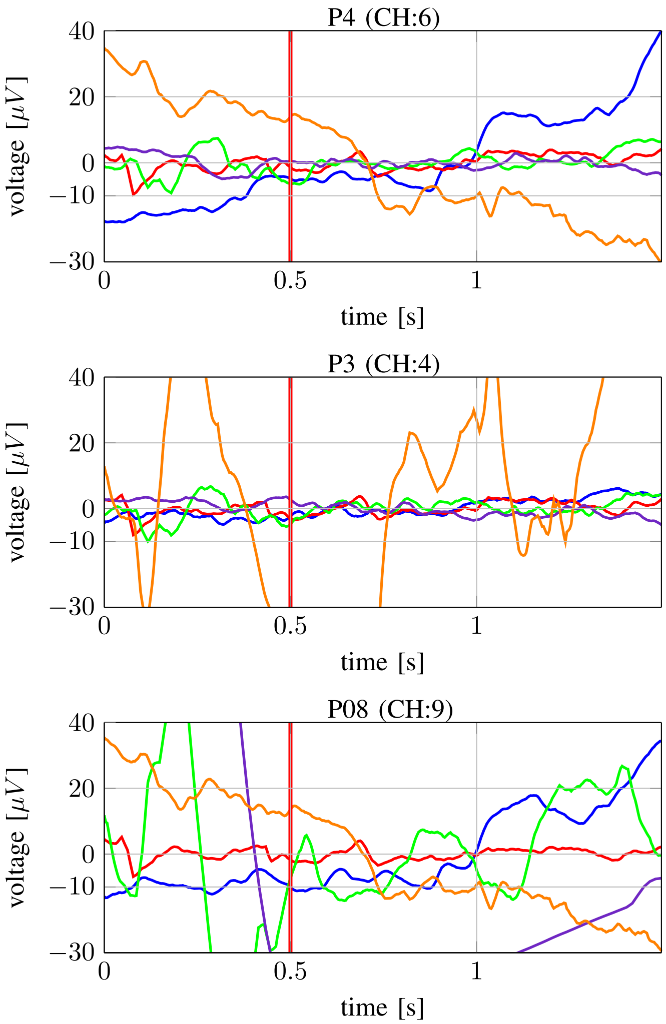

Fig. 8. Example of three of the electrode channels with all five participants. Legend: Participant 1 , Participant 2 , Participant 3 , Participant 4 , Participant 5

though the results from Participants 1, 2, 3 and 4 seem to be close to each other, they do not seem to have any correlations and they dont spike at similar time periods. In the P08 graph both Participant 3 and 4 show very spiky brainwaves and it does not seem to have any specific correlation at all, while the other participants' seem steadier, they also do not show any similarities or visible patterns and none of them seem to have a P300 spike. Figure 8 is just an example of the datasets and looking at all of the datasets, we believe that it is not possible to conclude upon, regarding a P300 related potential.

A. Errors (Andrea Keiser)

Some reasons to why the data was not clear enough to conclude upon was due to artefacts that could have interfered with the recording of the brainwaves. As mentioned in II-A EEG, there are several artefacts that can occur when performing experiments with brainwaves recordings. Some of the artefacts that were most likely to interfere with the gathered data during this experiment could have been the lack of waterbased gel, which could lead to unreadable neuronal synapses by the electrodes for some participants.

Another reason to why there seem to be some sudden spikes or peaks in the recordings could have been sudden movements, either of the body or just the eyes. The electrodes used in Figure 8 are P08, P3 and P4; these electrodes are located in the parietal lobe. It could have also happened when participants could have found the target and moving their eyes or head to check whether the target they found as indeed horizontal, even though they were asked to go with their first instinct, this could still occur. These movements might have caused the electrodes to move and have caused the large spikes in the P08, P3 and P4 channels. To conclude it is not possible to find any spikes in the datasets that can, without a doubt, show a P300 spike.

VI. Discussion to Relevance of Medialogy (Ann-Marie H. B. Bech)

Electroencephalography (EEG) and Brain Computer Interfaces (BCI) can be used to measure different aspects of Medialogy, this section will go through some of these possibilities. The first way to relate these to Medialogy is by using them as a testing method. Instead of just having qualitative and quantitative methods, EEG and BCI can be used as a methodological triangulation to test the mental process of participants. An example could be testing a horror game while measuring EEG to detect reactions, another example could also be the research made for this paper concerning the pip and pop effect, since it is used as an additional method to collect data. In this case, it was used to see whether there is any ERP after the participants had found the target using P300.

Another way EEG and BCI can be used in relations to Medialogy is when wanting to work with concentration. Exercises can be designed to train concentration within a participant. EEG can be used to design a game that helps the player concentrate. The brainwaves can guide the developers to create the optimal concentration game. An example could be the research made by Qiang Wang, Olga Sourina, and Minh Khoa Nguyen from the Nanvang Technological University in Singapore [14]. In their paper they write about and conduct tests based on games used for concentration. Since more technology has been made, the EEG has been given more attention regarding EEG-based games. What is required in order to work with said games, is an EEG reading cap for the electrodes and a device to play the game, such as a computer or PlayStation. The software used for this kind of game can be divided into two groups, signal processing algorithms and the game, which is the visualization part. When it comes to training a specific part of the body, the function of the brain is no exception and the EEG can be rectified. According to the paper, using EEG-based games can also be used as a treatment for different disorders such as ADHD, in the way that it works with attention/concentration. When it comes to healthy people, neuro-feedback can be used to increase the brain function. To detect the state of concentrations, they set up conditions for two states, a relaxed state and a state where concentration was needed in order to be compared. [14].

It is possible to use EEG and BCI as a sort of controller for a game. Seed of Evil, by Squabble Studios, is a game which integrates your meditation and attention level into its gameplay [11]. In the game you control Oswald the pumpkin who is trapped in a mansion. The goal of the game is to escape the mansion while avoiding the enemies. The enemies are attracted to the light which Oswald the pumpkin emits. The more scared the user is, the stronger the light becomes. While the user is focused, Oswald's power bar charges. The game was made for use with the NeuroSky MindWave. The MindWave is a portable EEG (Electroencephalography) brainwave headset [8]. It easily and safely measures the user's brainwave signals.

VII. Conclusion

Electroencephalography as an imaging tool is used to show event related potentials when performing a task. The study focused on the appearance of ERPs, more specifically a P300 potential when performing a visual search experiment similar to the pip and pop experiment conducted at Vrije University. Results gathered from participants did not show any obvious peaks after the target stimuli was found and no conclusion based on them could be made. This experiment is a good example of how EEG can be used in conjunction with a semester project as a Medialogy experiment.

Appendix A
Participant results

See attached pages.

Author's Note

All group members have participated in every activity that took place in the Augmented Cognition laboratory.

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