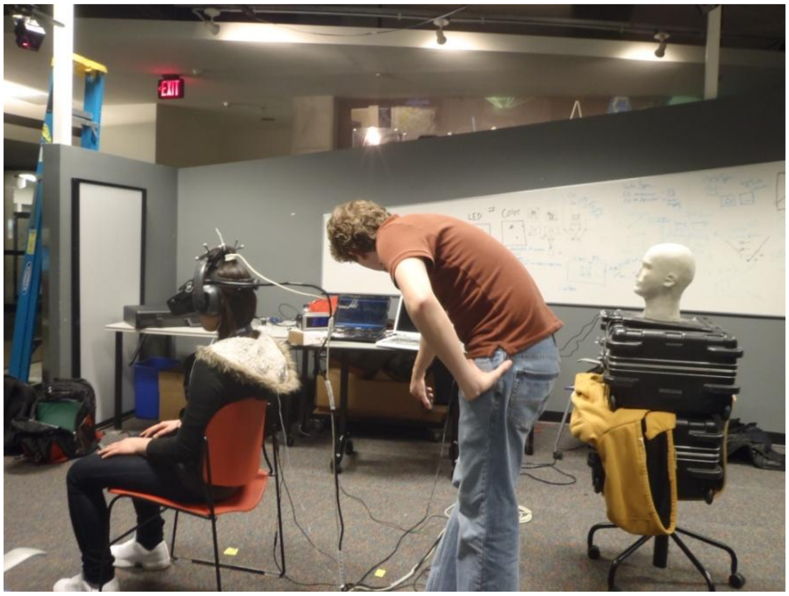
2011

Inducing Out-of-Body Experiences by Visual, Auditory and Tactile Sensor Modality Manipulation



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ABSTRACT

Two sets of multisensory replacement experiments were conducted to explore the concepts of the embodiment principle, self detection, and sensory replacement. The two experiments are designed to induce an out-of-body experience (OBE). The first experiment dealt with visual and tactile sensory replacement and data was collected from 11 test subjects. This experiment successfully replicated the results from Henrik Ehrsson's experimental induction of out-of-body experiment; the majority of test subjects from the first experiment reported the experience of an OBE. The second experiment dealt with visual and audio sensory replacement and data was collected from 20 test subjects. The majority of the test subjects from the second experiment also reported the experience of an OBE.

INDEX TERMS

Out-of-Body Experience, Self Detection, Embodiment Principle, Sensory substitution, Self-consciousness

I. INTRODUCTION

BACKGROUND

Out-of-body experiences (OBE) have been recorded by researchers and described as an experience that involves observing one self's physical body from a third person perspective. The causes of this phenomenon originated from disturbances to the normal brain functions, such as strokes, seizures, and drug abuses.

Since then, researchers were able to reproduce OBE on healthy participants by using sensory replacement experiments [10], [12], [15]. Vision and tactile senses are the most studied for sensory replacement [10], [12], [15]. It has been shown that multimodal sensory interaction creates a stronger effect in subjects in a wide variety of tests [10], [12], [15]. Multisensory replacement experiments require some level of embodiment principle [1], [2], [3] to be effective. In addition, sensory replacement experiments explore concepts of self-detection and self-consciousness [8], [9] [11], [13], [14].

MOTIVATION

Multisensory experiments allow the researchers to explore human perception [4], [5], [7] and knowledge representation [4], [6], [7] human cognitive psychology and expand knowledge in the field of developmental robotics. The results produced by the sensory replacement experiments will help to address key development in cognitive physiology benefit our understanding .

Outside of developmental robotics, the work on sensory replacement experiments will also benefit further research in future consumer application. One other possible application of sensory replacement is improving the OBE experience for virtual communication. Current long distance communication leaves the viewers disengaged from the virtual environment. Viewers view the video feed through the LCD monitor and are aware that they are removed from the environment on the other side. If we could demonstrate the effectiveness of OBE through audio, we could encourage communication companies to invest in more advance visual HUDs to complete the environment for OBE. The advantages of this application are that viewers can now perceive themselves to be in the location at the other end of the communication. This perception of physical proximity allows viewers to be engaging and improves non-verbal communication at the receiver's end.

Another possible application includes telepresence. For those individuals who are immobile. The use of telepresence can offer those individuals a sense of mobility. For further the experience, combining OBE and telepresence will allow immobile individuals an illusion of having a physical body that is capable of movement. This study will assist researchers looking into generating OBE through the use of vision and audio to enhance the telepresence experience.

PAPER LAYOUT

This paper is organized into six sections: Introduction, Previous Work, OBE Experiment, Results, Conclusion and Appendix. The Introduction section addresses experiment background, the goals of the experiments, target audience and layout. The Previous Work section presents work from other researches related to our work. The OBE Experiment section explains the resources needed, design and execution of our experiments and additional approaches tried for experiments. The Results section describes the surveys and the results from our experiments. Finally, the conclusion discusses the technical considerations during the experiments, issues that arose during the experiments and possible future work. The appendix contains additional diagrams and forms referenced throughout the paper.

II. TARGET AUDIENCE

The series of sensory replacement experiments will benefit researchers in developmental robotics in highlighting the use of multiple sensors to identify the self. Given that humans can experience OBE through manipulation of vision, touch, and sound, developmental robotics should be able to replicate the same mechanism on robots. Only through this process can developmental robotics create a reliable framework for self-embodiment.

Neurologists who are researching OBE would also greatly benefit from this study. Should this study conclude that visual and audio could generate the same level of OBE from visual and touch, neurologists would prefer using the visual and audio approach given the ease of setup. In addition, the visual and audio method would be more appropriate for OBE that spawn from near death experience. Neurologists would just rely on audio instead of touch.

Beside academic researchers benefiting from this OBE study, religious and spiritual individuals could draw on our research on how to better induce an OBE experience. Instead of relying on drugs or deep trance, an individual can induce OBE using the visual and audio method without being on the brink of consciousness.

III. RELATED WORK

SELF DETECTION

Many previous researches have focused on the concept of “self detection” in both animals and robots. The researches attempts to qualify characteristics that will allow the robot or the animal to identify oneself.

Gallup (1970) [8] studied self detection by giving chimpanzees mirrors and after a period of exposure to the mirror Gallup was able to verify chimpanzee’s self recognition where each chimpanzee was marked with red dye and the chimpanzees was able to use self-directed responses to correctly identify the marked location. Povinelli and company (1993) [9] conducted similar experiments as Gallup. They focused on various factors that affected the chimpanzees such as age and social conditions.

Gallup and Povinelli's research suggested that self detection in chimpanzees can be induced from a mirror and from self-directed responses (touching, and scratching) and also age plays a role in the effectiveness of the chimpanzee's self detection. The Chimpanzees was able to use vision and tactile senses to correctly Identify one self. This raises the question: can chimpanzees correctly identify oneself if one were to dismiss its tactile senses?

Figure 1 - Monkey

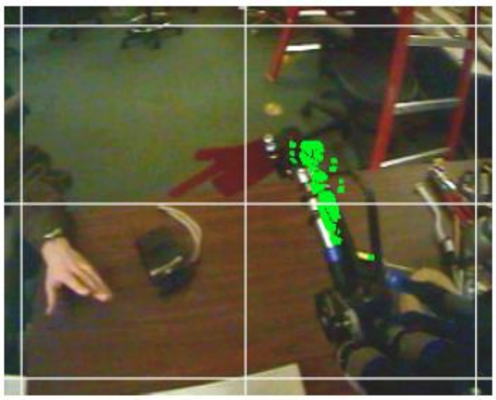

Figure 2 – Robotic self

First person view of the humanoid's arm, where the robot's motion is identified as self and is labeled with green dots [17]

Similar self detection experiments were conducted with robots. Michel and company (2004) [17] experimented with humanoid robot's motion and its corresponding visual field. The humanoid was able to identify self from other through effectively using the delayed temporal contingency in the action-perception loop as a basis for simple self-other discrimination. The humanoid has a concept of "self" through correlating its movements with what it sees in its visual field. Here the humanoid is physically grounded by its visual correlation of its action.

Yoshikawa and company [18] also explored alternative ways of self detection for robots. They were about to bind different modalities of the robot such as vision and touch to help the robot achieve self detection. This was done through a series of stages dealing with learning the multimodal representation of the body: double-touching detection, finding the major components of visual changes caused by its own camera head motions, and self-occlusion detection.

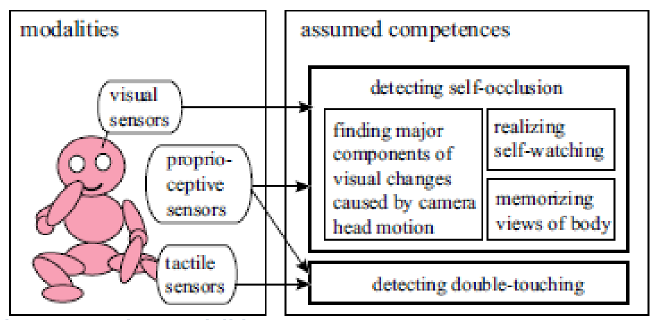

Figure 3 – Robot modalities

The modalities of the robot and the competences supposed to possess [18].

Other researchers such as Stoytchev [11] also explored ways for robot self detection through autonomous learning of the characteristic delay between motor commands and observed movements of visual stimuli.

All the related works for self detection described above depends on the interaction of one's physical body seen via one's visual feed for self detection and most works relies heavily on the correlation of vision and touch modalities perceived the "self". The sensory manipulation experiments of this paper explore self detection without the need of any interaction of one's physical body. Instead, a fake virtual body is introduced. The experiments of the paper will address the question: when similar modalities are associated with the fake body, does one self detect the fake body as one's own?

SENSORY MANIPULATION

There is numerous related sensory manipulation research aimed towards inducing an OBE. Ehrsson (2007) [10] was able to successful induced an OBE using vision and touch (tactile) stimulus. During the experiment, the subject was placed on a chair with a HMD connected to two cameras behind them. The subject was tapped on the chest at the same time the 'virtual body was tapped on the chest. This was repeated for two minutes. After that period a hammer was swung at the virtual body, not at the real one. The skin conductance response (SCR) was measured during the test.

Figure 4 – Ehrsson OBE induction

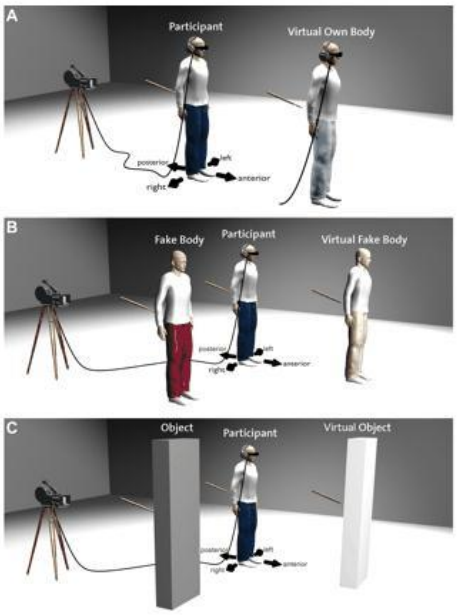

Figure 5 – Lenggenhager self-conciousness

(A) Participant (dark blue trousers) sees through a HMD his own virtual body (light blue trousers) in 3D, standing 2 m in front of him and being stroked synchronously or asynchronously at the participant's back. In other conditions (study II), the participant sees either (B) a virtual fake body (light red trousers) or (C) a virtual noncorporeal object (light gray) being stroked synchronously or asynchronously at the back. Dark colors indicate the actual location of the physical body or object, whereas light colors represent the virtual body or object seen on the HMD. [11]

Lenggenhager [11] explored self-consciousness through a series of experiments. Two set of experiments were conducted and both required the healthy participants to wear head-mounted displays (HMD). For the first set of experiments the participants saw their back as it was stroked either synchronously or asynchronously in respect to their virtually seen body for one minute. The second set of experiments incorporated virtual fake backs and virtual noncorporeal into the design. The second set of experiments modeled closely as the first set of experiments where the subject was either synchronously or asynchronously stroked in respect to their virtually seen body for one minute.

Researchers found that participants experienced a strong sense of association with the visually presented body to their own. For the first set of experiments the results showed a significant drift towards the virtual body when the subjects were synchronously stroked, whereas there was dramatically less amount of drift towards the virtual body when the subjects were a synchronously stroked. For the second set of experiments the results showed a significant drift towards the virtual body when the subjects were synchronously stroked with respect to the fake and real backs and the drift was almost non-existent in the case of the noncorporeal object. There was no effect in the case of asynchronously stroking with respect to the noncorporeal object.

Fiorio and company (2011) [15] reproduced the experiment where the test subject's hand is replaced with a fake rubber hand and the test subject can only see the fake hand. When the real hand and the fake hand are both synchronously stroked for duration of time, the test subject is tricked into questioning or believing the fake hand's owner; the test subject often perceived the fake hand as his/her own by the end of the experiment.

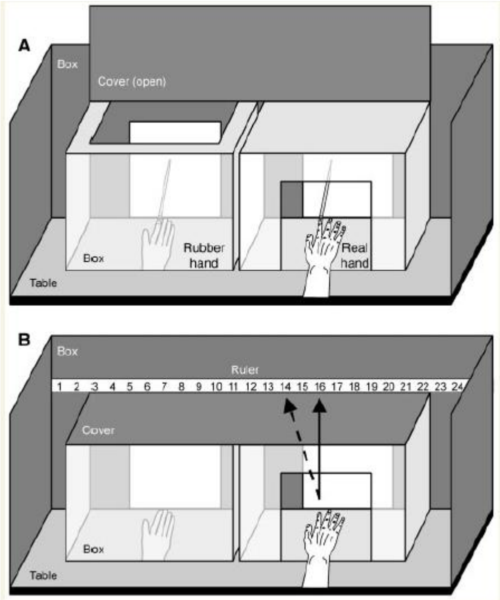

Figure 6 – Hand replacement

Schematic representation of the experimental set-up. Two black boxes (20 x33x15 cm) were placed on a table. The box containing the rubber hand was open on the top and at the back, while the box in which subjects put their real hand was open in the front and at the back. Subjects' real hands and arms were out of sight. A paperboard was used to cover the boxes. During the stimulation phase **(A)**, the cover was lifted and subjects could see the rubber hand from the top of the box and the stroking with the paintbrushes through the back lock. The experimenter was not visible. After the stimulation phase **(B)**, the cover was drawn down and a ruler was introduced. Subjects had to report the number on the ruler corresponding to the felt position of their index finger. A drift in the felt position of the real hand towards the rubber hand is to be expected after synchronous stroking (dashed arrow) compared to the measure collected before the stimulation (continuous arrow).

As summarized above, previous sensory replacement experiments had good success reproducing the effects of OBE when the subject's visual and touch senses were synchronously integrated with respect to a virtual body closely related to their own. Unlike the previous experiments, the experiment described from this paper will explore different combinations of modalities other than touch and visual. More specifically, the experiment described from this paper will focus on answering the question: Can an out-of-body illusion be created using only visual and audio cues?

IV. OBE EXPERIMENTS

This section is broken into three parts: General, Experiment 1 and Experiment 2. General addresses the commonality between the experiments to prevent reiteration. Experiment 1 and 2 explain the design, execution and special materials needed for each respective experiment. Following is a brief description of each experiment:

Experiment 1 (E1): Tap test, stationary subject, tactile and visual cues, tap subject and virtual body simultaneously

Experiment 2 (E2): Music test, stationary subject, audio, visual, and social cues, move object creating noise around environment.

Additional experiments were derived from experiment 2. They are elaborated and discussed after the set up of experiment 2.

GENERAL

EQUIPMENT

All experiments shared some common equipment, it is listed below.

- Two webcams
- Two microphones, with artificial ear

- Head-mounted display (HMD)
- Noise cancelling earmuffs to go over headphones
- Stand/mount for virtual head (webcams and microphones)
- Computer with two unused VGAs ports and VLC media player to stream video to HMD

The webcams were Logitech Pro 9000. The microphones were integrated into the webcams. The HMD was a Virtual Research Systems V8 Head Mount Display. It can handle mono or stereo vision with a resolution up to 640x480. VGA cables are used as inputs. A simple mount for the webcams was made out of balsa wood and the mount was placed at the approximate height of the subjects head. Artificial ears were paper cones made from standard white printer paper.

SETUP

The following pictures show the head-mounted display and virtual head setup.

Figure 9 – Virtual head Manikin head sitting on top of dual Logitech Pro 9000 webcams is pictured. The webcams have built in speakers on either side which serve as the subjects' auditory modality.

Figure 7 - HMD Virtual Research V8 Head Mounted display width earphones to cover in-the-ear headphones are picture here.

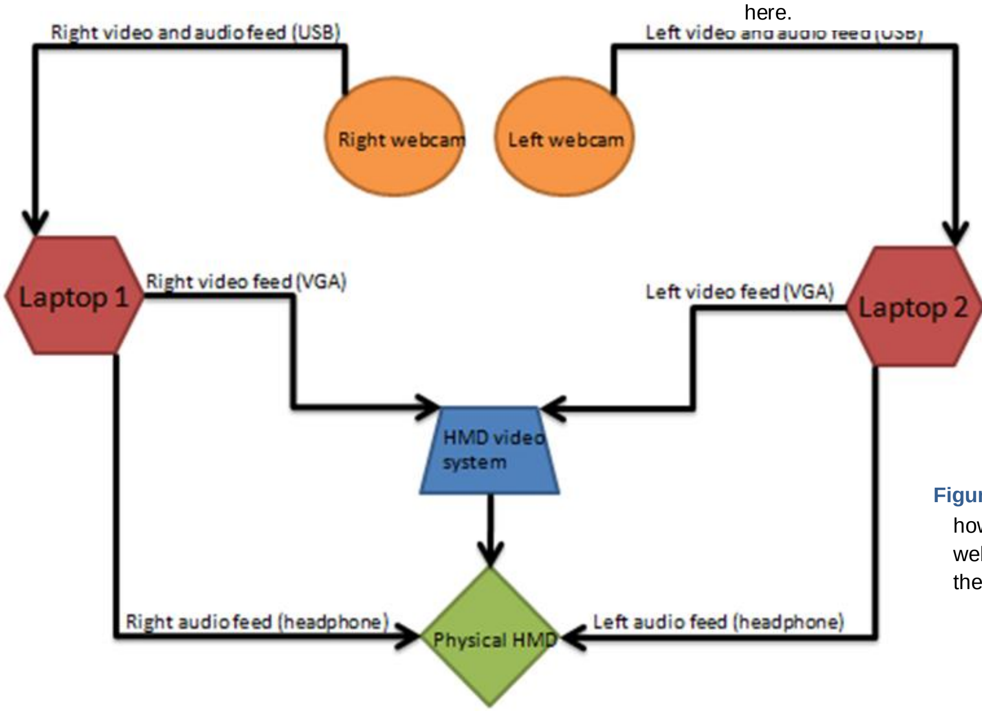

Figure 8 – Wiring diagram Showing how the audio and video from the webcams on the virtual head reach the head-mounted display (HMD)

EXECUTION

The subject was asked to close their eyes and led into the room where the experiment would take place. This was to remove possible biases from seeing the experiment setup. The subject was sat on a chair. The HMD was then placed on their head and they were instructed on how to adjust it to comfortably fit their head. After fitting a left and right in-the-ear headphone were given to the subject that contained the sound feeds from the left and right ear of the virtual head. A set of over-the-ear headphones were then placed on the subject to minimize background noise. The video feed was turned on to the HMD and the subject was instructed on how to focus the image. After focusing, the video feed was turned off. The subject was instructed to sit in a comfortable position, look straight forward, not to move any part of their body during the experiment and the length of the experiment. The video feed was then turned back on and the experiment began.

After the experiment was finished the video feed to the HMD was turned off. The subject was asked to close their eyes once more and the outer headphones for sound muffling were removed. The HMD was then loosened and lifted off the subject's head. The subject was asked to remove the in-the-ear headphones still with their eyes closed. The subject was asked to stand up and was then led out of the room. The subject was instructed to open their eyes and fill out the survey on the computer presented to them. Each experiment had a separate survey and they were presented with the corresponding one.

CONSTRAINTS

Given that our test subjects have varying head sizes and facial structure, the inflexibility of the HMD could influence the varying experiences of OBE. As we are limited to the equipments provided by the computer science department, we cannot fully resolve the varying discomfort in using the HMD across our test subjects. We can only ask that our test subjects individually adjust the HMD to the best of their ability and minimize any discomfort.

In choosing to use the integrate microphones on our webcams, we had to use separate laptops to read in the audio information and route the output audio using two separate pairs of headphones. The problem with this set up was that there would be huge differences in the audio quality and sound level. We did our best to calibrate the two pairs of headphones to provide the test subjects with real world acoustic hearing that is clear and in sync with each other.

The last significant issue is with the room layout where we conduct our experiments. The room is not in a closed environment. Instead, the room is very open in which it connects with problematic corridors and hallways. Sound echoes from these corridors and hallways which are then picked up by the webcam's microphones. The effect is that the test subjects perceive themselves to have super hearing. This ruins the illusion of tricking the test subject into having a virtual body because the auditory information is not realistic.

EXPERIMENT 1 (E1)

Tap-test: Stationary subject, tactile and visual cues, tap subject and virtual body simultaneously

OVERVIEW

This experiment is a replication of Henrik Ehrsson's experiment discussed in the Previous Work and Research section. The goal is to reproduce the exact OBE results using vision and touch (tactile) stimulus described in Ehrsson's The Experimental Induction of Out-of-Body Experiences [2]. The experiment lasts approximately four minutes and consisted of a tap every four seconds for a total of 60 taps. Unlike Ehrsson's experiment ours used two researchers. One held a stick he tapped the virtual body with and the other watched the video feed of the HMD and simultaneously tapped the subject.

EQUIPMENT

- Two identical objects for tapping

Two wooden rods about one inch in diameter were used. The one the subject saw was 4.5 feet long and the one the subject's body was tapped with was six inches long.

SETUP

Additional images of the specific setup for E1. The only additional part is the two objects for tapping. Picture of researches using the wooden rods to tap the subject's chest are below.

Figure 10 – Experiment 1

One researcher taps the virtual body (the sweatshirt) with long rod pole; this is seen by the subject. The other researcher taps the subject on the corresponding chest location with a short wooden rod; this is synchronized with the video the subject sees.

EXECUTION

One researcher was located directly to the subject's left and the other was standing in front of the virtual head. The researcher in front of the virtual head held the longer wooden rod and poked a location below the virtual head equidistant to the distance between the subject's eyes to center of chest. The researcher to the left tapped the subject in the center of their chest. The subject and researcher to their left were placed so that the subject could see himself/herself but not the researcher to their left.

The tapping was synchronize so that the subject saw the researching in front of the virtual head tapping the virtual body at the same time they were tapped by the researcher to their left. Since there was a delay of approximately 0.5 sec in the video/audio feed, this equated to the subject being tapped 0.5 sec after the virtual body was tapped when observing the experiment from afar. To the subject, however, they were being tapped on the chest the same time the virtual body was being tapped.

Tapping continued for about four minutes, approximately 60 taps.

CONSIDERATIONS

For E1, there are multiple factors that could play into the level of OBE experience generated by the tap test. For one thing, the time of the experiment conducted on the test subject could have varying results given the physiological cycle of the human body. We tried to minimize this effect by conducting our experiment with set start times and end times. The majority of our test subjects completed the experiment between the times of 8:00pm and 3:00am.

In addition, the two researchers performing the tapping will be subject to muscle fatigue. This will most likely affect the syncing between the perceived tap and the physical tap. To address this issue, we rotate the positions between the three members within our group. This will reduce the risk of major tapping errors during the experiments.

Lastly, one possible concern is the discrepancy between the lengths of the two wooden rods. The long rod is the one that is seen by the test subject. The shorter rod is used for tapping the physical body. Because the test subject sees the longer rod and anticipates a larger applied force, the shorter rod may provide insufficient amount. This discrepancy may seem insignificant. However, we do not fully understand if the conscious mind could pick up on the discrepancy and reduce the impact of an OBE experience.

EXPERIMENT 2 (E2)

Music test, stationary subject, audio, visual, and social cues, move object creating noise around environment.

OVERVIEW

This experiment is designed to study the effects of moving a subject's point-of-view for their visual and audio input to a third person perspective. A virtual head is created outside of the body which provides that visual and audio inputs for the subject. Visual and sound cues will be created around the virtual head. The experiment will test to see if an OBE can be created using visual and audio replacement.

EQUIPMENT

All equipment from General section

- Portable music player with speakers
- Yellow construction safety helmet
- Large cardboard box

For the portable music player, we used a cell phone playing a song.

SETUP

A single researcher moves around the subject's field of vision with a cellular phone playing a song.

Figure 11 - Experiment 2

Researcher (right) holder cellular phone directly in front of virtual head. Subject receives audio and vision as if located at virtual head, i.e. the phone is in front of them.

Figure 12 - Experiment 2

Researcher (left) moves phone around subject's physical head. Since audio and visual modalities are from virtual head, subject will ideally feel as if the phone is always in front of them event when circling their physical head.

EXECUTION

One researcher carried the cell phone that is playing a song. The researcher rocked the cell phone to the rhythm of the song. The researcher moved the cell phone in a predetermined pattern. This pattern was composed of alternating the position of the cell phone from the left webcam to the right webcam, and vice versa. In addition, the researcher also varied the distance of the cell phone in front of the webcam structure and the physical body of the test subject. During the execution, the researcher kept the cell phone visible for the test subject to view through the HMD.

At the half way mark of the song, another researcher put on the yellow construction safety helmet and walked into the test subject's field of vision. The researcher began on the left side in front of the test subject's physical body. The researcher then walked to the right side of the test subject's physical body, turned towards the webcam structure, and walked to a position between the webcam structure and the test subject's physical body. The research then waved at the webcam structure. The researcher then turned around, retraced to the starting position, and exited the test subject's field of vision.

Approximately near the quarter mark before the end of the song, the same researcher with the yellow construction safety helmet removed the helmet and picked up the cardboard box. The researcher carrying the cardboard box, followed the same route as before. However, instead of waving at the webcam structure, the researcher placed the cardboard box to the left side in between the webcam structure and the test subject's physical body. The researcher then will retrace their steps and exit from the field of vision.

Upon the end of the song playing on the cell phone, the experiment also ended.

CONSIDERATIONS

Given that E2 relies heavily on audio, we try our best to configure the headphones to output the clearest signal with minimum lag. However, we are aware that there are variations in the acceptable range of volume and pitch across our test subjects. What works for one individual may actually reduce the impact of audio OBE on another test subject.

Another important consideration is disturbance to the physical body of the test subject. As the researchers make any close movements to the test subject's physical body, there are drafts and ground vibrations that could be picked up by the test subjects. Those disturbances could alert the conscious mind that the body that the test subject perceives in the HMD is actually theirs. As a result, the test subject would be pick up slight tactile sensory information. We are aware of this effect and do our best slow down our movements as to not disturb the test subject's physical body.

Lastly, the test subjects will be tempted to rotate their head towards the cell phone as to track source of the sound. Our webcam structure does not allow for any movement. Therefore, any movement perform by the test subject will not be reflected in the HMD video feed. This restriction on the test subject's vision mobility is not guaranteed. Should the test subject inadvertently shift their head, their mind will pick up on the lack of vision change and be alerted of their situation. Our approach to limit this condition is by reminding the test subjects several times about the importance of keeping still, being relax, and not speaking during the set up phase of E2.

ADDITIONAL EXPERIMENTS

EXPERIMENT 2 - VARIATION 1 (E2-V1)

Under E2-V1, we made several modifications to the placement of object seen through the vision field of the test subject. These modifications included:

- The placement of the chair where the test subject sits is closer to the webcam structure.
- The placement of the chair where the test subject sits is located towards the left side of the webcam structure.
- The movement patterns of the cell phone consisted of circular movement around the webcam structure, circular movement around the webcam with the holder visible, and long distance in front of the webcam with the holder visible.
- The removal of the person with the yellow construction helmet and the person carrying the cardboard box.

INITIAL RESULTS FROM E2-V1

With these modifications, we conducted E2-V1 with the three team members. We all reported success with OBE experience. With the promising results, we decided to continue conducting E2-V1 with participants.

DISCUSSION ON E2-V1

The aim of E2-V1 is to test if OBE experience could be generate with just using visual and audio alone. There is limited social interaction with the test subject. The majority of the test subject's focus should be on the audio sound and correlating the source of that sound to the cell phone seen on the HMD. For this reason, we varied the movement pattern of the cell phone so that the test subject could continuously self-verify the audio sound to the cell phone seen on the HMD.

In addition, we intentionally place the chair to the left of the webcam structure as to draw less attention from the test subject when they are viewing through the HMD. With this, the test subject would be more focus on moving objects rather than their physical body.

Lastly, we removed the social component by removing the yellow safety helmet person and the cardboard carrying person. Since social cues give strong indication to the test subject where their perceive body is located at, we removed the social cue so that we could isolate the effects of visual and audio on OBE without social cues.

EXPERIMENT 2 - VARIATION 2 (E2-V2)

After the first iteration of E2, we brainstormed different ideas on how we could generate OBE experience using visual and audio feeds. Our brainstorming session identified reading children book to the test subject could invoke an OBE experience. Our rationalities for this approach included the need for social cues in the experiment to garner a stronger OBE experience.

In the tap experiment, the person performing the tap seen by the test subject serves as a social cue that the test subject's body is the one that is real. Under E2-V1, this form of social cue was not present. Therefore, reading a children book to the test subject provides the illusion of physical proximity and social closeness similar to that of a parent reading a storybook to a small child.

In implementing E2-V2, we drastically modified the setup of E2. We placed the test subject's chair quite far from the webcam structure. We had the reader put on mouth covering to hide their mouth and jaw movement. We chose three children story book with large fonts and large picture to make it easier for the test subject to see.

INITIAL RESULTS FROM E2-V2

We conducted E2-V2 on two of our team members. The results were discouraging. Both failed to generate OBE experience. Instead, the experiment revealed numerous technical challenges. These challenges included sound isolation, transmission lag, and low visual resolution. Given the negative results, we decided to drop E2-V2.

DISCUSSION ON E2-V2

Sound isolation issue was that the test subject could inadvertently hear the reader speak before the speech could travel from the webcam structure to the test subject's headphones. The sound cancelling headphones were not able to completely isolate the test subject's hearing capability. To remedy this issue, we had to move the placement of the test subject's chair further in front, away from the webcam structure. The physical distance did help with the sound isolation issue. However, we are not fully aware of what impact of increasing the distance of the test subject's physical body and the test subject's virtual body.

The transmission lag issue highlighted the problem of syncing visual and audio. Reading to the webcam structure under such close proximity allows the test subject to see to the mouth and jaw movement of the reader. Given that there are substantial discrepancies between the video and audio feeds to the test subject's, their conscious mind will pick up on the discrepancies and reduce the OBE experience. To address this issue, we had the reader cover their mouth with a custom made mouth pad covering. The mouth pad covering helped with the illusion of syncing visual and audio. However, the mouth pad covering is unnatural and could alert the test subject's conscious that there is something weird with their environment.

Lastly, the issue with low video resolution was that the test subject instinctively wants to follow along with the children story book. However, low video resolution could not display the fonts appropriately and images from the children books were slightly distorted. This may seems like a small problem, but we believe that the behavior of wanting to follow along with the children book is a self-verification behavior. The test subject needs to confirm that the audio speech that they are hearing correlates with the text they are perceived. We believing tricking the mind into confirming the self-verification behavior is a critical step in achieving OBE.

Given these challenges, we did our best to limit the negative factors affect OBE experience. In the end, the technical limitation of our equipments could not achieve the desired results. We leave the implementation of E1-V2 to future work.

V. RESULTS

This section describes the surveys used to collect data from subjects and the results from the experiments.

SURVEYS

Results were collected using surveys presented to the subjects after the experiment was completed. The survey was completed on a laptop computer using Google Forms for easy collection of data. Questions from the survey were designed to answer the following key questions:

KQ1) Did the subject feel as if they were located at their body or at the virtual head?

KQ2) Did the subject experience any other effects such as a floating feeling, transparency or ownership of multiple bodies?

KQ3) Where in the room did the subject feel as if they were located and where did they feel their body was located?

KQ4) If an OBE was present, how long did it take to induce, what was its duration and how intense was it?

The survey questions were formulated with assistance from the following Iowa State Psychology department professors: Jason C.K. Chan [16], Veronica J. Dark [17], and Jonathan Kelly [18]. Studies from other research groups were also drawn upon for experiments. Specifically [10] and [12] were used for question inspiration.

Both surveys contained 25 questions addressing the key questions above. The surveys had the following questions composition:

Figure 13 – Survey Questions

Key Question	# Survey 1	# Survey 2
KQ1	6	8
KQ2	10	9
KQ3	2	3*
KQ4	5	5

*Survey 2 varied based on the apparel o the person walking into the subject's field of view.

A complete list of survey questions and the key question they address can be found in the Appendix Survey 1 and Survey 2

DATA ANALYSIS

For E1 data was collected from 11 participants and for E2 data was collected for 20 participants. Each of the following sections presents data and conclusions drawn from the data. The following subsections focus on a single element of the results and its relevance to the experiment. To see a complete list of survey data please see the Appendix Survey Data.

SUMMARY STATISTICS

Summary statistics were computed for each of the key question groups. The results are as follows:

Figure 14 – Summary Statistics

	KQ1	KQ2	KQ3*	KQ4**
Mean	3.090909	1.732143	0.97549	0.636364
Med	3	1	1	1
Mode	4	1	1.414214	1
Std Dev	0.923659	0.890208	0.745983	0.488504

* KQ3 is reported distance between physical and virtual location

** KQ4 is reported as binary data with "Yes" being 1 and "No" being 0

The first observation is the high standard deviation of all the data. Although not unexpected with survey results, for KQ1 and KQ2 a standard deviation greater than one for data which has a range of four is quite high. The median and mode are not very meaningful for KQ4 because of the binary nature of the "Yes/No" question. Notice that for E2, KQ3 even though the mean distance is 0.897542 the most frequent answer was a distance of 0. A more thorough discussion of E1 vs. E2 data can be found in one of the following sections.

CORRELATION MATRICES

Before results can be considered valid, the first question that needs addressed is the validity of the data collection methods, in this case the survey questions. If our survey questions are too heavily correlated they all may be answering the same questions and if they are not correlated at all then they are addressing more questions then we are asking. To analyze the effectiveness of our survey questions, correlation matrices were computed. The correlation matrices for both sets of survey questions can be found in the Appendix Experiment 1 Correlation Matrix and Experiment 2 Correlation Matrix.

The correlation matrices aid in providing insight into the relationship between questions. They can be used to imply between questions and allow the surveys to be adjusted to optimize information. For example if two questions have a high correlation it may be sufficient to only include one version of the question on the survey to open up space for other questions. Ideally all questions on the survey will have either a low or high correlation. Low correlation questions imply the questions are addressing different points of interest in the experiment which are unrelated and high correlation questions provide error-tolerance from mistakes in the experiment, such as a subject filling in the wrong answer.

Looking at the correlation matrix many of the questions addressing KQ2 have a high correlation. This is especially evident in questions addressing effects such as disappearing/becoming transparent and having two bodies/feeling like you are in two locations at once. While these questions are good to provide a level of error tolerance for KQ2, it may be advantageous to forgo such questions and create some error tolerance in KQ1 since it is arguably the most important of the key questions. Overall, the question set seems sufficient for our testing and should provide adequate results for the purposes of the class project. If the research idea is to continue, however, the survey questions may need adjusted; this is discussed in the Future Work section.

EXPERIMENT 1 VS EXPERIMENT 2

Box plots of the KQs for E1 vs E2 were constructed. The thick boxes on the plots represent the mean and the thin bars are one standard deviation. The plots are presented below.

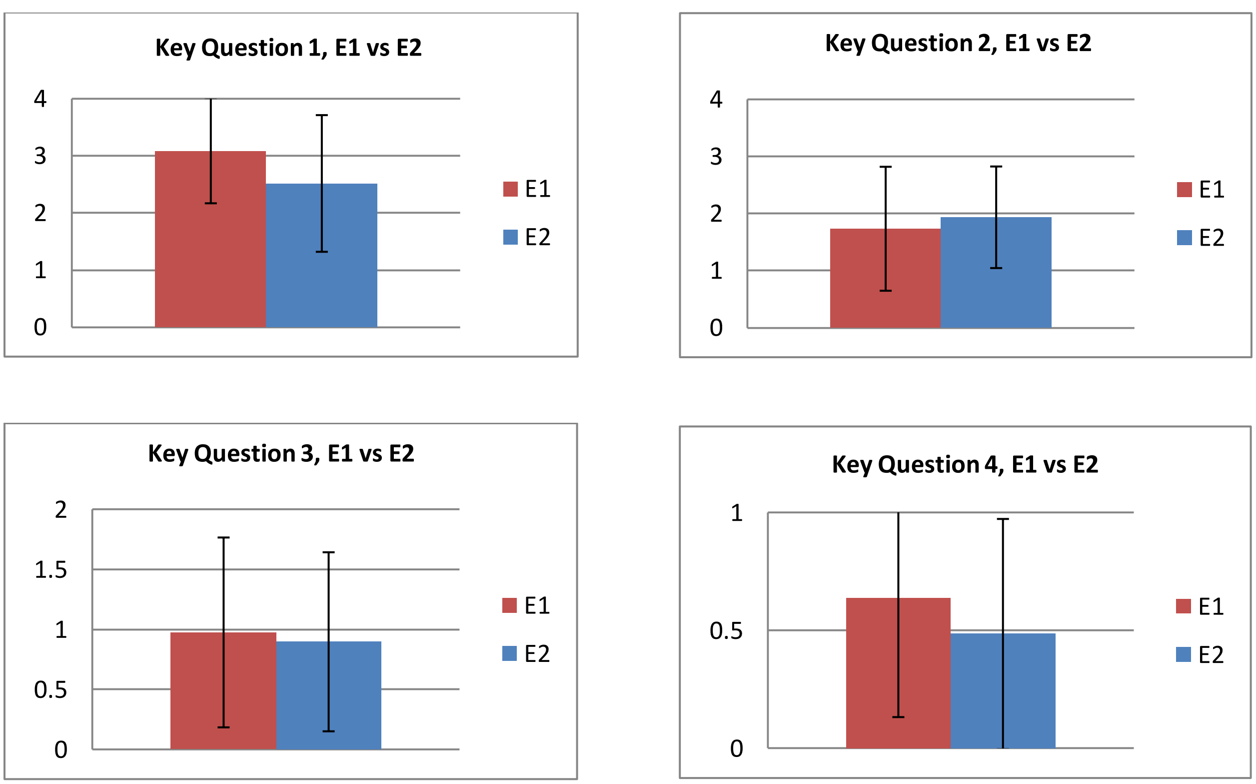

Figure 15 – Key Questions

As can be seen from the plots, the mean and standard deviation for KQ2 and KQ3 are comparable. However, the E1 has a higher mean for both KQ1 and KQ4. Since these key questions represent whether or not the subject experience an OBE, the higher values imply that E1 induces an OBE in a higher percentage of subject. As will soon be seen this is in fact the case.

OBE VS NO OBE

Box plots displaying the KQs for subjects who reported an OBE vs ones who did not are presented below. A subject was considered to be an OBE subject if they answered "Yes" to any of the "Yes/No" questions of the form "Did you have an out-of-body experience?" from KQ4.

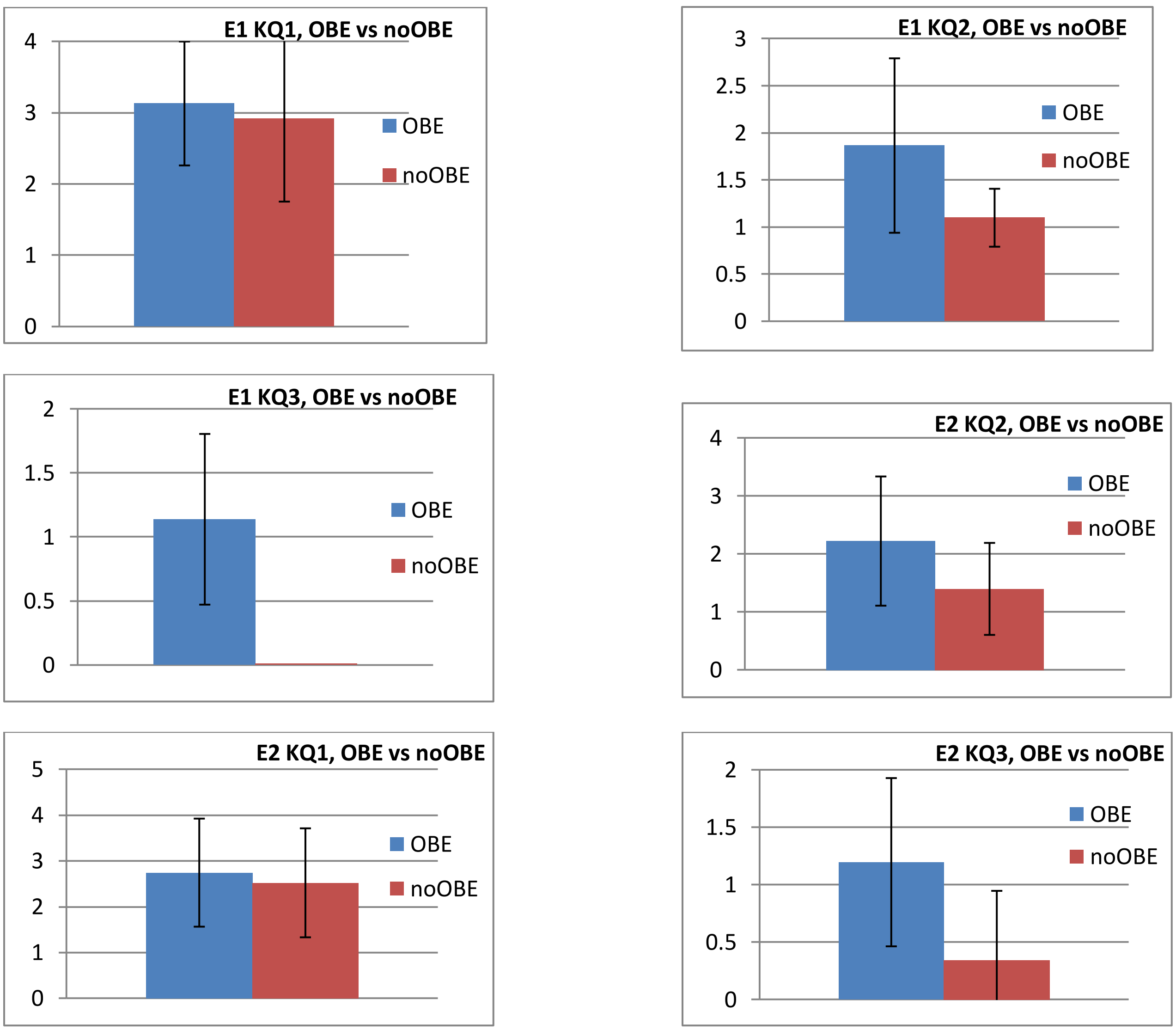

Figure 16 – OBE vs. no OBE

From the plots it can easily be seen that KQ1 does a poor job at categorizing into OBE and no OBE subjects. This holds true for both E1 and E2. Even though it seems logical that the survey questions which directly answer the question “Did the subject feel as if they were located at their body or at the virtual head?” (KQ1) would categorize well, this doesn’t appear to be the case. Instead questions from KQ2 and KQ3 appear to do a better job at discriminating between OBE and no OBE subjects. This suggests that in further study it may be important to include more questions from KQ2 and KQ3 since they appear to be important to answering the question “f an OBE was present, how long did it take to induce, what was its duration and how intense was it?” (KQ4). This result is discussed further in the Future Work section.

OUT-OF-BODY EXPERIENCE TIME

The following pie charts illustrate subjects’ answers to the following “Yes/No” questions relating to KQ4:

- I felt in the first few minutes the effects of OBE.
- I felt within roughly five minutes of the effects of OBE.
- I felt at one point during the experiment the effects of OBE.

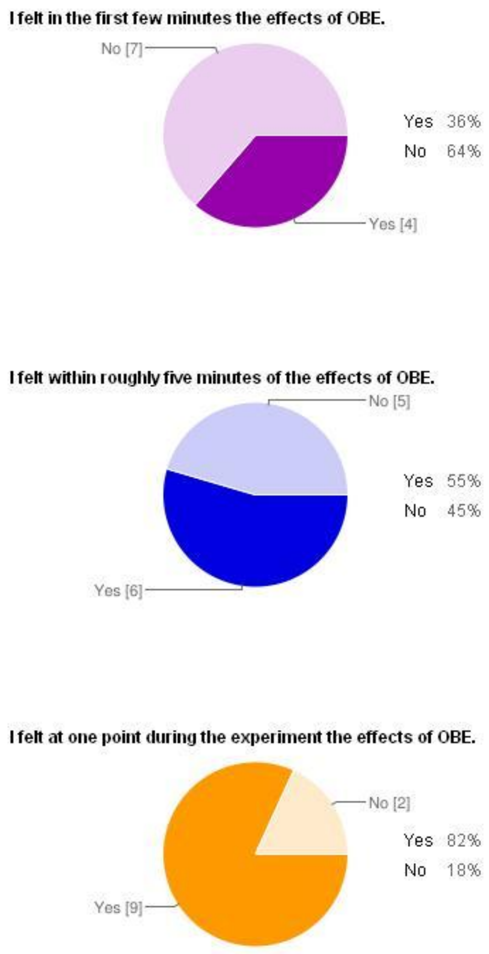

Figure 18 – E1, OBE Time

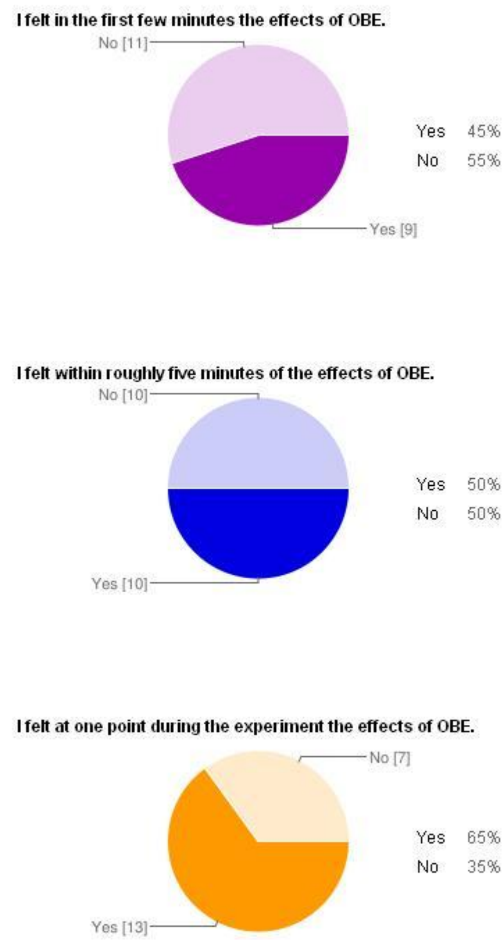

Figure 17 – E2, OBE Time

These charts are the meat of the study. They determine whether or not the experiments were successful. As can be clearly seen both experiments induced an OBE in over 50% of the subjects at some point during the experiment. There is also an apparent increase in the percentage of people who reported an OBE the longer the experiment had been taking place. Although E2 appears to induce an OBE slightly more quickly than E1 this has been attributed to the difficulty of syncing the chest tapping in E1 and should not be considered significant. The other two pie charts imply that E1 induces an OBE in marginally more subjects then E2. Again this is not considered significant and is attributed to the technical difficulties experienced during certain trials of E2. These difficulties are discussed in the section discussing variations on the experiments earlier in the paper. Overall the two experiments are considered to have similar results with neither being more effective than the other.

PERCEIVED LOCATION

The following is a copy of the chart that was provided with the surveys (see Appendix for original) with data filled in for where subjects believed both they and their body were located for E1.

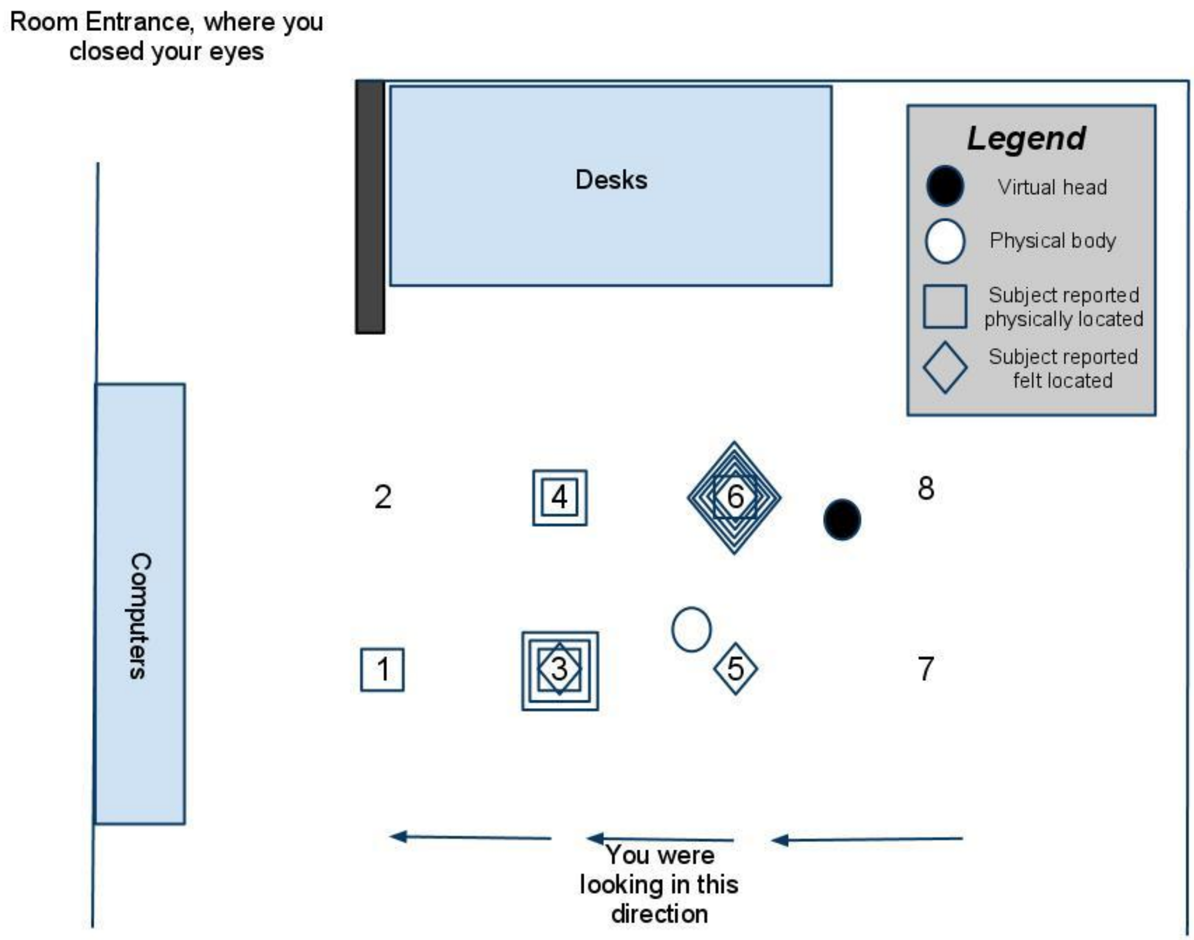

Figure 19 – E1 Body Locations

The highest concentrations for subjects are location 6 for “felt located” and location 3 for “physically located.” This is promising since the two locations have the same relative location the virtual head and physical body (black and white dot). A similar diagram was excluded for E2 since there were many more participants and the diagram quickly became cluttered and hard to read. However, this diagram shows that for at least the first experiment subject’s OBE location correlated with the location of the virtual head as expected.

VI. CONCLUSION

The goal of this project was to test the feasibility of inducing an out-of-body experience using visual, auditory and tactile sensory modality manipulation. The paper has laid out the goals, approach and results of the two experiments conducted.

The first experiment conducted showed that our setup was valid by imitating and reproducing the results of another researchers work. To test if other sensory modalities could produce an equivalent out-of-body experience the tactile was replaced with the auditory modality.

The results showed that a majority of subjects felt an out-of-body experience at some point during both experiments. They also confirmed that an equivalent out-of-body experience can be created with with either audio or tactile information coupled with vision.

FUTURE WORK

Since this project was meant as a feasibility study to using non-traditional modalities for inducing out-of-body experiences, it leaves plenty of room for future work. Besides the obvious extension of swapping out sensory modalities the following extensions have been considered:

- Head-tracking with a movable virtual head
- Manipulation of the characteristics of the virtual head
- Coordination tests
- Inducing a floating/flying effect
- Optimizing surveys based on results
- Diminishing return of OBE

CONTROL GROUP

To disassociate the impact of hearing and vision, the setup for the control group is the same as E2, except that the test subjects will now be tapped on the shoulder by a researcher visible on the HMD video feed. This is to keep the test subjects grounded that their body is still the physical body. Upon the completion of the experiment, the test subjects will complete the survey just as normal. We will then use the results as our control group.

Due to the lack of participants and time constraint, we chose to prioritize E1 and E2. We also confirmed that the results from E1 would serve as a control group to compare with the results from E2. As our survey questions for E1 and E2 are closely mirrored, we would still be able to identify failures and successes for when an OBE experience has occurred.

We leave the proper implementation of a control group for E2 for future work. Upon completion of this future work, we could compare our use of E1 as a control group and confirm that E1 is a valid source for grounded base line comparison.

HEAD TRACKING

The original scope of the project included using a head tracking system to detect movement of the subjects head. A servo would be attached to the base of the virtual head so that it can turn 180 deg in either direction. The servo would be synced with the movement of the subject so that when the subject looked left, the virtual head turned left. However, due to limited time and complications with the base setup the scope of the project was reduced to eliminate this additional test.

The idea behind the test comes from various studies which show sensory replacement is effective only when the subject has control over the added sensory unit. The subject must have the ability to manipulate their inputs by doing actions such as moving their eyes, turning their head or running their fingers across a surface. Since normal sensor modalities need this ability to control their inputs we hypothesize that allow the subject to turn the head (control their input) will create a more immersive out-of-body experience.

VIRTUAL HEAD CHARACTERISTICS

Another question to be explored is whether or not the human brain is bound to a certain type of body. This can be explored through testing for an OBE by manipulating the characteristics of the human head to see if the brain can still recognize self, creating an OBE. Our proposed initial idea was to vary the eye separation of the virtual head. Exploring whether or not there is a threshold of minimum or maximum separation at which the brain can no longer understand its surroundings may provide insights as to the coupling between our physical body structure and our brains.

The proposed idea, which again was dropped because it was decided to be out of scope, was to use a motor to slowly increase the distance between the two cameras on the virtual head while the subject is wearing the head-mounted display. The subject would be asked to report any adverse effects during and after the experiment and separation would slowly continue until the subject could no longer make sense of their environment.

COORDINATION TESTS

Coordination between vision and tactile could be potentially useful technique to generate an OBE experience. Possible implementations include placing the webcams on both sides behind the test subject's shoulders. The webcams should try to capture both arms in the field of vision. Researchers could then ask the test subjects to perform a number of coordination tests and observe the proficiency level as researchers decrease or increase the lag of the video feed.

The coordination test study would help in revealing the threshold time delay where human can operate proficiency. Other questions this type of study could answer are can human flexibly adapt tactile movement to accommodate sudden vision changes and how long of a time is needed for the test subject to adapt to their new perceived visual and motor capabilities.

OPTIMIZING SURVEYS

Two sections of the data mentioned future work which could be done to optimize the surveys: correlation matrices and OBE vs. no OBE. The correlation matrices show how strongly one question is associated with another question. Since we are addressing four key questions, there should ideally be four basic types of questions. These questions would be either true or false give one of the key questions is true. Although the real applications aren't this simple this is still a model we can strive for. The goal would then be to have four groups of question where each question has a high (negative or positive) correlation with each other member of its group and a low correlation with all questions that are not in its group. A few of the questions relating to KQ2 contain this property. By adjusting questions we may be able to optimize the question so that the simple model above works.

The other observation about the survey construction and results is how well KQ2 and KQ3 answered the "Did you have an OBE?" question. This implies that the results of questions addressing KQ1 do not give any hints as to whether or not the subject is having an OBE. From the plots the most effective key question set to determine if the subject is or isn't having a OBE is KQ3. The questions in KQ3 removed most personal sentiment with questions such as "Do you feel like…" and replaced them with questions that ask for more concrete data such as "Where was X located relative to you?" The data implies that more questions related to KQ3 would allow researchers to more easily determine if the subject had an OBE. The researcher determining whether or not an OBE occurred is important because the more we tested the more personality played a part in a subject's willingness to report an OBE. We suspect it may be because certain subjects have trouble believing an OBE is possible and therefore refuse to recognize it. By designing the survey to answer the question of whether a subject experienced an OBE instead of asking the subject we may get more meaningful result.

OBE DIMINISHING RETURN

As we conducted our experiments, we periodically tested the experiments on ourselves to configure the equipments. We noticed that our OBE experience diminished over multiple trials. There may have been many other factors that could have attributed to this diminishing return of OBE exposure. However, we postulate that repeated exposure to OBE experiment would lower the chance for OBE to occur.

Future work could be implemented by having test subjects come in for consecutive testing over any period of time. This could be hours, days, or weeks. The questions that this type of study would answer are whether our mind can be train to resist the effects of OBE and whether a particular type of sensory replacement approach would have a slower rate of diminishing return.

VII. APPENDIX

REFERENCES

[1] Stoytchev, Alexander. "Some Basic Principles of Developmental Robotics." *IEEE TRANSACTIONS ON AUTONOMOUS MENTAL DEVELOPMENT* 1.2 (AUGUST 2009). Print.

[2] Richard Sutton, Verification

[3] Richard Sutton, Verification, The Key to AI

[4] Neisser, U., Cognition and Reality (1976)

[5] Sternberg, R., The Nature of Cognition (1999)

[6] Strube, G., and Wonder, K., eds., The Cognitive Psychology of Knowledge (1993)

[7] Neisser, Ulric. "Cognitive Psychology." *Grolier Multimedia Encyclopedia*. 2009

[8] Gordon G. Gallup, Jr. "Chimpanzees: Self-Recognition" *Science*, New Series, Vol. 167, No. 3914 (Jan. 2, 1970), 86-87. Print.

[9] Povinelli, D. J., Rulf, A. B., Landau, K. R., & Bierschwale, D. T. (1993). Self-recognition in chimpanzees (Pan troglodytes): Distribution, ontogeny, and patterns of emergence. *Journal of Comparative Psychology, 107*(4), 347-372. doi:10.1037/0735-7036.107.4.347

[10] Ehrsson, Henrik H. "The Experimental Induction of Out-of-Body Experiences." *SCIENCE* 317 (2007). Print.

[11] Stoytchev, Alexander. "Self-detection in robots: a method based on detecting temporal contingencies." Robotica, Cambridge University Press, vol. 29, 1-21 (2011) Print.

[12] Lenggenhager, Bigna, Tej Tadi, Thomas Metzinger, and Olaf Blanke. "Video Ergo Sum: Manipulating Bodily Self-Consciousness." *Science* 317.24 (2007): 1096-099. Print.

[13] Michel, P., Gold, K., & Scassellati, B (2004). Motion-Based Robotic Self-Recognition: IEEE/RSJ International Conference on Intelligent Robots and Systems September 28 - October 2, 2004, Sendai, Japan

[14] Yoshikawa, Y., Hosoda, k., & Asada M., "Cross-anchoring for binding tactile and visual sensations via unique association through self-perception"HANDAI Frontier Research Center, Graduate School of Engineering, Osaka University Yamada-Oka 2-1, Suita, Osaka Japan

[15] Fiorio, M., Weise, D., Önal-Hartmann, C., Zeller, D., Tinazzi, M., & Classen, J., "Impairment of the rubber hand illusion in focal hand dystonia Brain" (2011). Brain Advance Access Vol. 1 1-10. Print.

[16] Jason C.K. Chan, assistant professor in Psychology at Iowa State University, Research Focus: Memory Distortions and Eyewitness Suggestibility, Applying Cognition to Education, and The Effects of Aging on Memory Performance

[17] Veronica J. Dark, Director of Undergraduate Studies in Psychology, Research Focus: role of semantic information in selective attention, role of awareness in attention and memory, relationship between attention and implicit memory, and individual differences in information processing

[18] Jonathan Kelly, Assistant Professor of Psychology, Research Focus: navigation and spatial memory, virtual reality

SURVEY 1

Tactile and visual cue test.

* Required

1: Not at all 2: Slightly, somewhat true 3: mostly true 4: Most definitely true

I experienced that I was located at some distance behind the visual image of myself, almost as if I was looking at someone else. *

1	2	3	4
○	○	○	○

It felt as if my (real) body was drifting towards the front (towards the virtual body). *

1	2	3	4
○	○	○	○

I felt as if my head and eyes were located at the same place as what I am seeing, and my body just below what I am seeing. *

1	2	3	4
○	○	○	○

I felt like the hand I was seeing was approaching me. *

1	2	3	4
○	○	○	○

I felt that I had two bodies *

1	2	3	4
○	○	○	○

I experienced that my body was located at two locations at the same time *

1	2	3	4
○	○	○	○

I experienced a movement-sensation that I was floating from my real body to the location of what I am seeing. *

1	2	3	4
○	○	○	○

I felt as if my head and body was at different locations, almost as if I had been 'decapitated' *

1	2	3	4
○	○	○	○

I did not feel the touch on my body but at some distance in space in front of me *

1	2	3	4
○	○	○	○

It seemed as if I was feeling the touch in the location where I saw the object about to touch. *

1	2	3	4
○	○	○	○

It seemed as though the touch I felt was caused by the touching of the object perceived *

1	2	3	4
○	○	○	○

I could no longer feel my body, it was almost as if it had disappeared *

1	2	3	4
○	○	○	○

The visual image of me started to change appearance so that I became (partly) transparent *

1	2	3	4
○	○	○	○

It felt as if the object was touching my body *

1	2	3	4
○	○	○	○

It seemed as if the touch I was feeling came from somewhere between my own body and the virtual body *

1	2	3	4
○	○	○	○

It appeared (visually) as if the virtual body was drifting backwards (towards the real body) *

1	2	3	4
○	○	○	○

How many feet away from you was the clock?

- ○ 0-4
- ○ 8-12
- ○ 12-16
- ○ 16+

OUT-OF-BODY EXPERIENCES (OBE) HAVE BEEN RECORDED BY RESEARCHERS AND DESCRIBED AS AN EXPERIENCE THAT INVOLVES OBSERVING ONE SELF'S PHYSICAL BODY FROM A THIRD PERSON PERSPECTIVE.

I felt in the first few minutes the effects of OBE. *

- Yes
- No

I felt within roughly five minutes of the effects of OBE. *

- Yes
- No

I felt at one point during the experiment the effects of OBE. *

- Yes
- No

I never felt the effects of OBE during the experiment. *

- Yes
- No

I have felt the effects of OBE before this experiment. *

- Yes
- No

Where was the researcher located? *

- To my left
- To my front left
- In front of me
- To my front right
- To my right

ON THE DESK IS A SHEET OF PAPER WITH AN APPROXIMATE LAYOUT OF THE ROOM THE EXPERIMENT TOOK PLACE IN. ANSWER THE FOLLOWING QUESTIONS WITH REGARD TO THE NUMBERED AREAS.

In what numbered location did you feel as if you were located. *

1 2 3 4 5 6 7 8

In what numbered location was your body most closely located. *

1	2	3	4	5	6	7	8
○	○	○	○	○	○	○	○

OTHER COMMENTS/QUESTIONS

Are there any other notes or comments about the experiment? Other topics that you don't feel were addressed?

Submit

SURVEY 2

This is a audio and visual cue experiment.

* Required

Answer the following questions.

1: Not at all 2: Slightly, somewhat true 3: mostly true 4: Most definitely true

I experienced that I was located at some distance behind the visual image of myself, almost as if I was looking at someone else. *

1	2	3	4
○	○	○	○

It felt as if my (real) body was drifting towards my virtual body. *

1	2	3	4
○	○	○	○

I felt as if my head and eyes were located at the same place as what I am seeing, and my body just below what I am seeing. *

1	2	3	4
○	○	○	○

I heard the person approaching me. *

1	2	3	4
○	○	○	○

I saw the person approaching me. *

1	2	3	4

I felt that I had two bodies *

1 2 3 4

I experienced that my body was located at two locations at the same time *

1 2 3 4

I experienced a movement-sensation that I was floating from my real body to the location of what I am seeing. *

1 2 3 4

I felt as if my head and body was at different locations, almost as if I had been 'decapitated' *

1 2 3 4

I did not feel that the sound was circling me but at some distance in space behind me *

1 2 3 4

It seemed as if the person was circling me. *

1 2 3 4

It seemed as though the sound I heard around me was caused by the person walking around my field of vision. *

1 2 3 4

I could no longer feel my body, it was almost as if it had disappeared *

1 2 3 4

The visual image of me started to change appearance so that I became (partly) transparent *

1 2 3 4

It felt as if my body was below my field of vision *

1 2 3 4

It seemed as if the sound I was hearing came from somewhere between my own body and the virtual body. *

1 2 3 4

It appeared (visually) as if the virtual body was drifting toward my physical body. *

1 2 3 4

○ ○ ○ ○

Out-of-body experiences (OBE) have been recorded by researchers and described as an experience that involves observing one self's physical body from a third person perspective.

I felt in the first few minutes the effects of OBE. *

○ Yes
○ No

I felt within roughly five minutes of the effects of OBE. *

○ Yes
○ No

I felt at one point during the experiment the effects of OBE. *

○ Yes
○ No

I never felt the effects of OBE during the experiment. *

○ Yes
○ No

I have felt the effects of OBE before. *

○ Yes
○ No

On the desk is a sheet of paper with an approximate layout of the room the experiment took place in. Answer the following questions with regard to the numbered areas.

In what numbered location were you located. *

1	2	3	4	5	6	7	8
○	○	○	○	○	○	○	○

In what location relative to you did person wearing the construction hat stop and wave at you from. *

○ In front of me

- To my left
- To my front left
- To my right
- To my front right
- Behind me
- I didn't see a person wearing a construction hat during the experiment

In what location relative to you did person wearing the mask and hat stop and wave at you from. *

- In front of me
- To my left
- To my front left
- To my right
- To my front right
- Behind me
- I didn't see a person wearing a construction hat during the experiment

In what location relative to you did person carrying the box stop and set down the box. *

- In front of me
- To my left
- To my front left
- To my right
- To my front right
- Behind me
- I didn't see a person wearing a construction hat during the experiment

In what numbered location did you feel your physical body was located. *

1	2	3	4	5	6	7	8
○	○	○	○	○	○	○	○

In what numbered location did you feel as if you were located *

1	2	3	4	5	6	7	8

Other comments/questions

Are there any other notes or comments about the experiment? Other topics that you don't feel were addressed?

Submit

ROOM LAYOUT DIAGRAM

This diagram accompanied the survey and was used for the location questions.

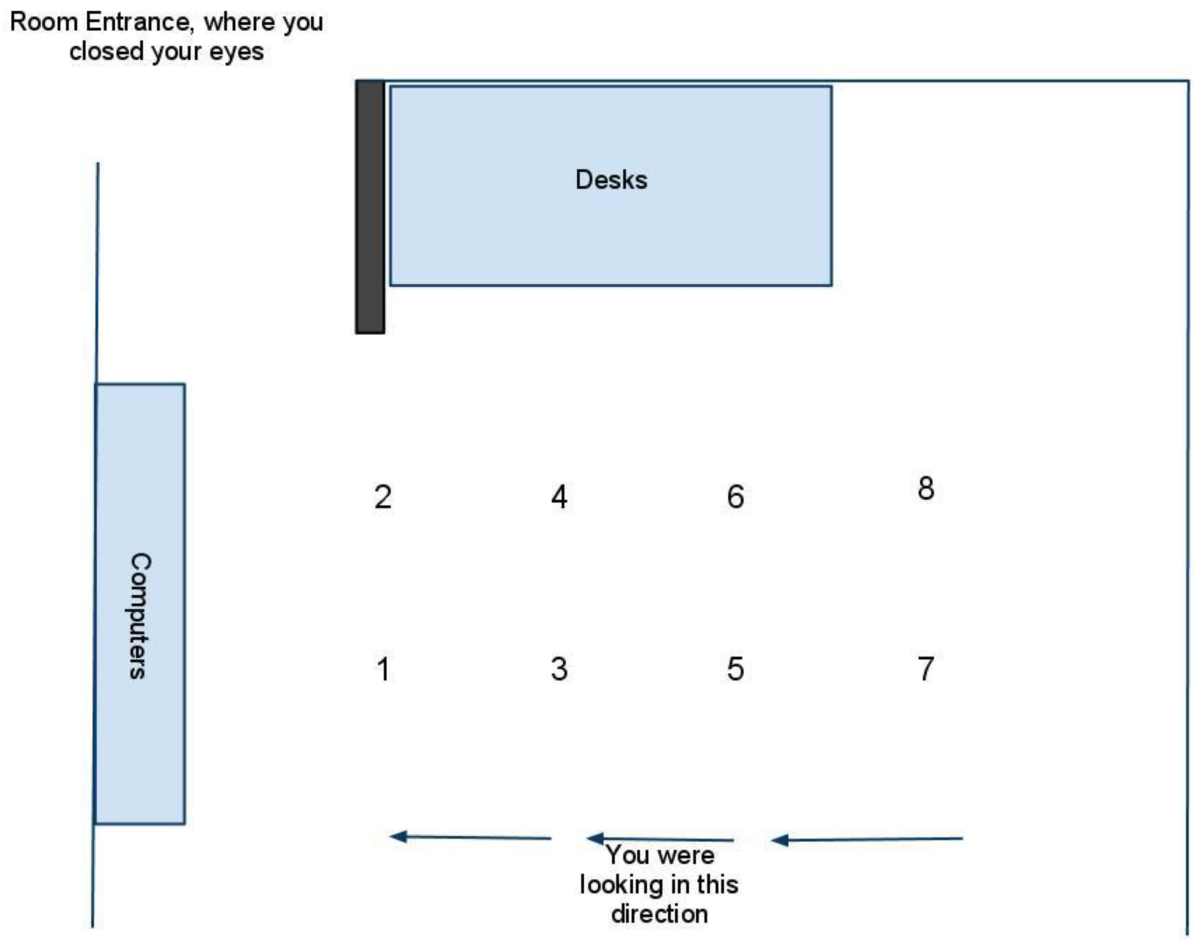

Figure 20 – Survey Body Location Reference

COMPLETE SURVEY DATA

Complete form data was not provided here to conserve space. Please email clausman@iastate.edu with any requests for the complete data set.

EXPERIMENT 1, CORRELATION MATRIX

Question#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1.00	0.00	0.78	0.28	-0.29	-0.42	-0.02	-0.27	-0.24	0.39	0.34	-0.05	0.48	0.38	0.09	-0.38
2	0.00	1.00	0.12	-0.33	0.38	0.49	0.30	0.55	0.49	-0.40	-0.33	0.33	0.33	-0.65	0.71	0.65
3	0.78	0.12	1.00	0.28	-0.01	-0.19	-0.05	-0.22	-0.04	0.33	0.42	0.04	0.58	0.04	0.29	-0.04
4	0.28	-0.33	0.28	1.00	0.06	-0.02	0.20	0.02	0.09	0.33	0.52	0.20	0.52	0.20	0.09	-0.20
5	-0.29	0.38	-0.01	0.06	1.00	0.94	0.49	0.83	0.65	-0.53	-0.35	0.51	0.15	-0.82	0.21	0.82
6	-0.42	0.49	-0.19	-0.02	0.94	1.00	0.46	0.88	0.70	-0.63	-0.42	0.58	0.06	-0.86	0.30	0.86
7	-0.02	0.30	-0.05	0.20	0.49	0.46	1.00	0.50	0.83	-0.73	-0.20	0.71	0.06	-0.44	0.48	0.44
8	-0.27	0.55	-0.22	0.02	0.83	0.88	0.50	1.00	0.65	-0.58	-0.30	0.54	0.17	-0.77	0.30	0.77
9	-0.24	0.49	-0.04	0.09	0.65	0.70	0.83	0.65	1.00	-0.78	-0.06	0.90	-0.06	-0.79	0.53	0.79
10	0.39	-0.40	0.33	0.33	-0.53	-0.63	-0.73	-0.58	-0.78	1.00	0.45	-0.62	0.27	0.60	-0.44	-0.60
11	0.34	-0.33	0.42	0.52	-0.35	-0.42	-0.20	-0.30	-0.06	0.45	1.00	0.06	0.15	0.27	-0.13	-0.27
12	-0.05	0.33	0.04	0.20	0.51	0.58	0.71	0.54	0.90	-0.62	0.06	1.00	-0.15	-0.69	0.40	0.69
13	0.48	0.33	0.58	0.52	0.15	0.06	0.06	0.17	-0.06	0.27	0.15	-0.15	1.00	0.06	0.53	-0.06
14	0.38	-0.65	0.04	0.20	-0.82	-0.86	-0.44	-0.77	-0.79	0.60	0.27	-0.69	0.06	1.00	-0.40	-1.00
15	0.09	0.71	0.29	0.09	0.21	0.30	0.48	0.30	0.53	-0.44	-0.13	0.40	0.53	-0.40	1.00	0.40
16	-0.38	0.65	-0.04	-0.20	0.82	0.86	0.44	0.77	0.79	-0.60	-0.27	0.69	-0.06	-1.00	0.40	1.00

Figure 21 – E1, Correlation Matrix

EXPERIMENT 2, CORRELATION MATRIX

Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	1.00	0.27	0.63	0.00	-0.10	0.63	0.53	0.23	0.12	0.16	0.29	0.16	0.26	0.21	0.52	0.58	0.32
2	0.27	1.00	0.13	-0.02	-0.12	0.36	0.43	0.47	0.12	-0.04	0.11	-0.21	0.15	-0.13	0.22	0.18	0.36
3	0.63	0.13	1.00	-0.17	-0.26	0.40	0.24	0.39	0.27	0.08	0.10	-0.02	0.46	0.46	0.47	0.21	0.50
4	0.00	-0.02	-0.17	1.00	0.68	0.21	0.19	0.10	-0.07	0.19	0.31	0.12	-0.32	-0.20	-0.14	-0.30	0.02
5	-0.10	-0.12	-0.26	0.68	1.00	-0.16	-0.21	0.24	0.01	0.20	0.03	-0.03	0.00	0.00	-0.19	-0.35	-0.08
6	0.63	0.36	0.40	0.21	-0.16	1.00	0.87	0.40	0.29	-0.01	0.29	0.12	0.04	0.18	0.27	0.30	0.14
7	0.53	0.43	0.24	0.19	-0.21	0.87	1.00	0.29	0.19	-0.08	0.28	0.08	0.00	0.13	0.28	0.33	0.05
8	0.23	0.47	0.39	0.10	0.24	0.40	0.29	1.00	0.48	-0.03	0.05	-0.18	0.57	0.46	0.23	0.00	0.24
9	0.12	0.12	0.27	-0.07	0.01	0.29	0.19	0.48	1.00	0.05	-0.34	-0.36	0.68	0.72	0.38	0.30	0.43
10	0.16	-0.04	0.08	0.19	0.20	-0.01	-0.08	-0.03	0.05	1.00	0.11	-0.41	-0.15	0.09	0.03	0.15	0.19
11	0.29	0.11	0.10	0.31	0.03	0.29	0.28	0.05	-0.34	0.11	1.00	0.48	-0.32	-0.10	-0.13	-0.15	0.10
12	0.16	-0.21	-0.02	0.12	-0.03	0.12	0.08	-0.18	-0.36	-0.41	0.48	1.00	-0.12	-0.06	0.02	0.12	-0.15
13	0.26	0.15	0.46	-0.32	0.00	0.04	0.00	0.57	0.68	-0.15	-0.32	-0.12	1.00	0.75	0.71	0.37	0.56
14	0.21	-0.13	0.46	-0.20	0.00	0.18	0.13	0.46	0.72	0.09	-0.10	-0.06	0.75	1.00	0.51	0.36	0.35
15	0.52	0.22	0.47	-0.14	-0.19	0.27	0.28	0.23	0.38	0.03	-0.13	0.02	0.71	0.51	1.00	0.67	0.64
16	0.58	0.18	0.21	-0.30	-0.35	0.30	0.33	0.00	0.30	0.15	-0.15	0.12	0.37	0.36	0.67	1.00	0.13
17	0.32	0.36	0.50	0.02	-0.08	0.14	0.05	0.24	0.43	0.19	0.10	-0.15	0.56	0.35	0.64	0.13	1.00

Figure 22 – E2, Correlation Matrix