# Viewing Media in stereo 3D produces a stronger emotional response than in equivalent 2D view

Group 7
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# Contents

# Design and Implementation Plan

The experiment was broken down into steps and an overview is available in appendix L).

## Software and Hardware

The 2D testing environment will be a 360° YouTube roller coaster ride video presented on an ordinary desktop computer screen. Users will not be able to interact with the video through the available mouse input. The content of choice will allow users to view the roller coaster ride from a first-person perspective, but the limitations on their view and ability to control the environment will put them in a position of a spectator who is not immersed in the environment. Content produced for 2D viewing purposes is not aimed to provide a sense of immersion or realism, which is why all interaction between participants and the video will be limited.

For the 3D testing environment, the same 360° YouTube roller coaster ride video will be presented on an Oculus Rift S device using the Veer software. The direction in which the user is looking will be detected by the Oculus sensors and participants will be able to look around and explore the environment independently. The combination of a 360° video and a VR headset was chosen for its immersive qualities with the intention to increase the sense of presence in users. This is to observe any potential connection between sense of presence and the self-reported strength of emotional response.

# Data Analysis Plan

The experiment will involve a control group of up to 15 people in a single control group. Dependent variable in the experimental context is the type of media presented in terms of its immersive capabilities and the sense of presence it evokes, while the dependent variables observed are the reported feelings of happiness, excitement and control, which represent the strength of emotional response. Paired-samples t-test will be used to gain insight on the subjective user experiences. The order in which the 2D and 3D alternative will be introduced to each participant will vary to ensure familiarity with the content does not affect the individual self-assessment.

The data collected through the SAM questionnaire (appendix C) will be put into table and bar chart format for visualization purposes. The mean scores of the group's reported sense of happiness, excitement, and control from their exposure to the 2D setting will be compared to the mean scores of these variables from their 3D experience to observe any statistical difference between the results. Furthermore, the standard deviation of the variables will be observed to calculate the statistical significance.

For the purpose of this study, strength of emotional response will be evaluated based on reported feelings of happiness and excitement. Data will be collected at two different stages, using three separate questionnaires with the aim to minimize Type I and Type II errors.

# Expected results

In the field of VR there is no clear connection observed between sense of presence and strength of emotional response, so presentation of media in 2D would have a similar impact to the alternative presentation in 3D.(H0) In an experimental setting, stereo 3D content presented in VR  is expected to show a significant increase of reported levels of happiness and/or excitement in users as compared to engaging with 2D media through a 2D screen.

(H1) To find the relationship between sense of presence and strength of emotional response, the self-reported feelings of happiness and excitement will be analysed for both the 2D video presentation and the more immersive Oculus Rift S alternative which enables for user interaction through head movement tracking done by the device's sensors. It is assumed the increased level of immersion and sense of presence would increase the strength of positive feelings and general excitement in subjects.

# Implementation of the test environment

## Software Description



The media that will be used for the experiment is a first person 360° view video of a roller coaster ride from YouTube and an application called Veer. 360° videos are created using omnidirectional cameras which capture a sphere around themselves. This means such videos provide viewers with an immersive experience and enable them to change their field of view. (Tang & Fakourfar, 2017) The video chosen is filmed from the perspective of a person riding a roller coaster.

For the 2D testing environment the user will not have any form of interaction with the media and will only engage with it as a spectator. 360° videos on YouTube provide the option to change the field of view using mouse input, which will not be disclosed to the participants in order to provide a two-dimensional experience.

The Veer application will further be used to present the same video through an Oculus Rift VR headset. This more interactive presentation will serve as the 3D experimental environment. The application allows the users to immerse themselves in the roller coaster video and engage in a more realistic experience. Users can interact with the media via head tracking which enables the user to look around like they would be able to do on an actual roller coaster. That way users would be able to experience the video in its full immersive potential.

# Data Collection Method

The primary questionnaire will gather information about the participants past experiences with virtual reality and roller coasters. This would identify the presence of any relevant phobias that would impact the test. The questionnaire will further ensure participants have not previously experienced nausea, anxiety or any other side effect, induced by VR exposure.

Majority of the data that would be used for statistical analysis would be the participants' self-reported feelings of happiness, excitement and control, using the Self-Assessment Manikin (SAM) pictorial questionnaire. This was chosen for its qualities of an easy and efficient means to assess emotional response in 3 dimensions through graphical representations of each type of emotion. (Bradley & Lang, 1994). The data collected underneath each variable name will be used as a measure of strength of emotional response in the context of this study.

The secondary questionnaire will be completed after participants have completed their SAM questionnaires. This would determine what the most important factors were that made the environments more or less immersive and if the participants have any suggestions that could potentially improve the level of immersion. Most importantly, the questionnaire will show their preferences in terms of 3D stereo media qualities compared to its 2D alternative.

# Data Analysis

Once the data was collected through the use of surveys, a spreadsheet was populated, splitting up 2D and 3D setting data. The tables were split into three sections to cover the emotions that were being examined in the SAM questionnaires. The columns of the table showed the emotional strength rating so that it is clear which rating was selected by how many users.

After the data was collected in one area, it allowed for direct emotion comparison to be done in the form of bar charts. This allowed for the overall strength of emotion that the participants experienced to be observed.

| 2D Setting | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Happiness | 0 | 0 | 3 | 3 | 4 | 0 | 1 | 0 | 1 |
| Control | 2 | 0 | 1 | 0 | 4 | 2 | 0 | 2 | 1 |
| Excitement | 5 | 1 | 0 | 4 | 0 | 0 | 2 | 0 | 0 |

| 3D Setting | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Happiness | 1 | 0 | 0 | 0 | 1 | 6 | 2 | 2 | 0 |
| Control | 1 | 1 | 0 | 1 | 6 | 1 | 1 | 1 | 0 |
| Excitement | 0 | 0 | 2 | 0 | 3 | 3 | 2 | 2 | 0 |

The overall number of participant responses collected during the testing stage of this experiment was 12 with each participant filling in all four questionnaires. In terms of the sense of immersion and sense of presence, participants were asked to identify the qualities of both types of media that made their experience more immersive. Five out of twelve respondents stated that the amount of interaction they had with the content made the video presentation in VR more immersive. Four respondents further identified the overall video quality as a factor impacting the sense of immersion induced. Despite this, eleven out of twelve agreed their level of engagement and the sense of presence was higher during their interaction with the stereo 3D media in VR than with its 2D alternative.

The strength of emotional response was measured in 3 dimensions as suggested by the SAM questionnaire. These dimensions were happiness, excitement, and sense of control. The respondent answers were collected, and statistical analysis was performed on each variable for both types of media. Paired-sample t-tests were performed for the happiness, excitement and sense of control measurements collected from the participants. This was to show if the subjective strength of emotional response induced differed between the two types of media.
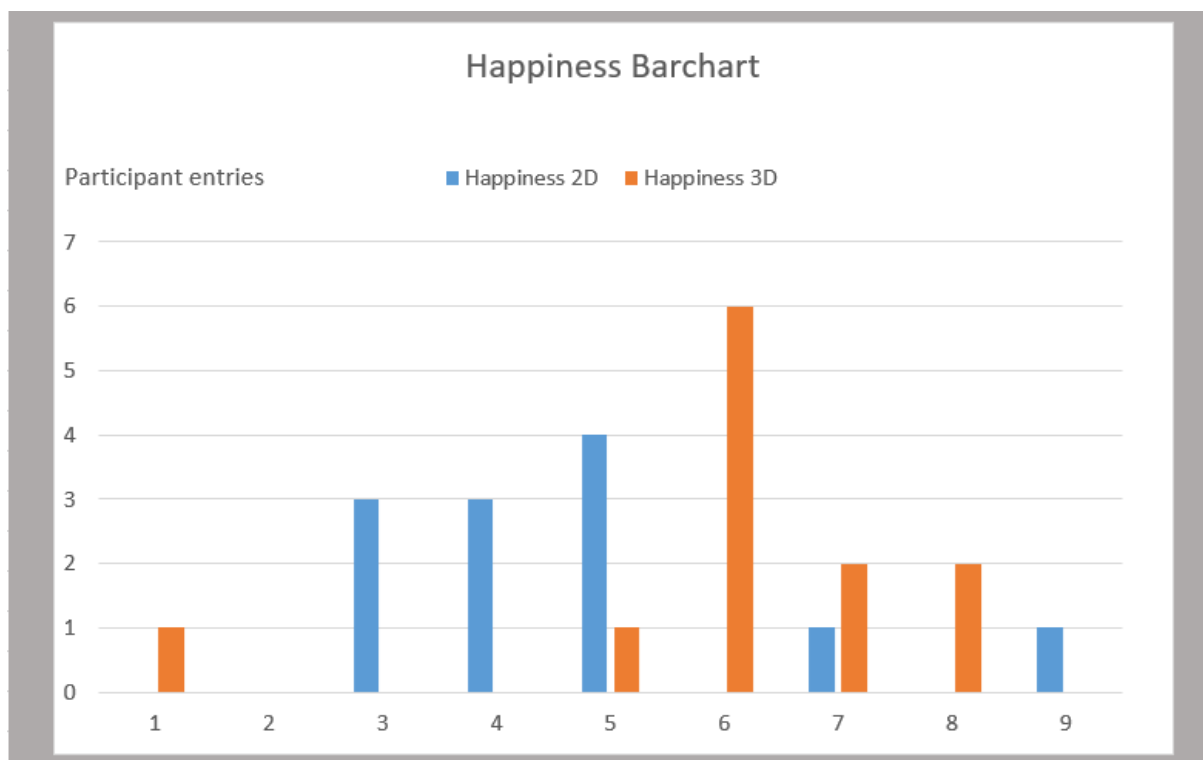
In the happiness dimension, bar charts showed a higher number identifying their feelings during the 3D media presentation as positive compared to a higher number of participants stating their feelings were neutral or negative during the alternative 2D presentation. With a p-value of 0.01, the t-value for this measurement was 1.71 which is much lower than the critical value of 2.07 which implies no statistical significance of the differences observed between the measurement scores for the two types of media, despite the visual differences in the bar charts. The mean score for the happiness measurement in the 2D presentation was 4.75, while for the 3D one it was 6. The standard deviation of the scores from the 2D setting was 1.76 compared to 1.81 for the 3D video presented in VR.

| | Happiness | |
| --- | --- | --- |
| | 2D | 3D |
| | 3 | 1 |
| | 3 | 5 |
| | 3 | 6 |
| | 4 | 6 |
| | 4 | 6 |
| | 4 | 6 |
| | 5 | 6 |
| | 5 | 6 |
| | 5 | 7 |
| | 5 | 7 |
| | 7 | 8 |
| | 9 | 8 |
| Mean | 4.75 | 6 |
| StDev | 1.76455 | 1.80907 |
| Variance | 3.11364 | 3.27273 |
| n | 12 | 12 |

| Value | Happiness |
| --- | --- |
| t-value | 1.713459384 |
| Critical value | 2.07 |
| T-TEST: | 0.011154325 |

| Emotion Strength | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Happiness 2D | 0 | 0 | 3 | 3 | 4 | 0 | 1 | 0 | 1 |
| Happiness 3D | 1 | 0 | 0 | 0 | 1 | 6 | 2 | 2 | 0 |
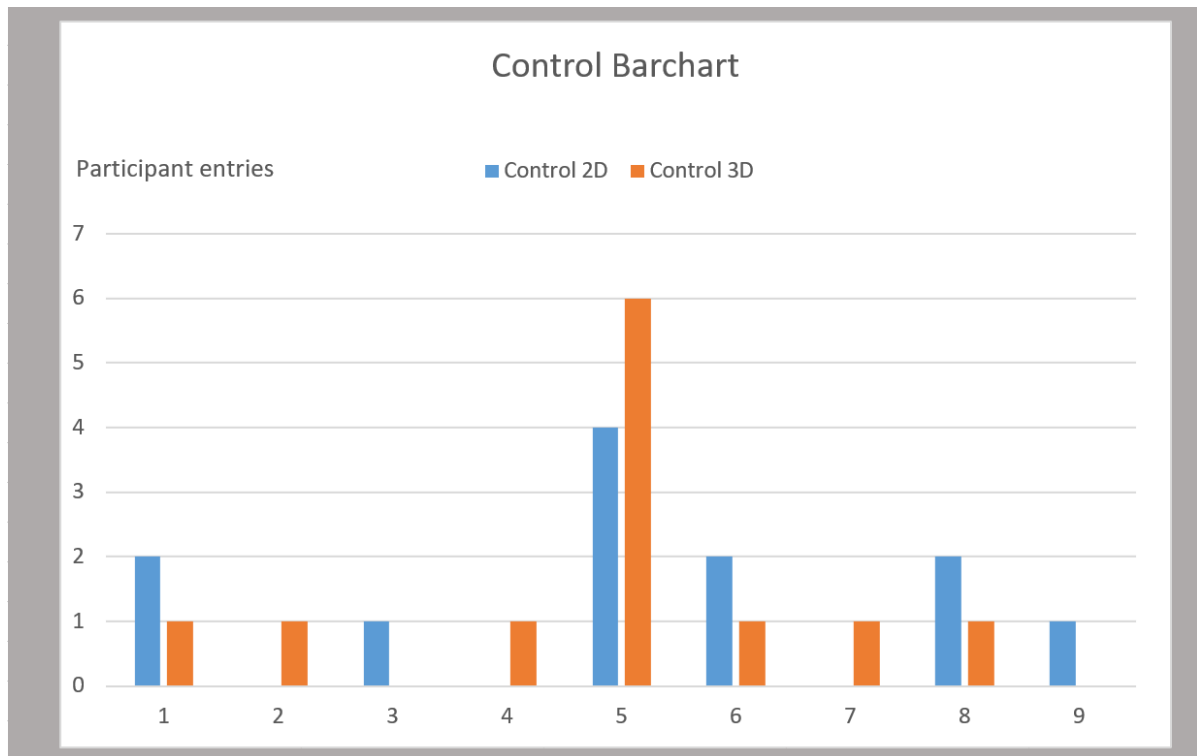
Control Barchart

In terms of sense of control, bar chart distribution seems comparatively even and the performed t-test further confirmed this. The p-value for the sense of control measurements of the two groups was 0.22. This meant the t-value of 0.37 had to be compared against the critical value of 2.07 per the t-table used, which again showed no statistical significance. Interestingly, at 5.17 the mean score for the sense of control participants reported for their 2D experience was higher than the mean score of the reported feelings from the 3D setting which was only 4.83. The standard deviation of 2.55 for the scores from the 2D presentation was much higher meaning the data was much more dispersed in relation to the mean score than it was for the 3D presentation with a standard deviation of 1.90.

|  | Control | |
|---|---|---|
|  | 2D | 3D |
|  | 1 | 1 |
|  | 1 | 2 |
|  | 3 | 4 |
|  | 5 | 5 |
|  | 5 | 5 |
|  | 5 | 5 |
|  | 5 | 5 |
|  | 6 | 5 |
|  | 6 | 5 |
|  | 8 | 6 |
|  | 8 | 7 |
|  | 9 | 8 |
| Mean | 5.166667 | 4.833333 |
| StDev | 2.552479 | 1.898963 |
| Variance | 6.515152 | 3.606061 |
| n | 12 | 13 |

| Value | Control |
|---|---|
| t-value | 0.368033603 |
| Critical value | 2.07 |
| t-test(p-value) | 0.219887843127559 |

| Emotion Strength | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Control 2D | 2 | 0 | 1 | 0 | 4 | 2 | 0 | 2 | 1 |
| Control 3D | 1 | 1 | 0 | 1 | 6 | 1 | 1 | 1 | 0 |
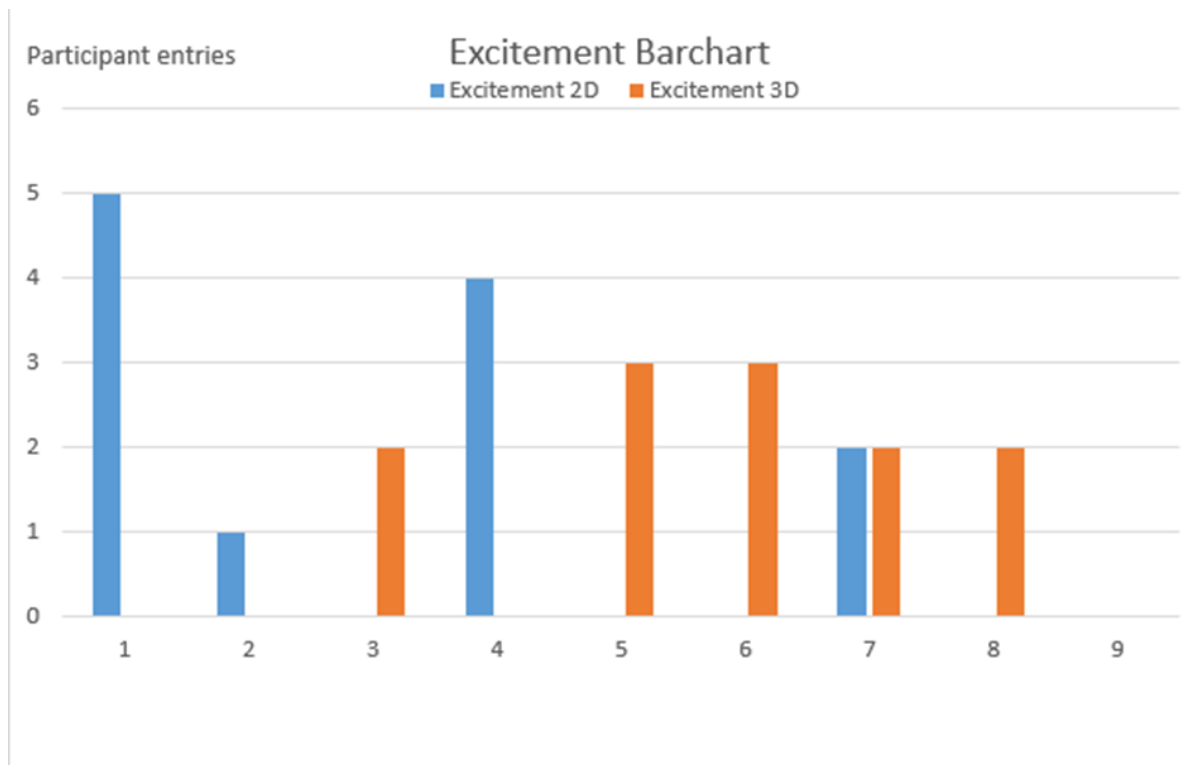
Finally, the t-test performed on the excitement dimension as reported by participants showed that the difference in data collected from the two presentations showed a statistical significance, which was also apparent from the bar chart visualization. The p-value from the t-test was a surprising value of 0.0000006532. The t-value calculated using the data's mean scores, variance and number of participants were 3.28 which is significantly higher than the critical value of 2.07.

The mean scores for the measurement in the two settings were also apparently different with excitement induced from the 2D presentation scoring 3.08 on average and excitement scores from the 3D alternative amounting to 5.75 on average. It is also important to note that the standard deviation of the results from the 2D setting was much higher at 2.27, while for the 3D one it was 1.66.

|  | Excitement | |
| --- | --- | --- |
|  | 2D | 3D |
|  | 1 | 3 |
|  | 1 | 3 |
|  | 1 | 5 |
|  | 1 | 5 |
|  | 1 | 5 |
|  | 2 | 6 |
|  | 4 | 6 |
|  | 4 | 6 |
|  | 4 | 7 |
|  | 4 | 7 |
|  | 7 | 8 |
|  | 7 | 8 |
| Mean | 3.08333 | 5.75 |
| StDev | 2.2747 | 1.65831 |
| Variance | 5.17424 | 2.75 |
| n | 12 | 12 |

| Value | Excitement |
| --- | --- |
| t-value | 3.281560977 |
| Critical value | 2.07 |
| t-test(p-value) | 0.00000653221715538473 |

| Emotion Strength | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Excitement 2D | 5 | 1 | 0 | 4 | 0 | 0 | 2 | 0 | 0 |
| Excitement 3D | 0 | 0 | 2 | 0 | 3 | 3 | 2 | 2 | 0 |

# Statement of Significance/Conclusions

Similarly, to previous studies, the results from this experiment concluded that the sense of realism and level of engagement is increased from viewing media in 3D rather than its 2D alternative. (Rooney & Hennessy, 2013) Participant responses also suggested that the sense of presence is mostly dependent on the amount of interaction between the viewer and the environment as concluded by Felnhofer et al. (2015). The equipment chosen for the presentation of the stereo 3D video was an Oculus Rift S headset, which was chosen in relation to a statement made by Kruijff et al. (2017) that there is a thin line between the strength of emotional response and the sense of presence in immersive systems.

The results of the experiment can be used to confirm the correctness of this statement as participants all agreed the use of a VR headset increased the subjective sense of presence, while statistical analysis showed a significant statistical difference between excitement levels in users when presented with 2D and stereo 3D media using VR equipment. For two of the emotional response measurements, the scores reported by the user did not suggest any statistical difference that could invalidate the original H0. The third dimension in the form of the excitement measure changes this as it implies the 3D setting induced a stronger emotional response in the majority of the participants.

As stated previously, all participants agreed the 3D setting provided an increased sense of presence in them as subjective viewers. This when considered along the reported increase in excitement levels in the 3D setting suggests that H1 is correct, and an increased sense of presence implies a stronger emotional response in viewers in terms of excitement induced. The significance of these results stems from the questions they raise about the subjective experience of users with 2D, and 3D media and the impact immersive technology has on the sense of presence and levels of engagement in individuals.

Previous studies looked at different groups of people, which did not necessarily answer these questions about subjective users' preferences. The experiment revealed users seek better experiences and the way to provide that is through an increased sense of presence induced by media. The realism of stereo 3D media and the use of immersive systems for presentation seems to be the key to user engagement and excitement and thus might be the key to increasing user satisfaction of consumers of all types of media in the future.

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Tang, A. & Fakourfar, O. (2017) Watching 360 videos together. *Proceedings of the 2017 CHI conference on human factors in computing systems*, Calgary, 2 May 2017, 4501-4506. Available online: http://www.hcitang.org/papers/2017-chi2017-watching360video.pdf [Accessed 30/11/2021].

## Appendix

A)

Questionnaire 1

1. Have you previously interacted with media presented on an Oculus Rift S headset? (Please select one option)

   Yes: ☐          No: ☐

2. To the best of your knowledge, have you experienced nausea, dizziness, disorientation, or any type of motion-sickness related to virtual environment exposure? (Please select one option)

   Yes: ☐          No: ☐

3. Do you have any previous negative experiences with roller coasters? (Please select one option)

   Yes: ☐          No: ☐

4. Do you consider yourself to have a fear of heights? (Please select one option)

   Yes: ☐          No: ☐

   **If your response to any of questions 2 – 4 was 'Yes' you might opt out of taking part in this experiment.**

B)

Questionnaire 2

1. Have you experienced any nausea, dizziness, disorientation, or any type of motion-sickness during the experiment ? (Please select one option)

   Yes: ☐          No: ☐

2. Have you experienced any other side effects during the experiment that have concerned you? (Please select one option)

Yes: ☐          No:  ☐

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3. Did you feel more engaged or immersed in the 3D stereo media compared to the 2D counterpart? (Please select one option)

Yes: ☐          No:  ☐


4. Do you have any suggestions or recommendations for the experiment that could potentially improve the level of immersion or emotional affect? (If yes, please fill out the textbox)

Yes: ☐          No:  ☐

…………………………………………………………………………………………………...

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In your opinion, what has made the media exposed to you immersive or non-immersive ?

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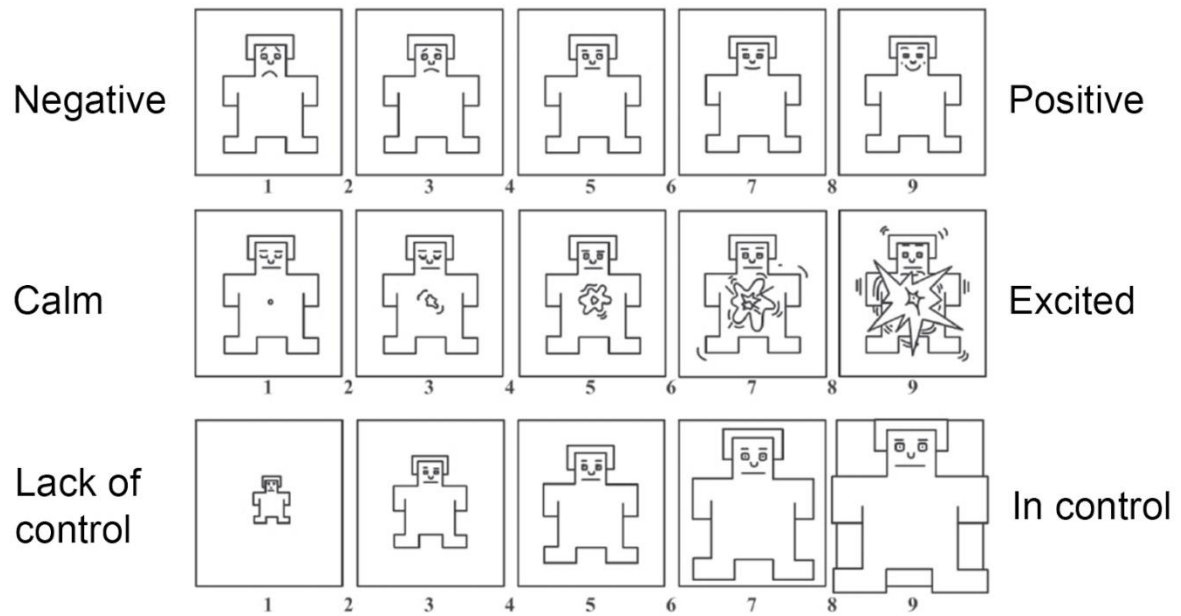…………………………………………………………………………………………………

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C)

Self-Assessment Manikin (SAM)



D)
Happiness Chart

E)

Excitement Chart
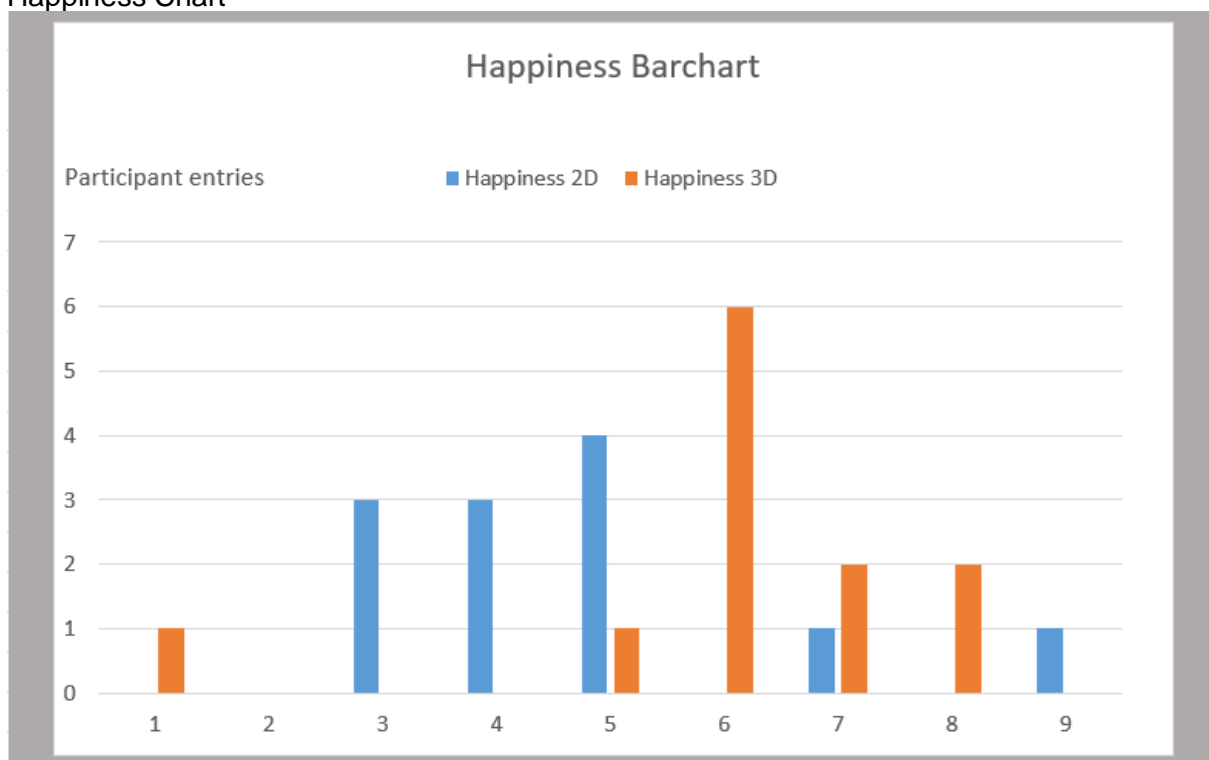


Excitement Barchart

F)
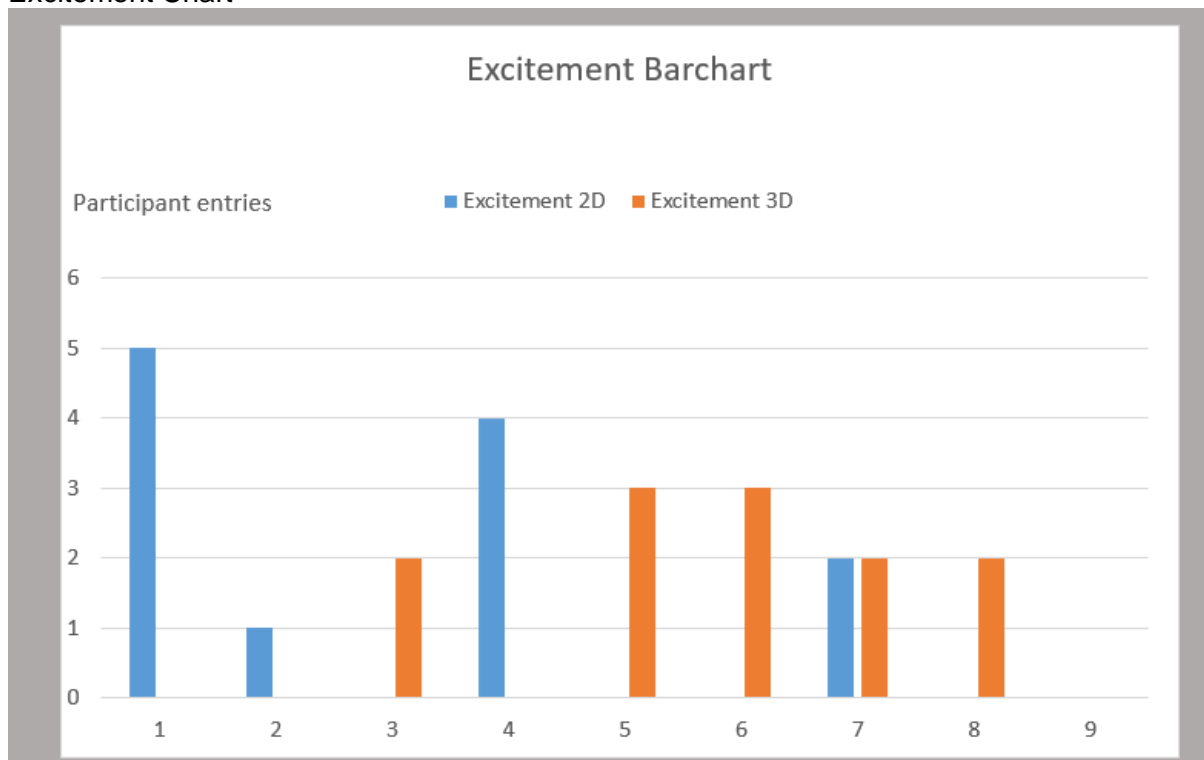
Control Chart



Control Barchart
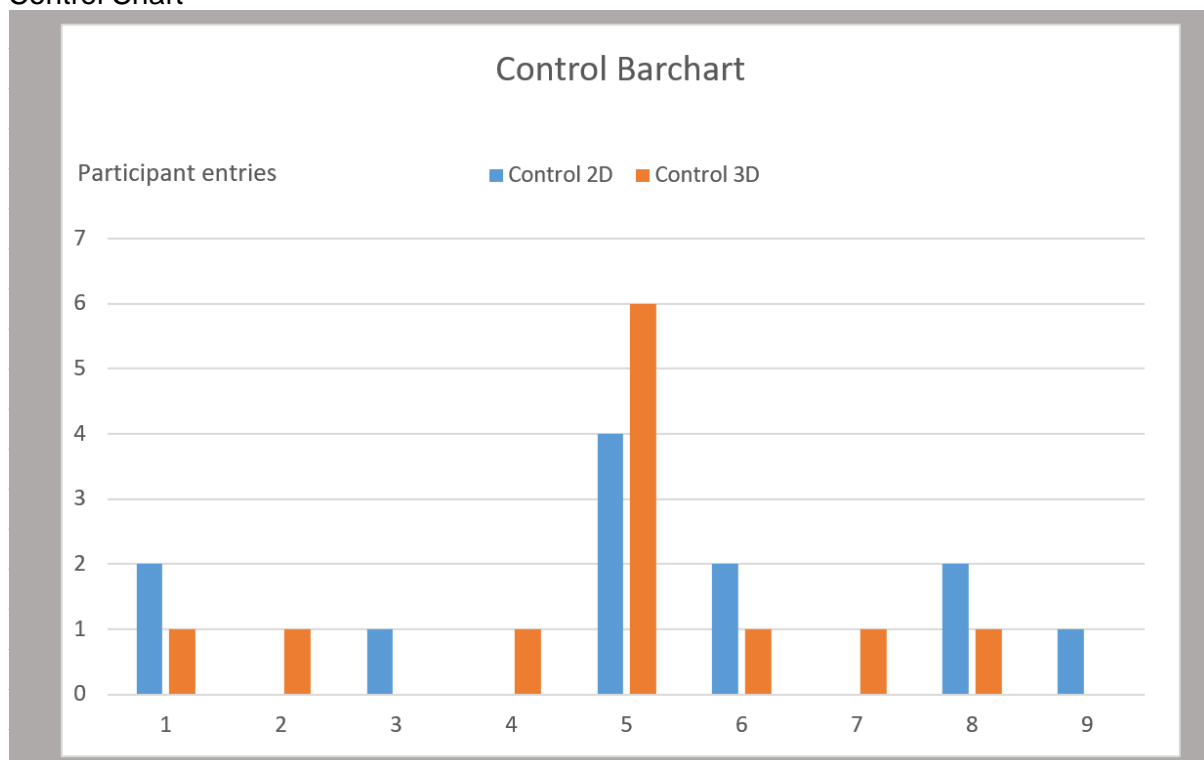
## G)

### Values for T-Test

| | H2D | H3D | | E2D | E3D | | C2D | C3D |
|---|---|---|---|---|---|---|---|---|
| | 3 | 1 | | 1 | 3 | | 1 | 1 |
| | 3 | 5 | | 1 | 3 | | 1 | 2 |
| | 3 | 6 | | 1 | 5 | | 3 | 4 |
| | 4 | 6 | | 1 | 5 | | 5 | 5 |
| | 4 | 6 | | 1 | 5 | | 5 | 5 |
| | 4 | 6 | | 2 | 6 | | 5 | 5 |
| | 5 | 6 | | 4 | 6 | | 5 | 5 |
| | 5 | 6 | | 4 | 6 | | 6 | 5 |
| | 5 | 7 | | 4 | 7 | | 6 | 5 |
| | 5 | 7 | | 4 | 7 | | 8 | 6 |
| | 7 | 8 | | 7 | 8 | | 8 | 7 |
| | 9 | 8 | | 7 | 8 | | 9 | 8 |
| Mean | 4.75 | 6 | | 3.08333 | 5.75 | | 5.16667 | 4.83333 |
| StDev | 1.76455 | 1.80907 | | 2.2747 | 1.65831 | | 2.55248 | 1.89896 |
| Variance | 3.11364 | 3.27273 | | 5.17424 | 2.75 | | 6.51515 | 3.60606 |
| n | 12 | 12 | | 12 | 12 | | 12 | 13 |

## H)

### T-Test results

| Value | Happiness | Excitement | Control |
|---|---|---|---|
| t-value | 1.713459384 | 3.281560977 | 0.368033603 |
| Critical | 2.07 | 2.07 | 2.07 |
| T-TEST: | 0.011154325 | 0.00000653221715538473 | 0.219887843127559 |

## I)

### Emotion Strength Comparison

| Emotion Strength | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Happiness 2D | 0 | 0 | 3 | 3 | 4 | 0 | 1 | 0 | 1 |
| Happiness 3D | 1 | 0 | 0 | 0 | 1 | 6 | 2 | 2 | 0 |

| Emotion Strength | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Control 2D | 2 | 0 | 1 | 0 | 4 | 2 | 0 | 2 | 1 |
| Control 3D | 1 | 1 | 0 | 1 | 6 | 1 | 1 | 1 | 0 |

| Emotion Strength | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Excitement 2D | 5 | 1 | 0 | 4 | 0 | 0 | 2 | 0 | 0 |
| Excitement 3D | 0 | 0 | 2 | 0 | 3 | 3 | 2 | 2 | 0 |

J)

T table used



| Degrees of Freedom | p=0.05 | p=0.025 | p=0.01 |
|---|---|---|---|
| 1 | 12.71 | 25.45 | 63.66 |
| 2 | 4.30 | 6.20 | 9.92 |
| 3 | 3.18 | 4.17 | 5.84 |
| 4 | 2.78 | 3.50 | 4.60 |
| 5 | 2.57 | 3.16 | 4.03 |
| 6 | 2.45 | 2.97 | 3.71 |
| 7 | 2.36 | 2.84 | 3.50 |
| 8 | 2.31 | 2.75 | 3.36 |
| 9 | 2.26 | 2.68 | 3.25 |
| 10 | 2.23 | 2.63 | 3.17 |
| 11 | 2.20 | 2.59 | 3.11 |
| 12 | 2.18 | 2.56 | 3.05 |
| 13 | 2.16 | 2.53 | 3.01 |
| 14 | 2.14 | 2.51 | 2.98 |
| 15 | 2.13 | 2.49 | 2.95 |
| 16 | 2.12 | 2.47 | 2.92 |
| 17 | 2.11 | 2.46 | 2.90 |
| 18 | 2.10 | 2.44 | 2.88 |
| 19 | 2.09 | 2.43 | 2.86 |
| 20 | 2.09 | 2.42 | 2.84 |
| 21 | 2.08 | 2.41 | 2.83 |
| 22 | 2.07 | 2.41 | 2.82 |
| 23 | 2.07 | 2.40 | 2.81 |
| 24 | 2.06 | 2.39 | 2.80 |
| 25 | 2.06 | 2.38 | 2.79 |
| 26 | 2.06 | 2.38 | 2.78 |
| 27 | 2.05 | 2.37 | 2.77 |
| 28 | 2.05 | 2.37 | 2.76 |
| 29 | 2.04 | 2.36 | 2.76 |
| 30 | 2.04 | 2.36 | 2.75 |

K)

https://www.surveymonkey.co.uk/r/YTJKKZM - Questionnaire 1

https://www.surveymonkey.co.uk/r/YTGR8JP - Questionnaire 2

https://www.surveymonkey.co.uk/r/YMCS2D7 - SAM Questionnaire 2D

https://www.surveymonkey.co.uk/r/YMSZRX7 - SAM Questionnaire 3D

## L)

## Experiment steps

Overview of the experiment

- ° Inform participants they can withdraw their responses at any time

- ° Inform participants they can quit, if they feel uncomfortable

Collect information about users general experiences

- ° Have they experienced nausea/or other discomfort due to VR exposure before?

Participants are shown 2d/3d version of the media of choice

Re-sanitize headset between participants

SAM questionnaire (Figure 1)

Additional questionnaire

- ° Feedback on the participants' experience during the experiment
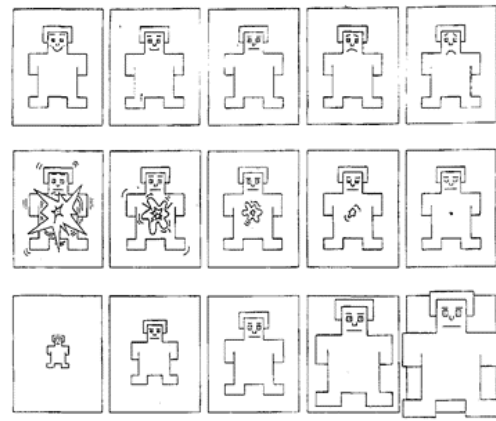
- ° Reported sense of presence and comfort/discomfort



Figure 1 - Self-Assessment Manikin (SAM)