Kanazawa Izummigaoka High School

Physical and Psychological Effects of Virtual Reality

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Abstract

VR (virtual reality) provides a person with virtual information and allows users to have a simulated experience. The purpose of this study is to clarify the difference in physical and psychological effects between using a VR device and a computer. To measure physical and psychological effects, we measured heart rate, calculation skills and how emotions changed. Heart rate increased and emotions were more variable after using VR. From this experiment, we found that stronger psychological effects can be expected from viewing videos using VR.

1.Introduction

VR is a way to experience virtual reality by putting on a HMD (Head Mounted Display) and getting visual information in 360 degrees. Humans get 87% of their information from their eyes. Therefore we assumed that visual information has a significant impact on our psychological and physical health. One example comes from a medical institution in Australia that is using VR as a tool to provide distraction therapy. By showing cancer patients images of nature, activities, and other less everyday scenes, the purpose of this therapy is to reduce stress caused by the physical effects of cancer. However, there are no studies that have quantified and objectively shown the psychological and physical effects of visual information using VR. In addition to VR, there are other means of obtaining visual information, such as via computers, television, and Augmented Reality - which is information in virtual space superimposed on the real world - but the differences in the psychological and physical effects of these and VR have not been clarified. In this study, we will use VR and a Chrome book to clarify the differences in the psychological and physical effects of the same visual information on both devices, and the essential characteristics of VR.

2.Hypothesis

VR is characterized by the ability to wear an HMD to block out other visual information and get 360-degree visual information. Chromebooks, on the other hand, have a narrower field of view and other visual information comes in. Because of this, we believe that VR has a greater impact on psychological and physical effects.

picture1 (Tsujiguchi wearing HMD)

3.Method 1

We recruited subjects from Izumigaoka High School and divided the 44 students into five groups. Each of these five groups were in turn divided into two groups, VR-first group and Chromebook-first group.

Participants watched the same 1 minute and 30 seconds of video twice in total, in the order of VR and Chromebook for the VR-first group, and Chromebook, VR for the Chromebook-first group. Five different videos were used for each group: A roller coaster, B horror (walking in the dark), C forest, D ocean, and E starry sky. The videos were played - one to each person - without sound to reveal the influence of visual information only.

Heart rate and calculation ability were measured before watching the videos. Heart rate was measured in order to objectively capture changes in psychological state. Changes in psychological state, i.e. emotional changes affect the sympathetic and parasympathetic nervous system functions. When calm, the parasympathetic nervous system suppresses the heart rate, and when excited, the parasympathetic nervous system increases the heart rate. Heart rate was measured using the "Stress Measurement" smartphone application. The heart rate was measured in order to capture physical effects: participants were asked to fill in simple addition tables for 30 seconds, and the number of questions answered correctly was used as the score. The physical effect of the calculation was measured because it is a familiar and simple task. All subjects were subjected to the same psychological burden.

After the second viewing of the video, the Multiple Emotional State Scale was used to objectively capture changes in emotion, showing 44 main adjectives describing emotions. The ratings of feeling nothing at all', 'feeling almost nothing', 'feeling a little' and 'feeling clearly' in each item obtained from the Multiple Emotional State Scale were converted into a score from 1 to 4 points.

Heart rate and computational processing ability were measured three times: before watching the video, after watching the first video, and after watching the second video. Emotional changes were examined after the first and second video viewing.

4. Experimental results 1

1) Change in heart rate

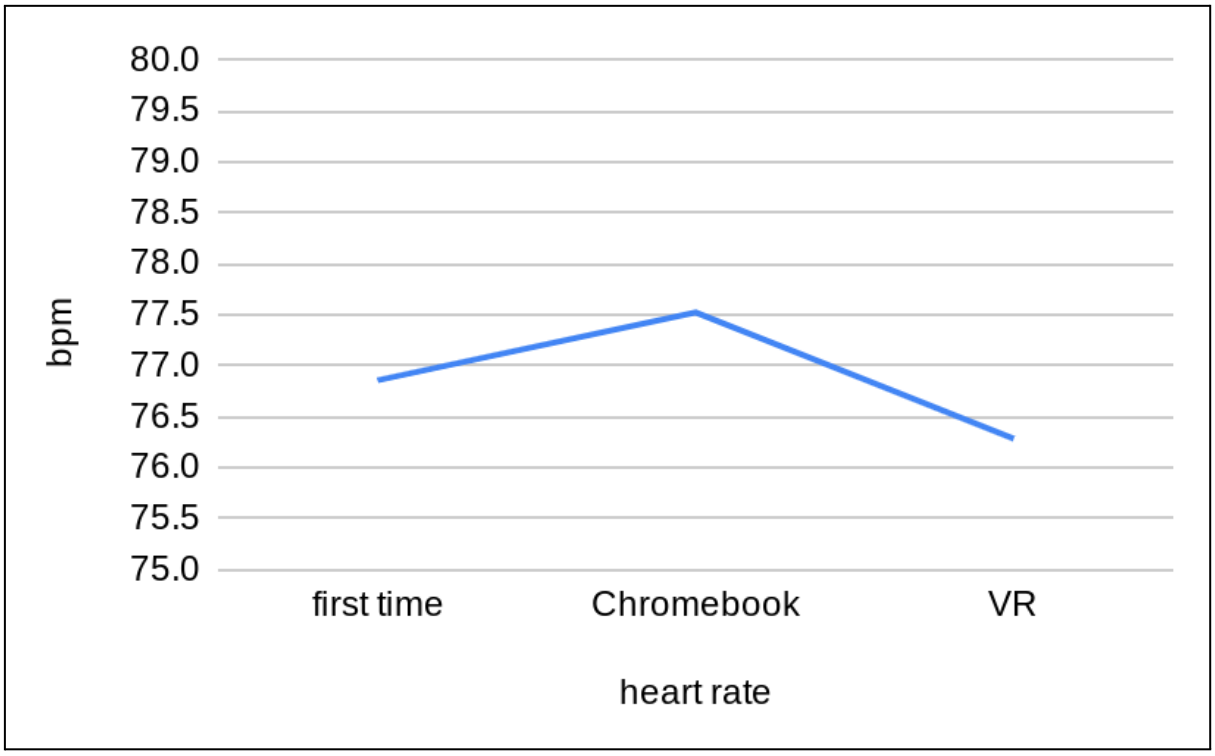
Figures 1 and 2 show graphs of the changes in the average heart rate of 44 subjects before and after watching the video using the VR or Chromebook.

When the VR was viewed first, the average heart rate after viewing the VR increased by 3 bpm from before viewing. Then, after watching the Chromebook, the average heart rate went down by 1 bpm. (Figure 1)

When the Chromebook was viewed first, the heart rate increased by 0.5 bpm after viewing the Chromebook. After viewing the VR, the heart rate went down by 2 bpm. (Figure 2)

The standard deviation of the change in heart rate was 5.588 for the VR viewing and 10.62 for the Chromebook viewing. The standard deviation of the change in heart rate was 5.588 for the VR viewing and 10.62 for the Chromebook viewing, indicating that the degree of data scatter was smaller for the change in heart rate caused by the VR viewing than for the Chromebook viewing.

fig.1



2) Emotional changes

For each of the five videos, eight emotions were quantified after viewing the video, and the averages were illustrated in a bar graph. When processing the data, the score for each item in the normal state was set to zero, and each question was given a score of one to three points, with a maximum of 15 points since there were five questions per item. The red bar graph shows the average score after viewing the Chromebook, and the blue bar graph shows the average score after viewing the VR.

In Roller Coaster (A), active pleasure was the highest in both Chromebook and VR, and active pleasure and surprise were more than two points higher in VR than in Chromebook. In addition, the values of anxiety, hostility, affinity, and concentration were larger in VR than in Chromebook. (Figure 3)

In Horror (B), the VR values were higher than the Chromebook values in the following categories: Anxiety, Active Pleasure, Affinity, Concentration, and Startle. There was not much of a trend in the comparison of each emotional item. (Figure 4)

In Forest (C), the numerical value of the Inactive Pleasure item with VR is outstandingly large. (Fig. 4) In the forest of C, the value of Inactive pleasure of VR is much larger than that of VR, and the value of Fatigue of Chromebook is larger than that of VR. (Figure 5)

In Sea (D), the Chromebook's inactive pleasure value was the largest, and in contrast to the other videos, there were five items with larger values on the Chromebook than on the VR: anxiety, fatigue, inactive pleasure, affinity, and concentration. (Figure 6)

In Star (E), the VR values were higher than the Chromebook values for all items except hostility. (Figure 7)

fig. 2

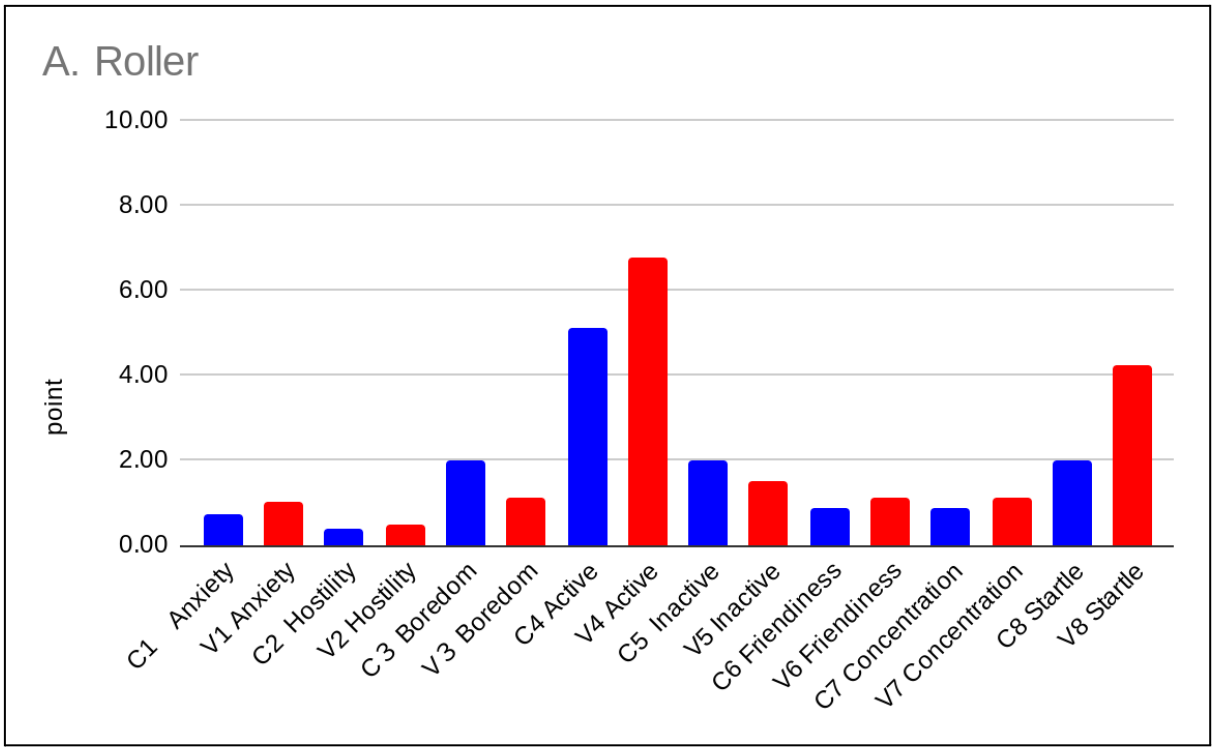
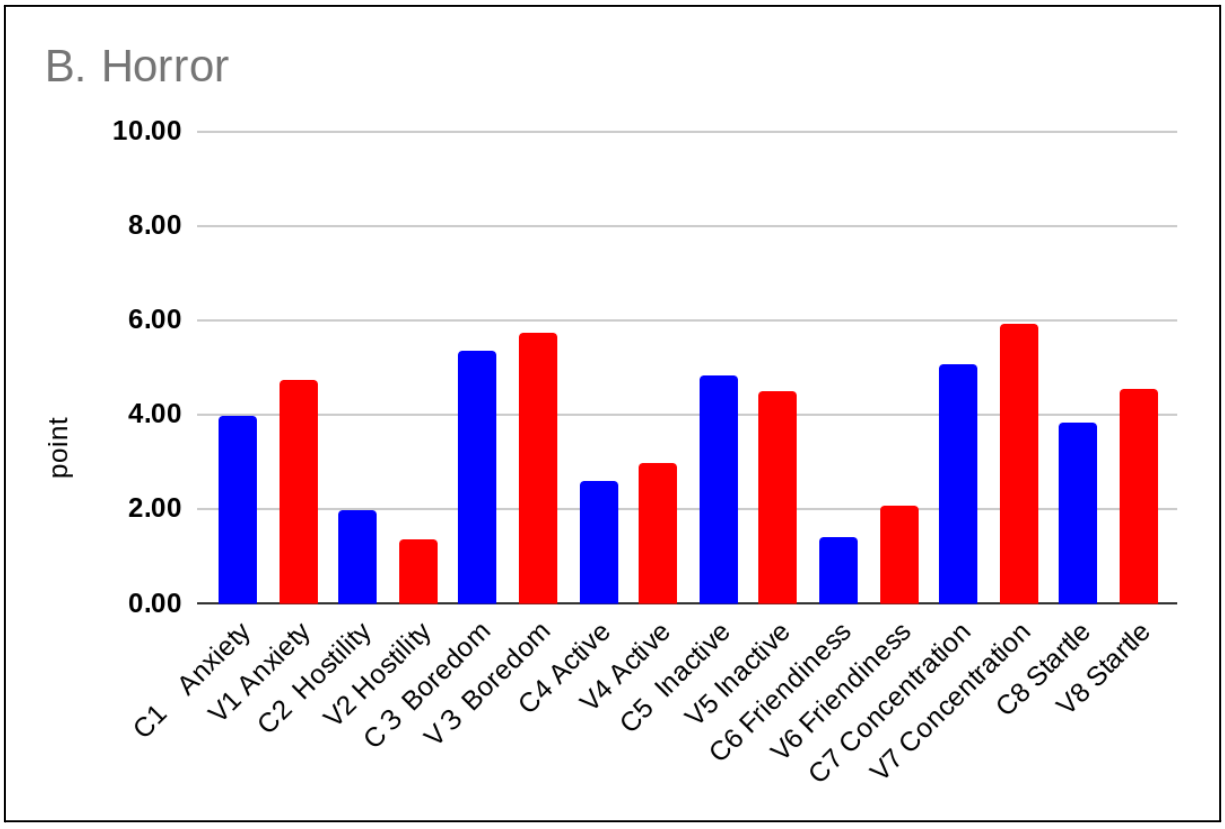


fig.3


B. Horror
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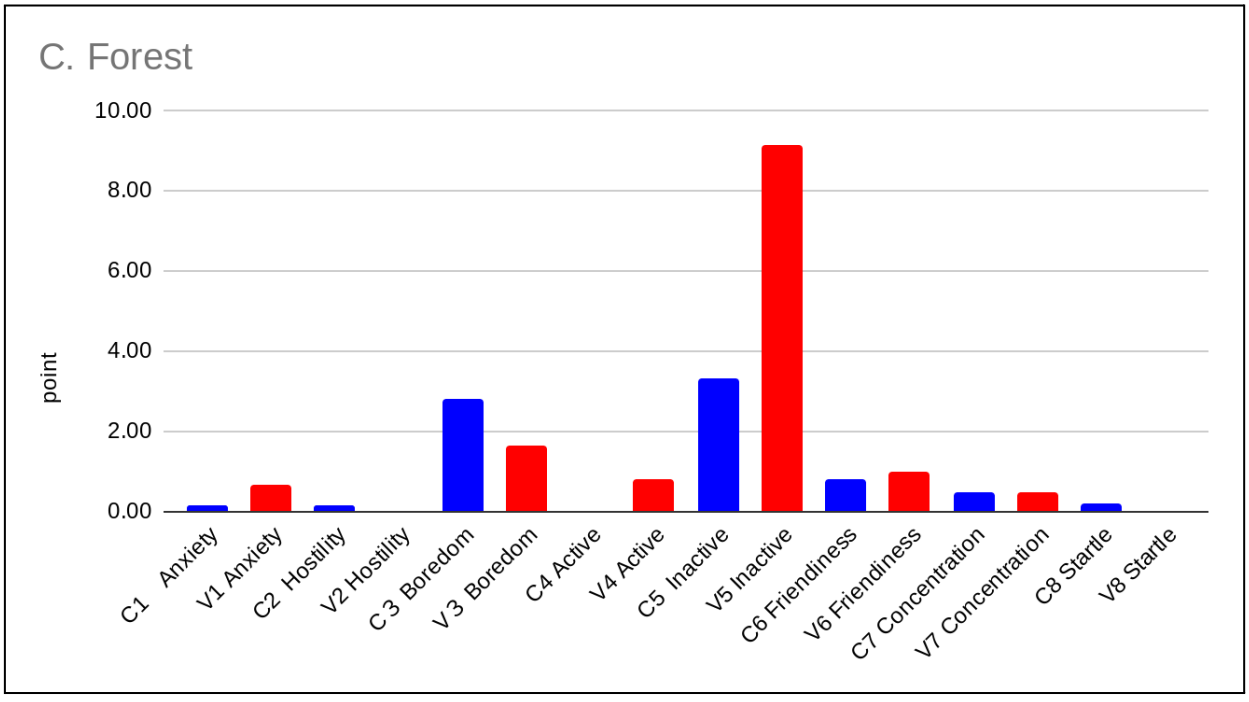
6.00
4.00
2.00
0.00
point
C1 Anxiety
V1 Anxiety
C2 Hostility
V2 Hostility
C 3 Boredom
V 3 Boredom
C4 Active
V4 Active
C5 Inactive
V5 Inactive
C6 Friendiness
V6 Friendiness
C7 Concentration
V7 Concentration
C8 Startle
V8 Startle

fig.4


C. Forest
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point
C1 Anxiety
V1 Anxiety
C2 Hostility
V2 Hostility
C 3 Boredom
V 3 Boredom
C4 Active
V4 Active
C5 Inactive
V5 Inactive
C6 Friendiness
V6 Friendiness
C7 Concentration
V7 Concentration
C8 Startle
V8 Startle

fig.5

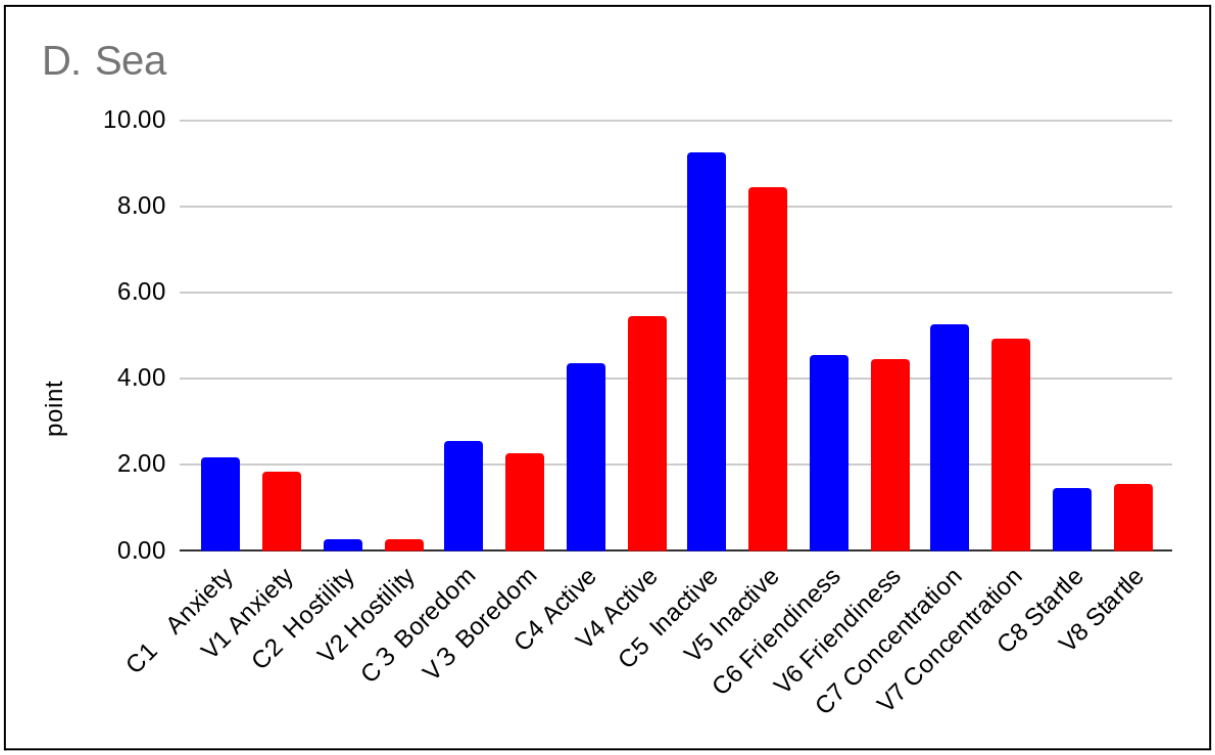
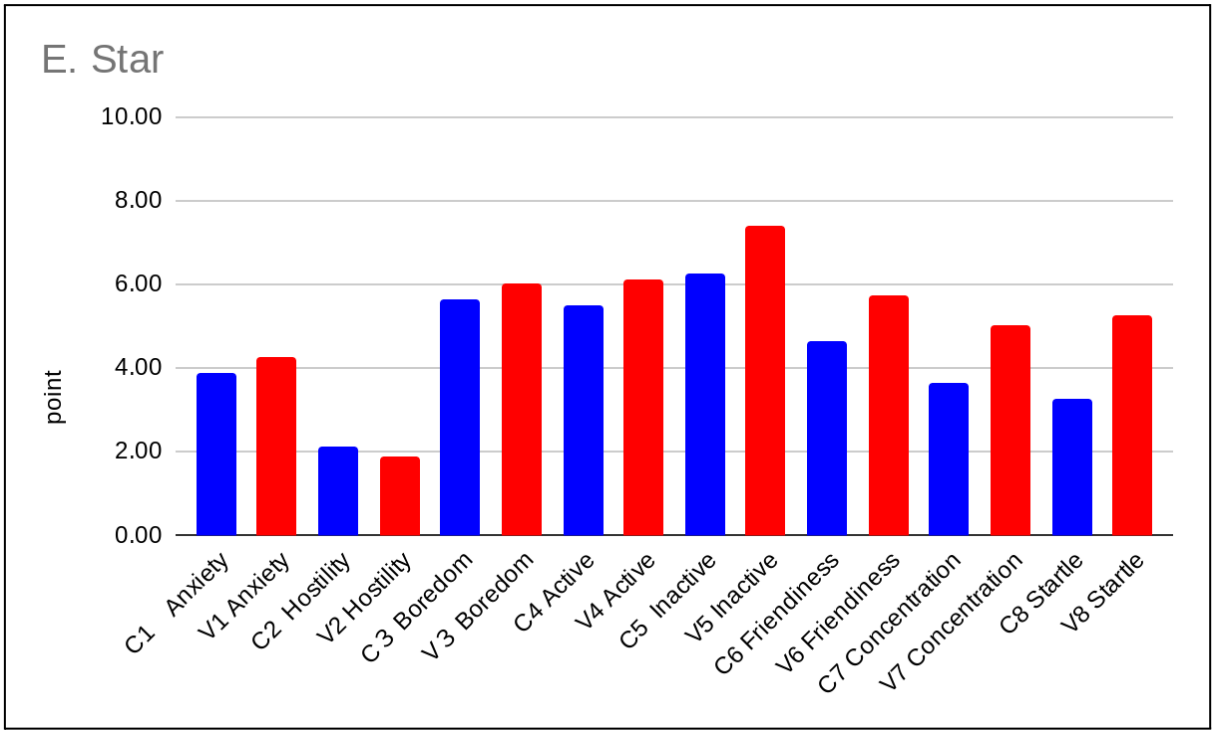


fig.6



3) Change in the number of correct answers to calculation questions

The average change in the number of correct answers to calculation problems before and after viewing the VR or Chromebook was graphed for each video. Blue is for Chromebooks and red is for VR.

Since the difficulty level of calculations varies depending on the problem, it is not possible to say that processing power has improved or decreased just by looking at the calculation results. Therefore, we focused on the amount of change in the calculation results. First, let's compare VR and Chromebook. If we look at the change in the number of correct answers between the calculation results before and after watching the video for the first time, we can see that the number of correct answers increased for Chromebooks in the roller coaster, forest, and star videos, and for VR in the horror and ocean videos, indicating that VR and Chromebooks show different results for each video. At this time, we have not been able to identify a trend. (Figure8)

In the graph in fig.7, the vertical axis shows the average change in the number of correct answers for the first and third calculations, and the second and third calculations, and the horizonta axis shows the type of video.

fig.7

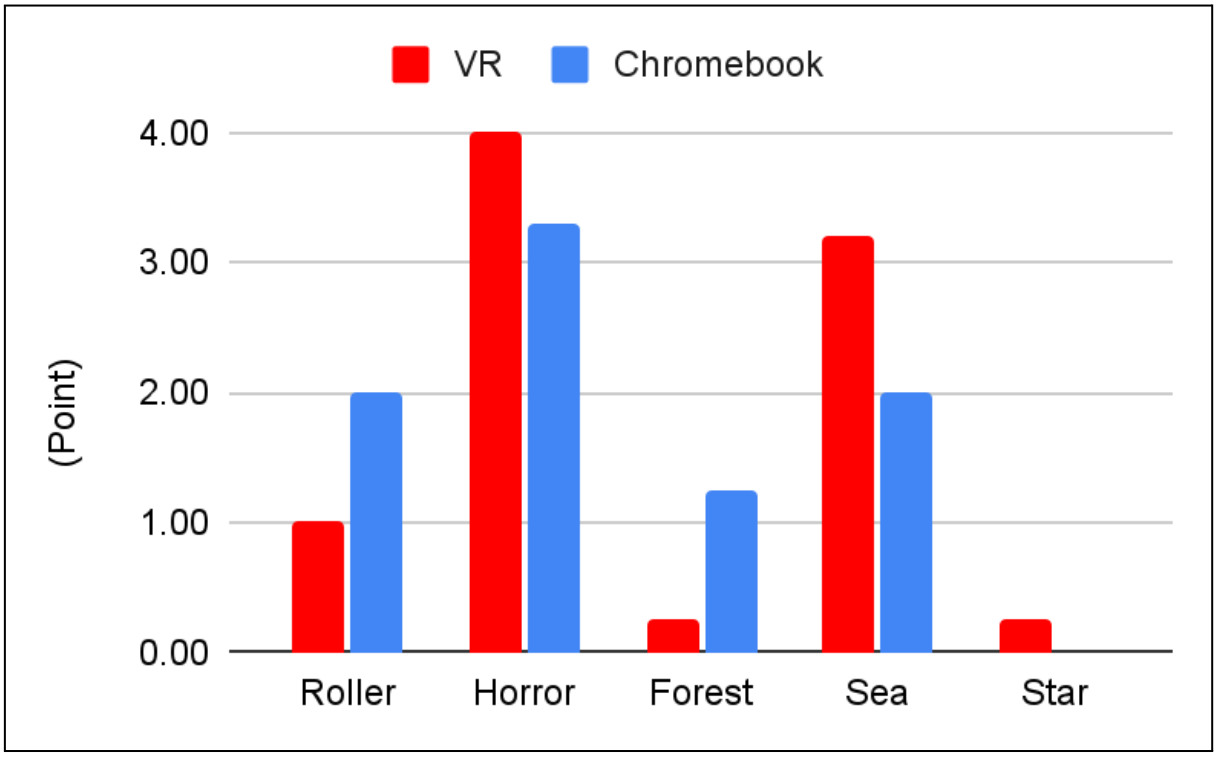
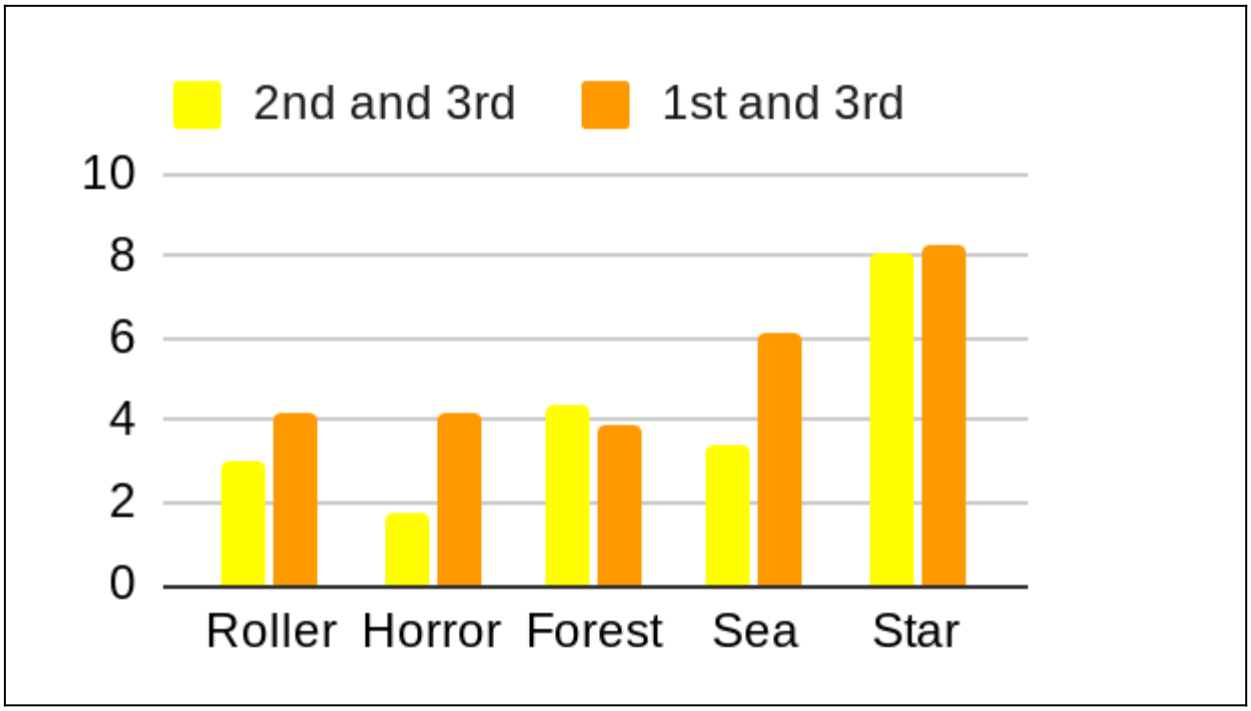


fig.8



5. Discussion 1

In the results obtained from the Multiple Emotional State Scale, there were characteristic changes in emotion depending on the type of video, and these changes were more common in VR. In addition, some subjects felt that the image quality of the D. Sea video was worse than the other videos during the actual experiment, and it is thought that eye fatigue and sickness caused by the image quality may have affected the results.

From the results obtained from the heart rate measurement, the standard deviation of the change in heart rate was smaller in VR than in Chromebook, suggesting that VR brought similar changes regardless of the differences in the subjects. VR has a larger and more homogeneous effect on psychological state than Chromebooks

6.Reflections on Experiment 1

In the first experiment, there was no clear trend in the measurements of heart rate and computing power after watching the video in VR and on the Chromebook. This led us to consider why the results were so different. First of all, the environment during the experiment was brightly lit, and there were sounds that had nothing to do with the experiment when watching the video on the Chromebook. Second, in this experiment, after watching the video and filling out the Multidimensional Emotional State Scale, we had a few minutes to measure the heart rate. We thought that during this time, the heart rate that had been changed by watching the video would return to the normal heart rate. We decided to improve on these two points and investigate the apparent trend of heart rate and computational processing power in an additional experiment.

7.Method 2

The subjects were recruited from the students of Izumigaoka High School, and 28 students were divided into two groups (VR first group and Chromebook first group). We asked the subjects to watch the same one and a half minute movie twice, in the order of VR and Chromebook for the VR first group, and Chromebook and VR for the Chromebook first group. The video used was a forest video. The reason for using this video was that it was relatively easy to grasp the trend of the results in the Multiple Emotional State Scale in Experiment 1. The video was played without sound in order to clarify the influence of visual information only. In order to create an environment as similar as possible to that of VR, we surrounded the subject with cardboard boxes and created an environment that blocked out all visual information except for the video when watching the video on a Chromebook.

This time, the heart rate was measured three times in total: before watching the video, during the first video, and during the second video. The reason why the heart rate was measured while watching the video was to immediately measure the change in heart rate caused by the video without any time delay.

Calculation ability was measured three times: before watching the video, after watching the first video, and after watching the second video.

Next, we focused on the amount of change in the calculation results for each image shown. The amount of increase in the number of correct answers to the questions was larger for the nature-based movies (forest, ocean, starry sky) than for the thrill-based movies (roller coaster, horror), suggesting that the processing power was improved by the nature-based images. (Figure 9)

8. Experimental results 1

1) Change in heart rate

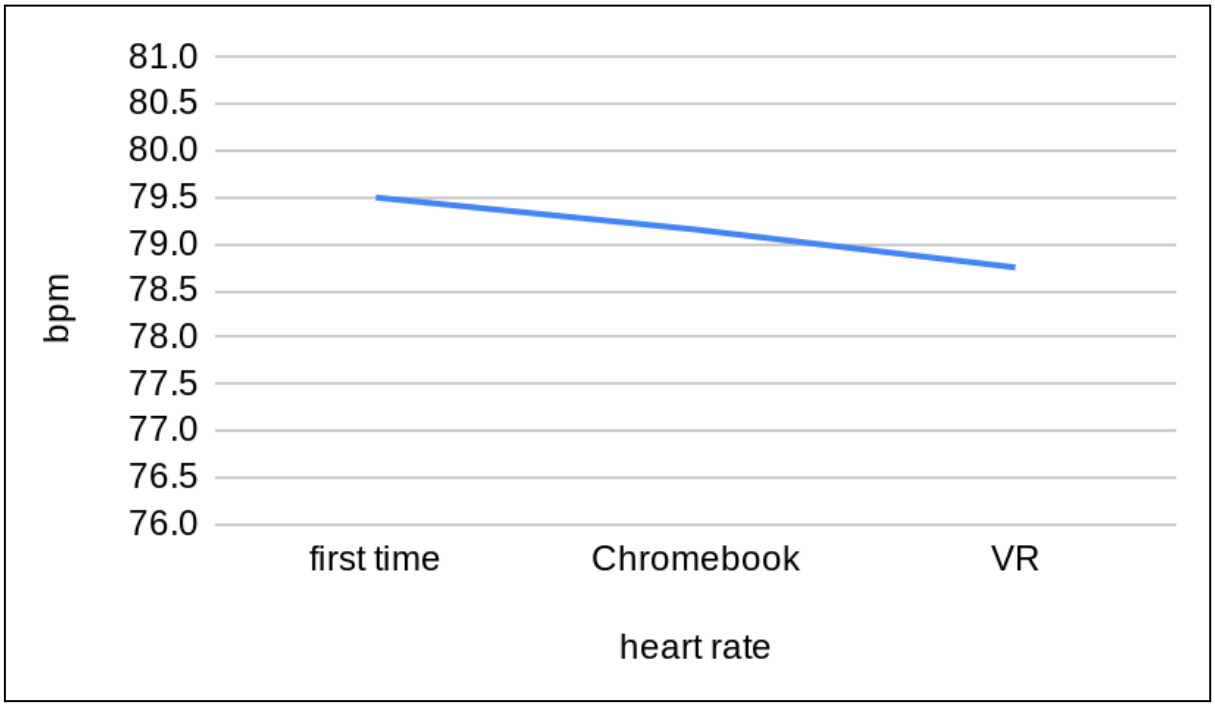
Figs. 10 and 11 show graphs of the changes in the average heart rate of 44 subjects before and after watching the video using the VR or Chromebook.

When the VR was viewed first, the average heart rate during the VR viewing was 0.5 bpm lower than before viewing; during the Chromebook viewing, the heart rate was 2 bpm lower. (Figure 10)

When the Chromebook was viewed first, the mean heart rate during the Chromebook viewing was 0.5 bpm lower than before viewing; after viewing the VR, the heart rate further decreased by 1 bpm. (Figure 11)

The standard deviation of the heart rate measured before and during viewing was 5.712 for VR viewing and 6.517 for Chromebook viewing. The standard deviation was 5.712 for VR viewing, and 6.517 for Chromebook viewing. Therefore, it was found that the changes in heart rate caused by VR viewing were less scattered than those caused by Chromebook viewing.

fig.9



2) Change in the number of correct answers to calculation questions

The average change in the number of correct answers between the first and second calculation was compared between VR and Chromebook. 1.47 more questions were answered correctly, on average, when viewing the VR than when viewing the Chromebook. (Figure 12)

When comparing the average change in the number of correct answers between the second and third calculations between VR and Chromebook, the number of correct answers was 0.33 more when viewing VR than when viewing the Chromebook. (Figure 13)

fig. 10

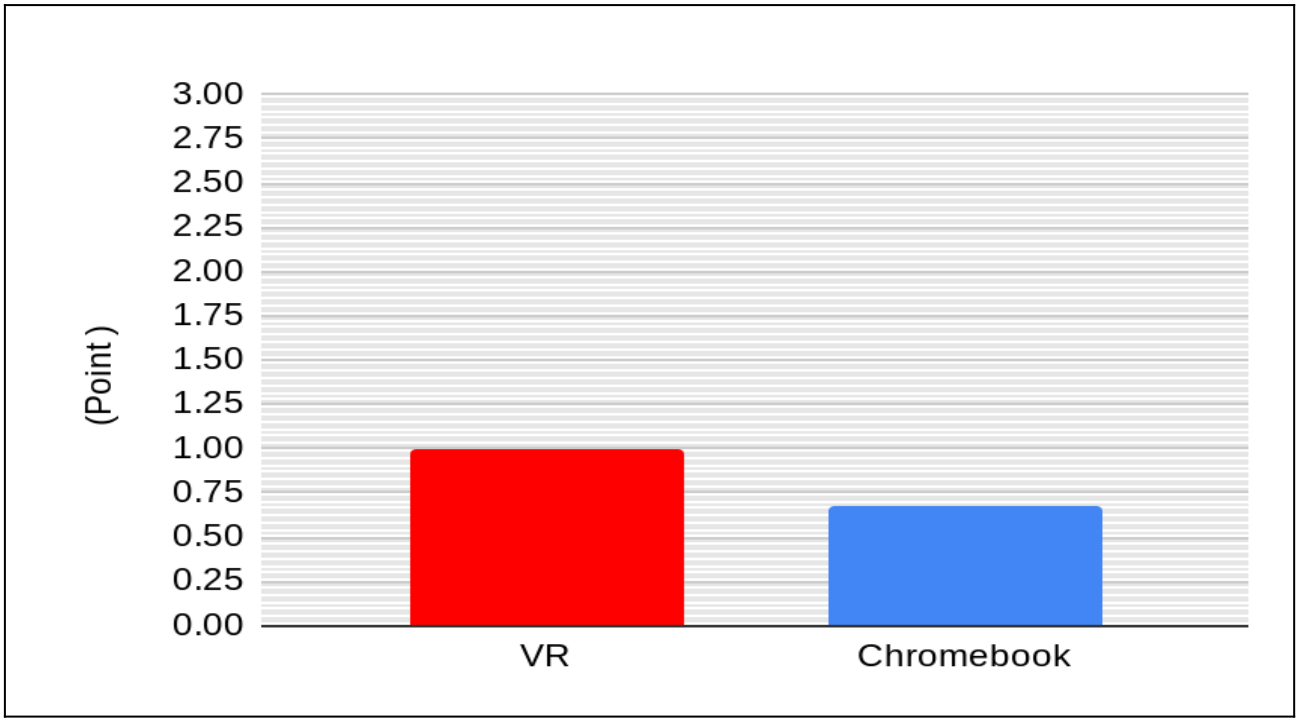
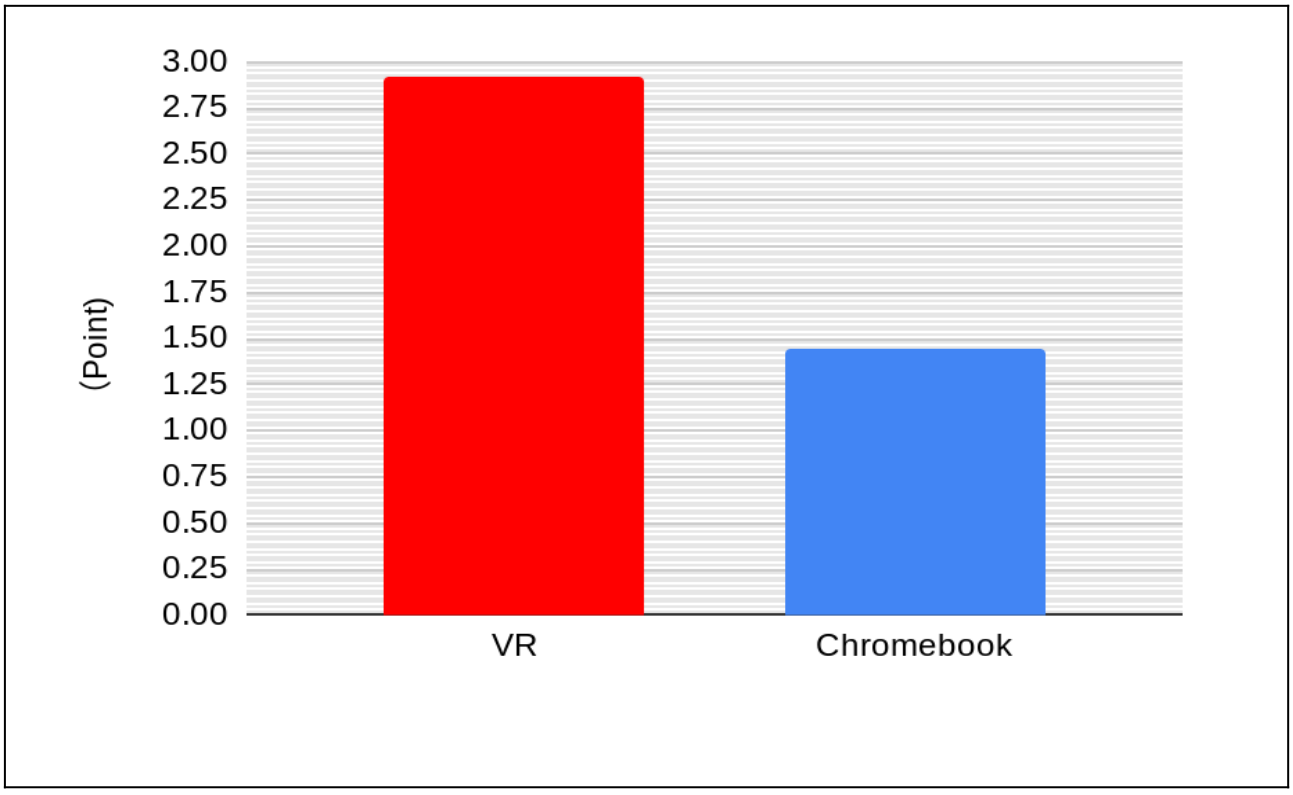


fig.11



9. Discussion 1

The results from the heart rate measurement showed that the standard deviation of the change in heart rate was smaller in the VR than in the Chromebook, suggesting that the VR had a more homogeneous effect on psychological state than the Chromebook. The effect of VR on psychological state was larger and more homogeneous than that of Chromebooks.

In addition, since the change in the number of correct calculations was larger with VR than with Chromebooks, the physical effect of VR is also considered to be large.

10.Future Prospects

Although the subjects of this experiment were high school students of Sengaoka High School, we would like to clarify the trend in other age groups and by gender.

11.Acknowledgments

I would like to express my sincere gratitude to Ms. Terai for his guidance and encouragement, and to the first and second year students of Kanazawa Izumigaoka High School for their cooperation in this experiment.

12.References

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13.Key words
virtual reality, HMD(Head Mounted Display), the Multiple Emotional State Scale