Factors Affecting Motion Sickness in an Augment Reality Environment

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1. Background

1. Simulator Sickness

- There are many cases of motion sickness in virtual reality (VR) environment.

- Older participants had a greater likelihood of simulator sickness than younger participants.
- The longer exposure time, the more motion sickness symptoms increase.

There are not many studies dealing with motion sickness in AR environment.

1. Background

2. Purpose

To check the factors affecting motion sickness in augmented reality (AR) environment

3. Method

- In this study, VRSQ tools were selected to measure motion sickness in the AR environment.

Measure degree of
Motion Sickness of AR

VRSQ
(VR sickness questionnaire)

2. VRSQ

1. Virtual Reality Sickness Questionnaire

- VRSQ is a motion sickness measurement specialized for VR environments.
  - VRSQ consists of nine symptoms, which are divided into two factors.
  - VRSQ scores can be calculated using the following formula

VRSQ symptom	Oculomotor	Disorientation
1. General discomfort	O	
2. Fatigue	O	
3. Eyestrain	O	
4. Difficulty focusing	O	
5. Headache		O
6. Fullness of head		O
7. Blurred vision		O
8. Dizzy (eyes closed)		O
9. Vertigo		O
Total	[1]	[2]

[Table 1] Virtual reality sickness questionnaire (VRSQ)

Components	Computation
Oculomotor	([1]/12)*100
Disorientation	([2]/15)*100
Total	(Oculomotor + Disorientation score)/2

[Table 2] Computation score of VRSQ

3. Experimental Design

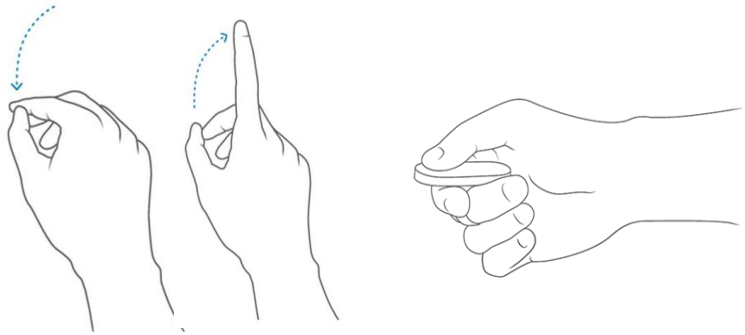
1. Participants

- 12 female and 12 male (average age: 21.2 years old, standard deviation: 1.26 years old)
- Corrected vision of 0.6 or higher (No physical or visual health problems)
- Korean and had no experience in using AR devices (11 people had experience using VR devices)
- 22 of them were right-handed and 2 were left-handed

2. Apparantus

- Microsoft Hololens (1st generation) developer edition
- Holographic resolution 2HD 16:9 light engines producing 2.3M total light points

- Ways to perform a task
  - 1) Gaze at the hologram which want to select.
  - 2) Point the index finger straight up toward the ceiling.
  - 3-1) Air tap : lower the finger, quickly raise it.
  - 3-2) Clicker : click the element with using clicker.



[Figure 1] Finger gesture and clicker

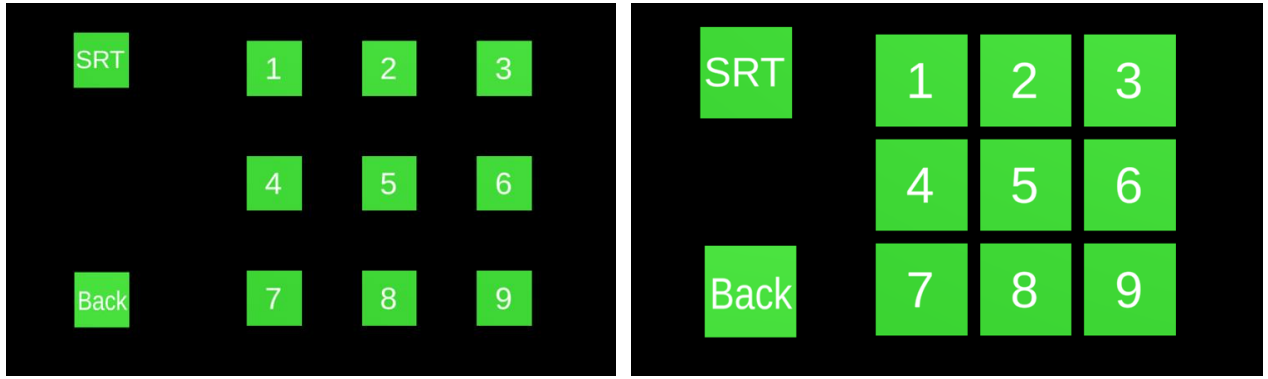
3. Experimental Design

3. Tasks

- After wearing the Hololens HMD, finger gestures and clickers were used to perform the task of repeatedly selecting specific buttons.
- Nine buttons are marked in an array of 3×3.
- Buttons consist of two sizes and three distances.
  - The small button : 1°55'4" field of view based on the length of the large side of the mobile phone's 3×4 keyboard.
  - The large button : 3°49'48" field of view. Twice the size of the small button.

FOV	Distance (cm)	Size of button (cm)
3°49”48’	60	3.68
	80	4.90
	100	6.14
1°55”4’	60	2.00
	80	2.68
	100	3.35

[Table 3] Settings of buttons



[Figure 2] An example of target buttons

3. Experimental Design

4. Procedure

- The experiment lasted about 90 minutes, including break time.

I. The purpose and contents of the experiment were introduced.

- If participants feel severe motion sickness, they can rest and stop at any time.
- It is evaluating the device, not the ability of the participants.
- Before starting the experiment, the subjects had a chance to practice until they got used to the device.

II. Participants performed a task consisting of 12 treatments

- 2 methods of selection × 2 button sizes × 3 distances = 12 treatments
- Each treatment consisted of five sets and one set was to select four randomly highlighted buttons.
- A total of 240 button selections (12 treatment × 4 choices × 5 sets = 240 tasks)
- The Latin Square design was used to minimize the effect of order.

III. A questionnaire was conducted after each treatment.

- Motion sickness levels were assessed through the difficulty level and SSQ of performing the task.
- The score was based on a five-point recurve scale (1 = not at all, 2 = slightly, 3 = normal, 4 = moderately, 5 = very).

4. Result

1. ANOVA with VRSQ

- Analysis of variance (ANOVA) was performed to check if there were differences in Oculomotor, Disorientation, and VRSQ total score depending on the method of selection, the size of the buttons, and the distance.
- As a result of the analysis of variance, items with a P value of 0.05 or less were analyzed Tukey post-analysis.
- There were no significant differences in the disorientation score and VRSQ total score according to the selection methods, button sizes, and distances.

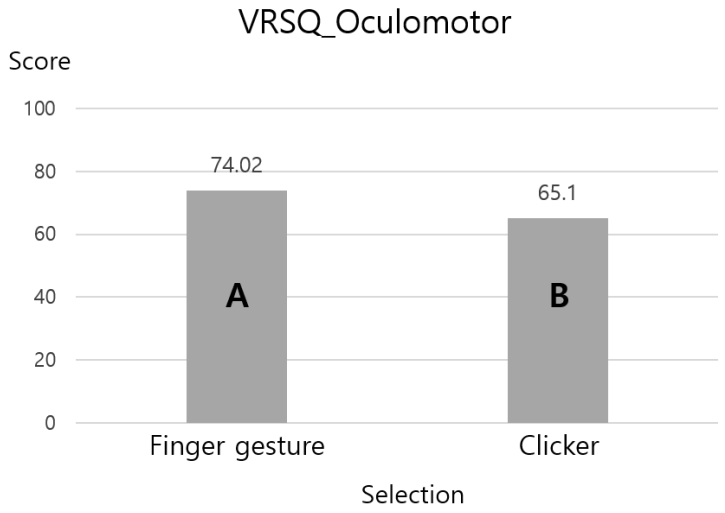
	VRSQ		VRSQ-Oculomotor		VRSQ-Disorientation	
	F	P	F	P	F	P
Selection (A)	2.97	0.09	5.62	0.02	0.11	0.75
Size (B)	1.90	0.17	2.66	0.10	0.45	0.51
Distance (C)	3.95	0.05	5.91	0.02	0.71	0.40
(A)×(B)	0.94	0.33	1.10	0.30	0.40	0.53
(A)×(C)	0.05	0.82	0.16	0.69	0.10	0.93
(B)×(C)	0.79	0.38	1.00	0.32	0.26	0.61
(A)×(B)×(C)	0.00	0.95	0.13	0.72	0.18	0.67

[Table 4] Effect testing between Selection method, Size, Distance

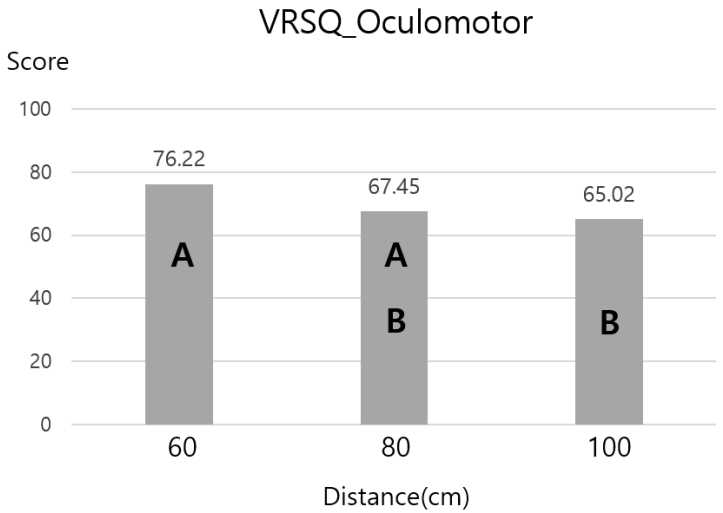
4. Result

1. ANOVA with VRSQ

- In Oculomotor, there was a significant difference in the Selection method and the Distance.
  - In Oculomotor, the P value of Selection was 0.0185 ($p<0.05$).
  - The VRSQ Oculomotor score of finger gesture selection is 74.02, and the score of clicker is 65.1.
  - The P value of Distance was 0.0157($p<0.05$) and there was a significant difference between 60cm and 100cm.
  - The VRSQ Oculomotor score of distance 60cm is 76.22, and the score of 100cm is 65.02.



[Figure 4] VRSQ_Oculomotor scores for Selection methods (Different letters indicate a statistically significant difference).



[Figure 5] VRSQ_Oculomotor scores for Distance (Different letters indicate a statistically significant difference).

5. Discussion

1. Discussion

- The study also showed that the physical button, the clipper method, had a low motion sickness score.
- The button at a distance of 100 cm caused less motion sickness.
- Due to the differences in arm position, the degree of motion sickness must have been different.
  - In the case of finger gesture, the experiment was carried out with the arms stretched forward. Depending on the movement of the eyes, the hands had to move together and the subjects had to pay attention to it.
  - The clicker was connected by Bluetooth, so it could be operated comfortably without raising its arms.
- The experiment was carried out standing in place, facing one direction.
  - Body movements were generally not required.
  - This may have affected directional loss scores.

[Figure 3] A person wearing the HMD equipment and clicking the buttons

6. Conclusion

1. Limitation

- This study used 5-point Likert scale and SSQ uses a 4-point Likert scale (0=not at all, 1=slightly, 2=moderately, and 3=very). So, there were limitations in converting to scores using 1-5 scales.
- This study did not identify differences in the effects of motion sickness by gender.
- Gender differences need to be checked in further studies.
- 24 subjects cannot represent all populations.

2. Conclusion

- This study revealed that Oculomotor among motion sicknesses in AR environment is related to the method and distance of button selection.
- This study can suggest the possible user interface element of AR environment to reduce motion sickness.

Thank you