

Cybersickness in Augmented Reality: Subjective and physiological changes with the course of prolonged exposure

Virtual Reality

Zion Park, Seyoon Song, Subin Jeon, Yuyeon Jung, Yeha Cha, Jiyoung Oh, Minsung Jin, Chai-Youn Kim⁺

⁺Corresponding author

Chai-Youn Kim

School of Psychology, Korea University, 145 Anam-ro, Seongbuk-gu, Seoul, Republic of Korea

chaikim@korea.ac.kr / <https://orcid.org/0000-0002-9867-1309>

1 Supplementary Materials

1.1 Videos

Video recordings of a first-person simulation racing game, *Forza Horizon 5* (Playground Games 2021). Video S1 and Video S2 are samples of each movement speed stimulus (S1: slow, S2: fast), including a gradual change of color to black-and-white.

1.2 Tables

SSQ symptoms ^a	Weight			
	N	O	D	
General discomfort	1	1		
Fatigue		1		
Headache		1		
Eye strain		1		
Difficulty focusing		1	1	
Increased salivation	1			
Sweating	1			
Nausea	1		1	
Difficulty concentrating	1	1		
Fullness of head			1	
Blurred vision		1	1	
Dizzy (eye open)			1	
Dizzy (eye closed)			1	
Vertigo			1	
Stomach awareness	1			
Burping	1			
Total ^b	[1]	[2]	[3]	
[1] + [2] + [3] = [4]				
Score	TS	N	O	D
	[4] x 3.74	[1] x 9.54	[2] x 7.58	[3] x 13.92

Table S1 Computation of SSQ scores from Kennedy et al. (1993). ^aScored 0, 1, 2, 3. ^bSum obtained by adding symptom scores

Post-hoc comparisons		Mean Diff.	SE	t	Cohen's d	pbonf
N, Pre-test	N, Block 1	-6.439	2.859	-2.252	-0.214	1
	N, Block 2	-13.833	4.064	-3.404	-0.46	0.456
	N, Block 3	-18.126	4.467	-4.058	-0.603	0.103
	N, Post-test	-10.971	3.285	-3.34	-0.365	0.526
	N, Post-removal	-6.678	3.57	-1.871	-0.222	1
N, Block1	N, Block 2	-7.394	1.91	-3.87	-0.246	0.158
	N, Block 3	-11.687	2.926	-3.995	-0.389	0.119
	N, Post-test	-4.532	2.409	-1.881	-0.151	1
	N, Post-removal	-0.238	3.066	-0.078	-0.008	1
N, Block2	N, Block 3	-4.293	1.985	-2.163	-0.143	1
	N, Post-test	2.862	2.382	1.201	0.095	1
	N, Post-removal	7.155	2.987	2.395	0.238	1
N, Block3	N, Post-test	7.155	2.119	3.376	0.238	0.485
	N, Post-removal	11.448	2.599	4.405	0.381	0.047*
N, Post-test	N, Post-removal	4.293	2.42	1.774	0.143	1
O, Pre-test	O, Block 1	-16.108	3.667	-4.392	-0.536	0.048*
	O, Block 2	-24.066	4.796	-5.018	-0.801	0.012*
	O, Block 3	-31.836	5.474	-5.816	-1.059	0.002**
	O, Post-test	-19.518	5.124	-3.809	-0.649	0.181
	O, Post-removal	-14.212	4.132	-3.439	-0.473	0.421
O, Block1	O, Block 2	-7.959	1.942	-4.098	-0.265	0.094
	O, Block 3	-15.728	3.138	-5.012	-0.523	0.012*
	O, Post-test	-3.411	4.002	-0.852	-0.113	1
	O, Post-removal	1.895	4.273	0.443	0.063	1

O, Block2	O, Block 3	-7.769	2.084	-3.727	-0.258	0.219
	O, Post-test	4.548	3.56	1.278	0.151	1
	O, Post-removal	9.854	4.245	2.321	0.328	1
O, Block3	O, Post-test	12.317	3.048	4.041	0.41	0.107
	O, Post-removal	17.623	4.554	3.87	0.586	0.158
O, Post-test	O, Post-removal	5.306	3.96	1.34	0.177	1
<hr/>						
D, Pre-test	D, Block 1	-12.528	6.517	-1.922	-0.417	1
	D, Block 2	-19.488	7.767	-2.509	-0.648	1
	D, Block 3	-28.536	8.387	-3.402	-0.949	0.457
	D, Post-test	-16.008	6.309	-2.537	-0.533	1
	D, Post-removal	-3.828	4.209	-0.91	-0.127	1
D, Block1	D, Block 2	-6.96	2.368	-2.939	-0.232	1
	D, Block 3	-16.008	4.376	-3.658	-0.533	0.256
	D, Post-test	-3.48	4.445	-0.783	-0.116	1
	D, Post-removal	8.7	5.642	1.542	0.289	1
D, Block2	D, Block 3	-9.048	3.465	-2.611	-0.301	1
	D, Post-test	3.48	4.908	0.709	0.116	1
	D, Post-removal	15.66	6.62	2.366	0.521	1
D, Block3	D, Post-test	12.528	3.865	3.241	0.417	0.658
	D, Post-removal	24.708	7.185	3.439	0.822	0.421
D, Post-test	D, Post-removal	12.18	5.096	2.39	0.405	1

Table S2 Post-hoc comparisons between SSQ subscale scores and exposure duration. Asterisks indicate statistical significance (* $p < .05$, ** $p < .01$)

1.3 Figures

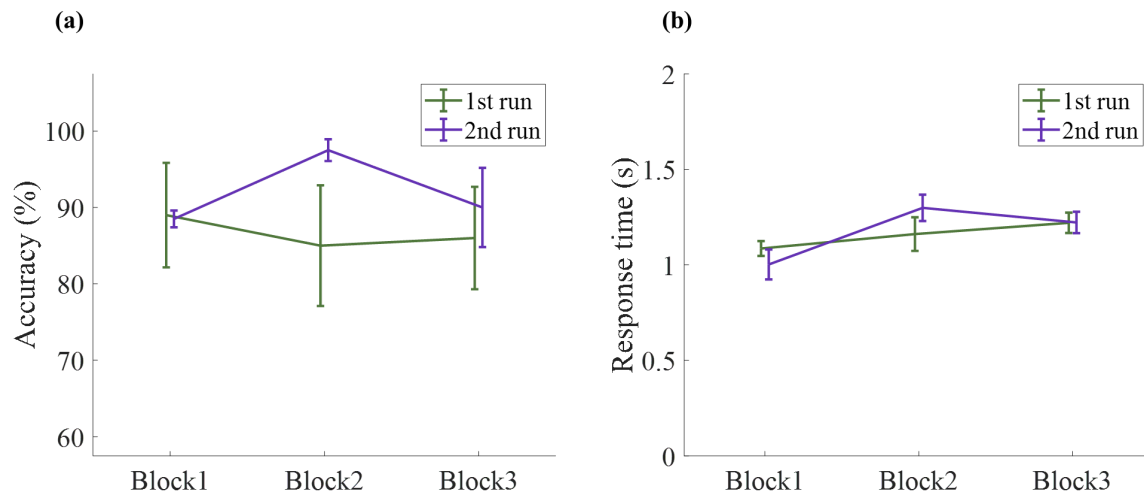


Figure S1 Behavioral performances across blocks for the first experimental run (green) and the second (violet). Error bars indicate standard errors; (a) accuracy rate, (b) response time

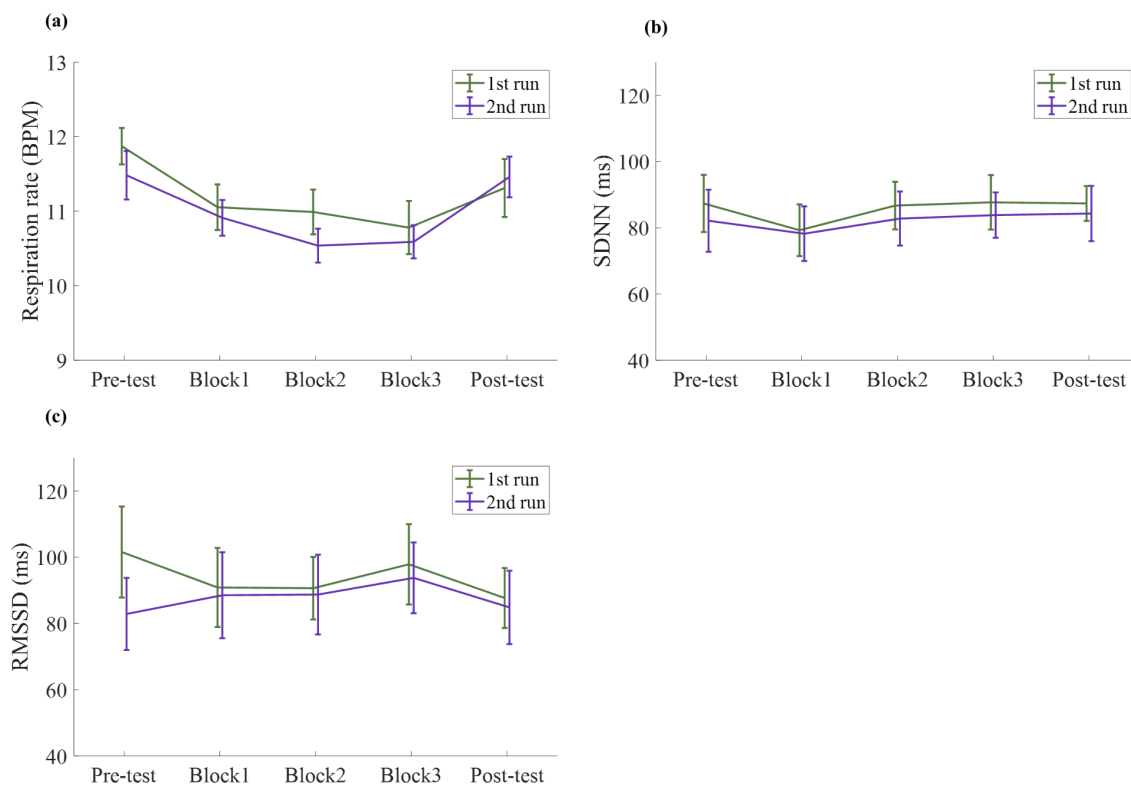


Figure S2 Physiological results across blocks for the first experimental run (green) and the second (violet). Error bars indicate standard errors; (a) respiration rate, (b) SDNN, (c) RMSSD

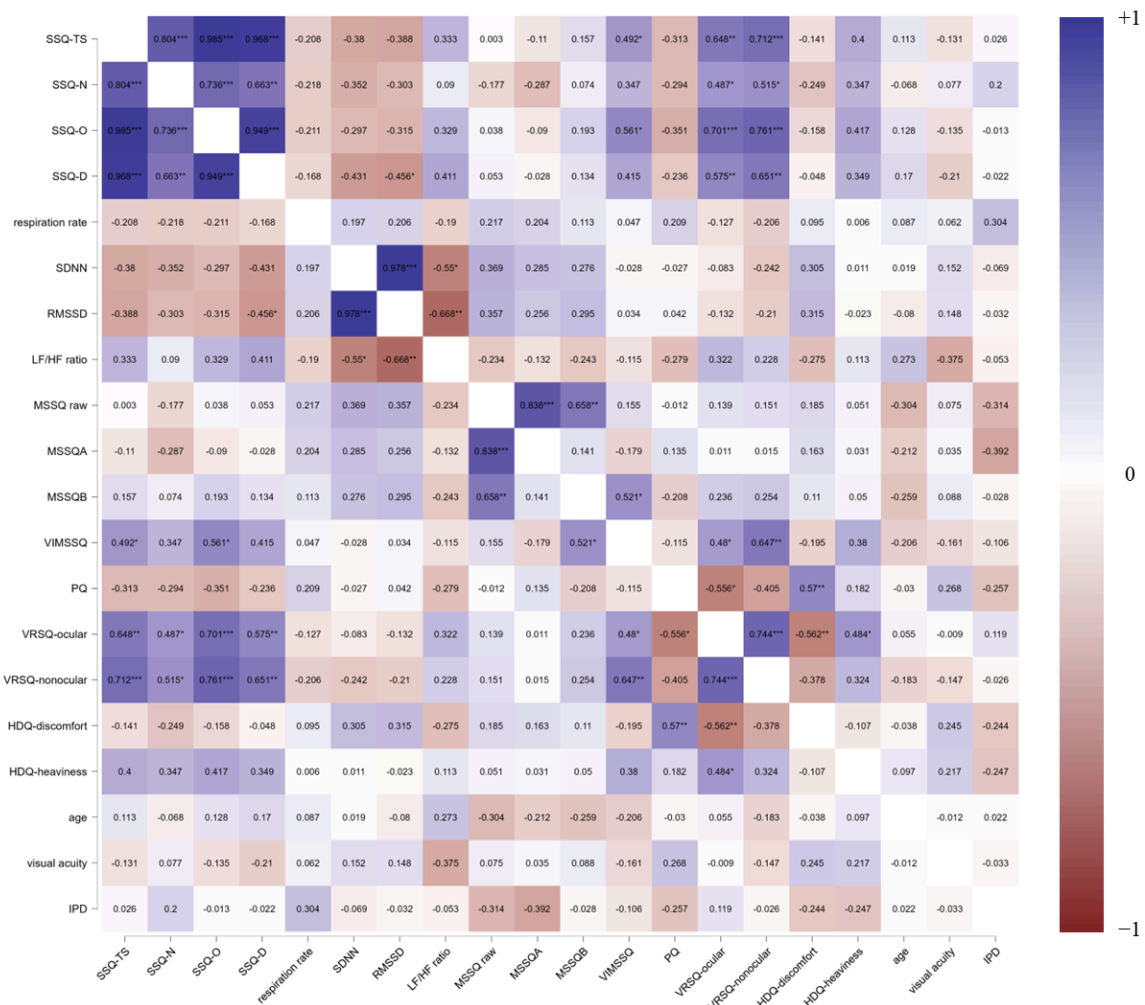


Figure S3 Heat-maps for results of correlation analyses. Each cell contains a value of Pearson's r.

Asterisks indicate statistical significance (* p < .05, ** p < .01, *** p < .001)

1.4 Spreadsheets

Spreadsheets S1 The statistical results of repeated measures ANOVAs with exposure duration and movement speed as within-subject factors. Sheet 1 contains the main results, while Sheet 2 contains the results of post-hoc comparisons

Spreadsheets S2 The statistical results of mixed ANOVAs with exposure duration and movement speed as within-subject factors, and group as a between-subject factor. Sheet 1 contains the main results, while Sheet 2 contains the results of post-hoc comparisons