Rankings Against Susceptibility, Sickness & Presence

Broadly, there was little to discriminate between the in-motion conditions. However, user rankings (see Table 1) revealed differing preferences, with half of participants preferring some form of conveyance of motion. Examining motion sickness susceptibility scores against preferences hints at these preferences being aligned with susceptibility, as seen in Figure 3. An ANOVA on susceptibility scores showed a significant difference $F(2,15) = 4.12, p < 0.05$ on user preference, with *post-hoc* Tukey showing differences between preferring Conditions 4–6 ($p < 0.05$) but not 5–6 ($p = 0.09$) or 4–5 ($p = 0.69$), suggesting that those that preferred the peripheral blending condition featured a greater susceptibility to motion sickness.

Metric	4 VR Video+Motion	5 VR V+M w/compensation	6 VR V+M w/peripheral feedback
User preferences	4 (22%)	8 (44%)	6 (33%)
Excluding (4)	–	9 (50%)	9 (50%)

Table 1. Total of preferred conditions, and preferred conditions excluding (4) by taking second preferences.

Examining the real-time illness rating (Figure 4), we see how preferences were influenced by perceived sickness. For those that preferred Condition 4 (VR Video+Motion, with the view rotating as the car turned), the stabilized view of Condition 5 led to a steady and continual increase in sickness. Whilst this was somewhat diminished by the peripheral cues of Condition 6, the more overt presentation of rotation in Condition 4 was best suited to this group and matched their inherent motion sickness. For those that preferred Condition 5 (VR V+M w/ Compensation, with the rotations of the car not affecting viewing), the visual perception of motion in Conditions 4/6 appeared to make their symptoms worse, especially the combination of visual cues of Condition 6. With these participants, their sickness was minimized by not presenting motion. It appears that these individuals are particularly susceptible to visual discrepancies in motion, suggesting that our conveyance of motion was insufficiently synchronized, or that perceiving different conflicting cues is particularly problematic for them. For those that preferred Condition 6 (VR V+M w/ Peripheral Feedback), the peripheral cues appeared to slow the onset of sickness, however all conditions provoked a consistent level of sickness throughout.

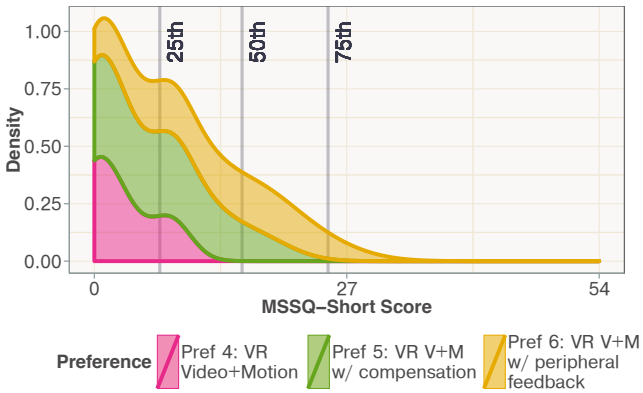

Figure 3. Stacked density plot (*geom_density* in R, using ..count.. and "stack") of motion sickness susceptibility against preferred condition (higher is more susceptible), with labels indicating susceptibility percentiles for the general population from [41]. 50th%ile is considered "slightly susceptible", and 75th%ile "moderately susceptible".

Examining SSQ total sickness against first preference and Condition, a two-factor ANOVA showed no main effects on Condition ($p = 0.37$) or preference ($p = 0.54$), but a significant interaction effect ($F(4,30) = 5.65, p < 0.01$), with contrasts showing an effect on Condition 4 versus 5 against preference for Condition 4 versus 5 ($b = -12.02, t(30) = -4.08, p < 0.01$), which can be seen in Figure 5. There was no significant con-

Metric	1 VR Video	2 Motion Only	3 VR Motion Env.	4 VR Video+Motion	5 VR V+M w/ Compensation	6 VR V+M w/ Peripheral Feedback	RM-Anova	Tukey *Post-hoc*
Mean Duration (sec)	600.0 (0.0)	600.0 (0.0)	569.9 (122.9)	563.5 (118.5)	567.2 (96.8)	555.4 (95.6)	$\chi^2(5) = 8.99, p = 0.1$	NA
Total Stopped early	0	0	2	3	3	5	$\chi^2(5) = 12.9, p < 0.05$	1-6, 2-6
IPQ Score	3.5 (0.9)	–	–	3.6 (0.9)	3.3 (0.9)	3.4 (0.8)	$\chi^2(3) = 2.54, p = 0.47$	NA
SSQ.N Nausea	9.0 (15.6)	8.5 (14.6)	39.2 (29.8)	53.5 (52.4)	58.8 (49.9)	60.4 (49.7)	$\chi^2(5) = 49.59, p < 0.01$	1-{3,4,5,6}, 2-{3,4,5,6}
SSQ.O Oculomotor	12.9 (16.5)	3.4 (9.1)	35.0 (28.0)	37.9 (33.7)	43.0 (37.3)	43.4 (35.3)	$\chi^2(5) = 51.83, p < 0.01$	1-{3,4,5,6}, 2-{3,4,5,6}
SSQ.D Disorientation	13.1 (26.3)	6.2 (10.9)	57.2 (62.4)	62.6 (71.5)	71.9 (72.1)	72.7 (71.4)	$\chi^2(5) = 44.8, p < 0.01$	1-{3,4,5,6}, 2-{3,4,5,6}
SSQ.TS Total Score	6.2 (10.4)	3.0 (5.0)	24.1 (23.1)	27.4 (28.6)	31.2 (28.9)	31.6 (28.0)	$\chi^2(5) = 49.80, p < 0.01$	1-{3,4,5,6}, 2-{3,4,5,6}
Rotation (NP)	–	–	4.1 (1.1)	3.9 (1.8)	–	3.3 (1.7)	$\chi^2(2) = 1.4, p = 0.5$	NA
Motion (NP)	–	–	4.1 (1.2)	–	–	3.4 (1.8)	$\chi^2(1) = 1.6, p = 0.2$	NA
Acceleration (NP)	–	–	4.5 (1.0)	–	–	3.4 (1.5)	$\chi^2(1) = 12, p < 0.01$	NA

Table 2. Statistics and questionnaire results. IPQ score 0–6, higher is more presence; SSQ score higher is more sickness (max 235); Ranking lower is better; Rotation/Motion/Acceleration 0–6 from strongly disagree to strongly agree that visual and physical motion cues were aligned. Green denotes $p < 0.05$, NP denotes non-parametric tests.