

Supplementary material

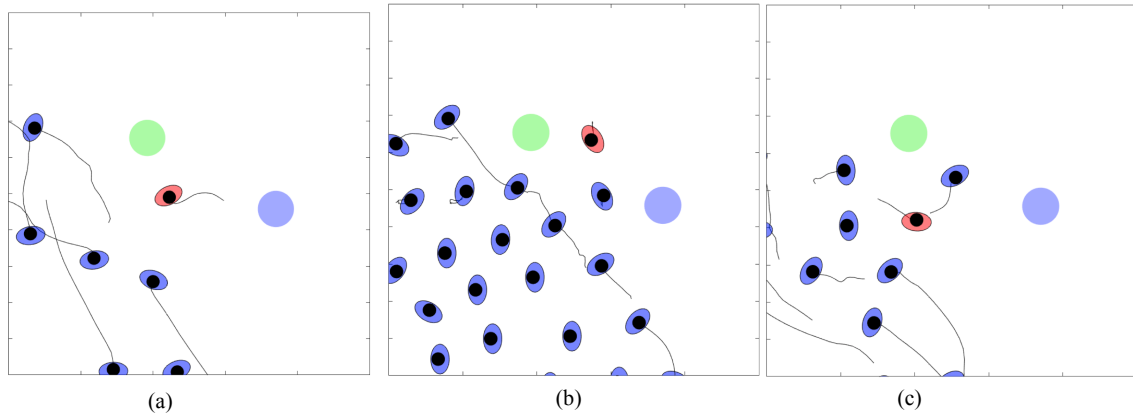


Figure S1: Sample trajectories of participant (red) and virtual characters (blue) during three different experiments where the participant was moving between cylinders (a), multiple characters had stopped and looked up with a few others finding gaps to pass by and (c) where the participant engaged with the virtual characters who actively avoided collisions with the participant's avatar. The blue and green solid circles mark the cylinders between which the participants were instructed to walk during a habituation phase

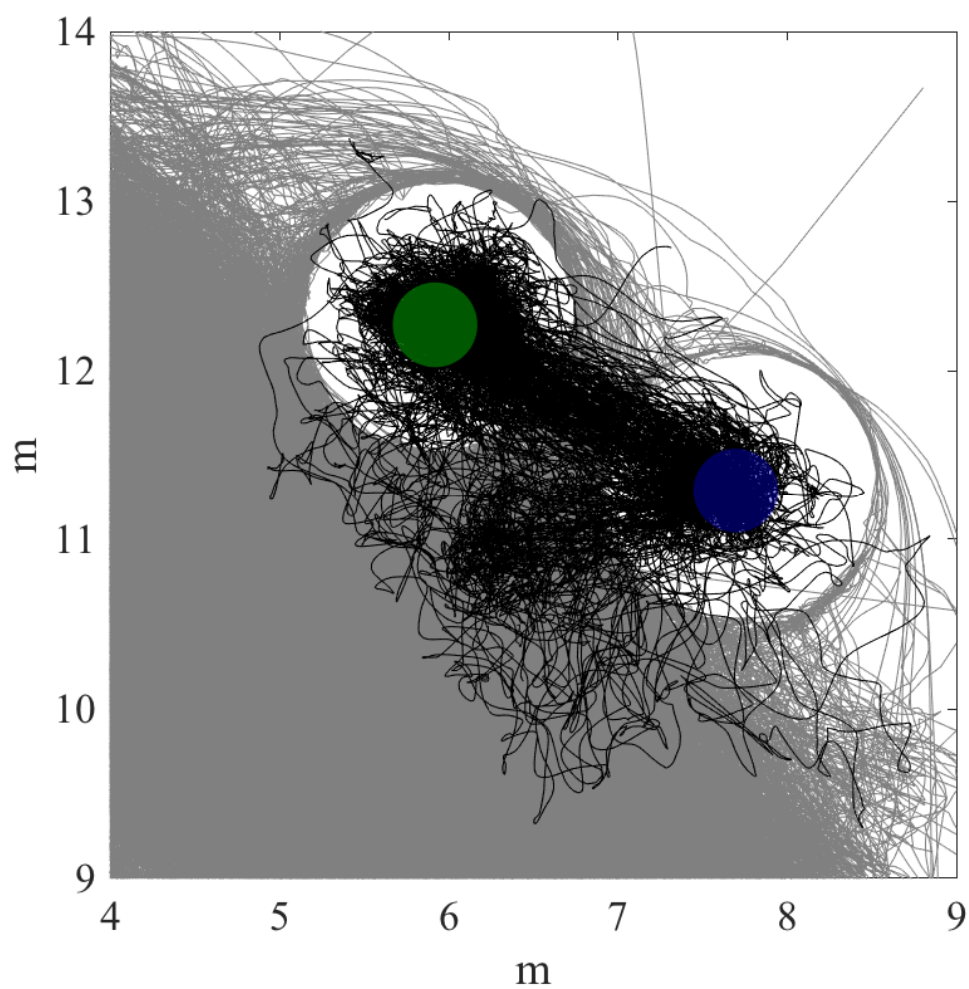


Figure S2: Trajectories of participants (black) and nearby virtual characters (grey) across all trials. The blue and green cylinder locations mark the objects between which the participants walked during the habituation phase.

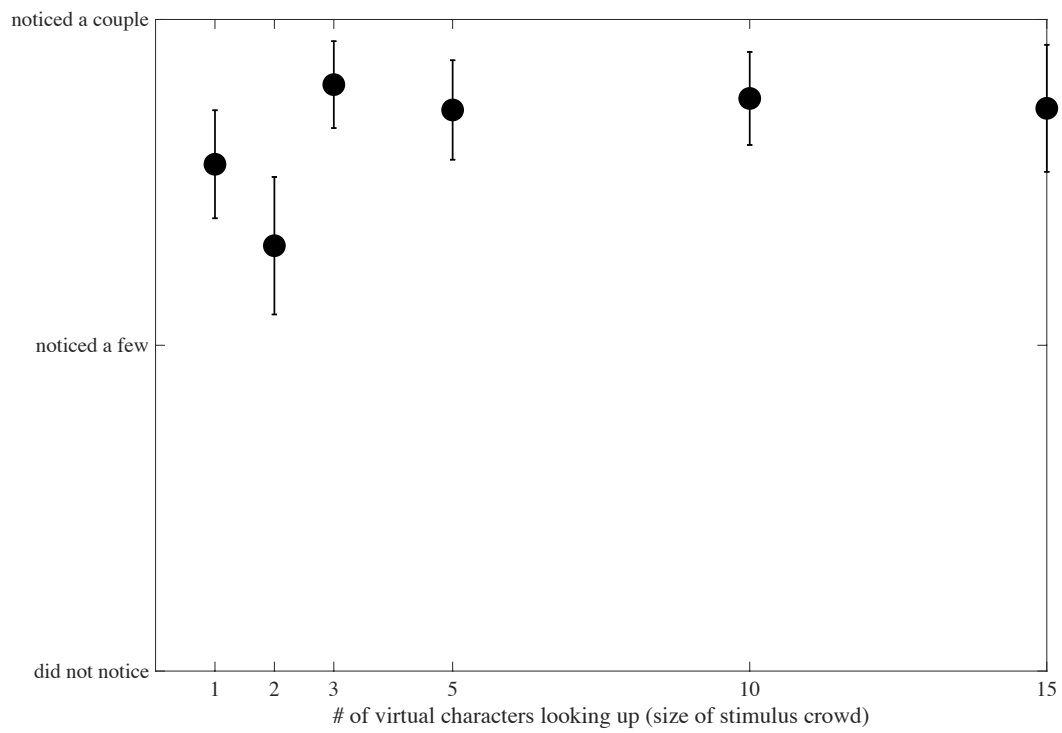


Figure S3: Response to survey question 9 which asked whether participants noted any of the characters look up after the experiment was conducted. Points indicate mean $\pm$ standard error

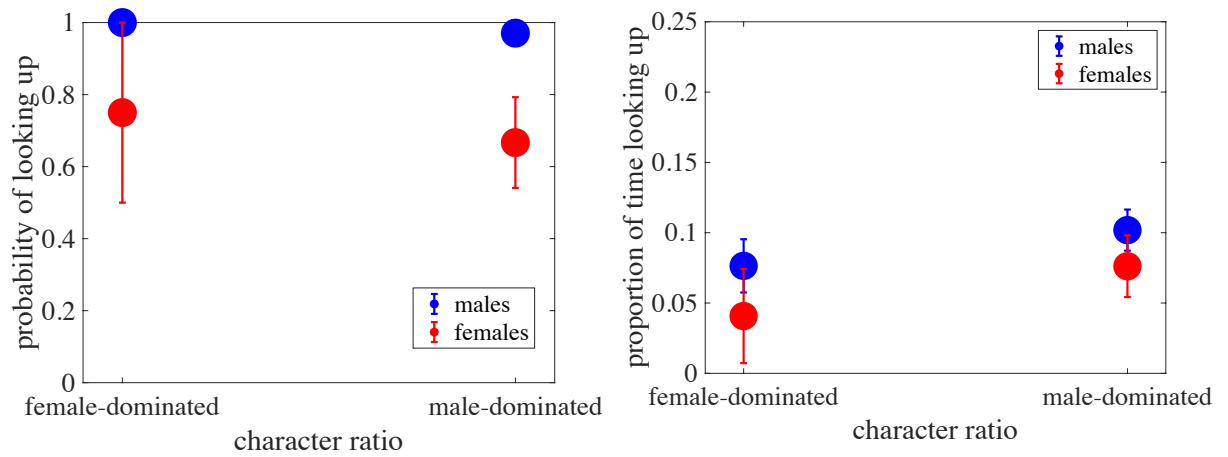


Figure S4: Probability of looking up (left) and proportion of time looking up (right) were not affected by the gender ratio of the virtual characters who were looking up and visible in the participant's perspective.

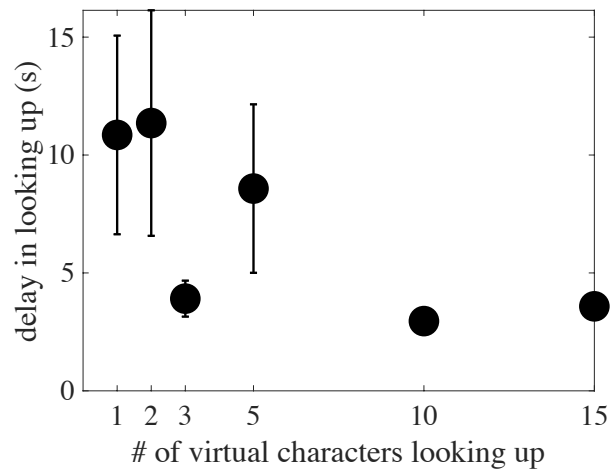


Figure S5: Delay in looking up (latency) among the participants who looked up was not significantly different across conditions.

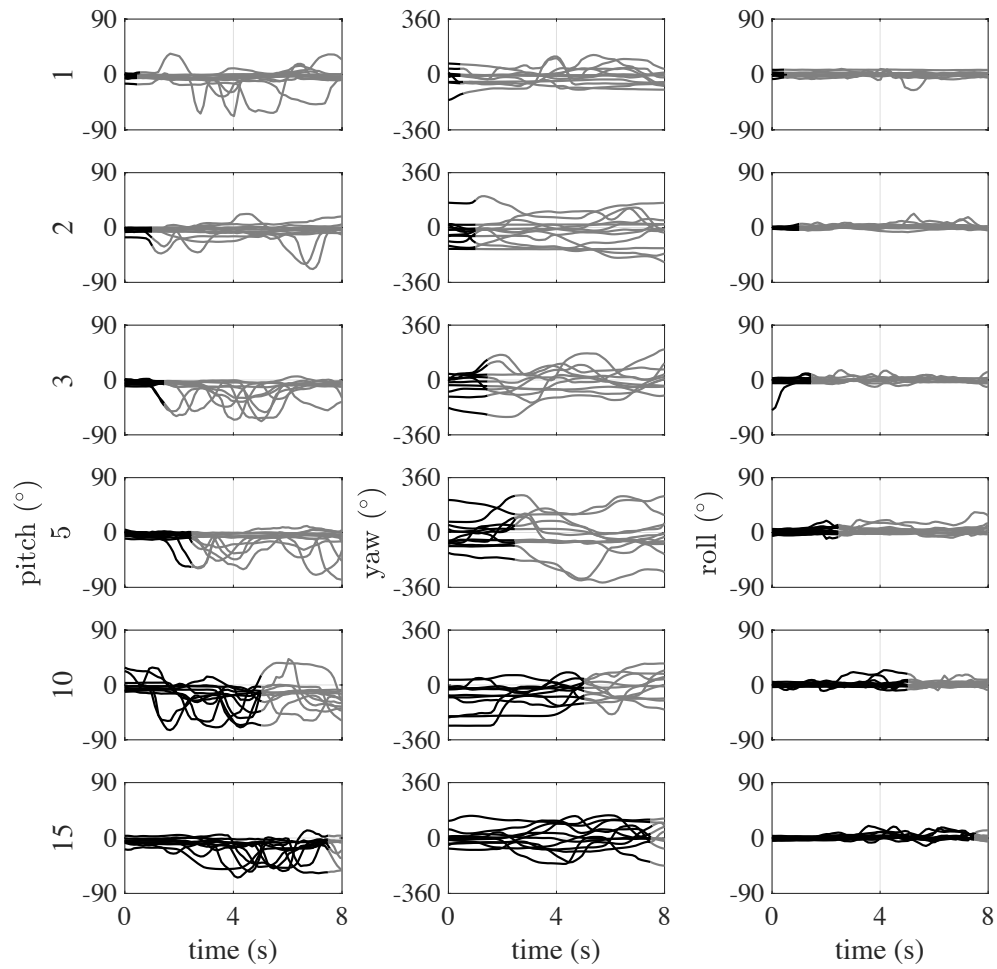


Figure S6: Head orientation (pitch, yaw, roll) of all participants for 8 seconds after the stimulus is triggered. The duration during which the characters are looking up is plotted in black and the remaining in grey. Each row corresponds to a certain number of virtual characters.

Table S1: Sensitivity of results to the threshold selected for marking a look up

Measure/Threshold value	-15 degrees p, F(5,62)	-17 degrees p, F(5,62)	-19 degrees p, F(5,62)
Probability of looking up	0.0124, 14.54	0.0125, 14.54	0.0125, 14.54
Proportion of time spent looking up	<0.0001, 28.61	<0.0001, 29.89	<0.0001, 29.97

Table S2: Comparison of probability of looking up and percentage time spent looking by male and female participants

# of virtual characters looking up	# of females (# of males) participants	p-value (Kruskal-Wallis)	Females	Males
			Probability of looking up	
1	5 (7)	0.113	0.40 ± 0.55	0.86 ± 0.38
2	5 (7)	0.023	0.40 ± 0.55	1.00 ± 0.00
3	0 (10)	-	-	1.00 ± 0.00
5	4 (8)	-	1.00 ± 0.00	1.00 ± 0.00
10	3 (8)	-	1.00 ± 0.00	1.00 ± 0.00
15	2 (9)	-	1.00 ± 0.00	1.00 ± 0.00
			Time spent looking up	
1	5 (7)	0.069	0.01 ± 0.01	0.06 ± 0.07
2	5 (7)	0.041	0.02 ± 0.04	0.05 ± 0.03
3	0 (10)	-	-	0.11 ± 0.07
5	4 (8)	0.041	0.10 ± 0.05	0.05 ± 0.03
10	3 (8)	0.838	0.20 ± 0.10	0.18 ± 0.10
15	2 (9)	0.814	0.09 ± 0.01	0.11 ± 0.09

Table S3: Survey questions, anchors, and average response. The p-value and F value are for one-way ANOVA comparisons between male and female responses.

Question	Scale anchors			mean $\pm$ std	p	F(1,66)
	1	4	7			
How would you describe your past experience with virtual reality?	Very rare	Occasional	Very frequent	2.24 $\pm$ 1.70	0.817	0.054
How natural did you find the movement of the characters?	Very artificial	Borderline	Completely natural	3.81 $\pm$ 1.43	0.622	0.246
How responsive did you find the virtual environment?	Not responsive	Moderately responsive	Completely responsive	4.75 $\pm$ 1.56	0.316	1.023
How well could you walk towards the cylindrical targets?	With great difficulty	With some difficulty	With ease	6.90 $\pm$ 0.31	0.969	0.001
How crowded did the environment feel?	Very crowded	Somewhat crowded	Not at all crowded	3.41 $\pm$ 1.45	0.48	0.506
How comfortable did you feel?	Very uncomfortable	Somewhat comfortable	Very comfortable	5.40 $\pm$ 1.51	0.529	0.4
The extent to which you felt as if you were moving when standing still?	Not at all	Somewhat	Very much	2.03 $\pm$ 1.56	0.019	5.777
The extent to which you felt the characters were reacting to your presence?	Not responsive	Moderately responsive	Completely responsive	3.85 $\pm$ 1.93	0.344	0.908
Did you notice any of the characters stop and look up?	Did not notice	Noticed a few	Noticed a couple	5.91 $\pm$ 1.74	0.413	0.678
How interested were you to explore the virtual environment or interact with characters?	Not interested at all	Somewhat interested	Very interested	5.90 $\pm$ 1.37	0.075	3.278

HUMAN INTERACTIONS WITH CROWDS IN VIRTUAL REALITY

You are invited to participate in an experiment to investigate human interactions with virtual crowds. The study is conducted by Dr. Sachit Butail, Department of Mechanical Engineering, Northern Illinois University, DeKalb, IL 60115.

The goal of this study is to evaluate human response dynamics to virtual environment consisting of human crowds. Compensation available.

If you are at least 18 years old, and would like more information about participating, kindly contact: Dr. Sachit Butail at 815-753-9987 or sbutail@niu.edu or Elham Mohammadi at Z1807010@students.niu.edu (copy to Dr. Butail)

Figure S7: Flyer used to recruit participants