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Emergent & Autonomous  
Systems laboratory  
Northern Illinois University



# The effect of instructional priming on postural responses to virtual crowds

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Amsterdam, Netherlands, 2010



Bilaspur, India, 2008



Duisburg, Germany, 2010



Shanghai, China, 2014

# Crowd behavior

- Behavioral studies
  - require a large number of people for faithful reproduction of collective behavior/response
- Physics based models that capture the interaction between individuals (social, anticipatory)
  - limited predictive power for new experiments/ situations
    1. Kurvers, et al.. *Behavioral Ecology and Sociobiology*, 2013
    2. Dyers et al., *Philosophical Transactions of the Royal Society B: Biological Sciences*, 2009
    3. Isobe et al., *Physical Review E*, 2004
    4. Helbing et al., *Nature*, 2000
    5. Van Den Berg, et al., Robotics research, 2011
    6. Karamouzas et al., *Physical Review Letters*, 2014
    7. Bosse et al., *Autonomous Agents and Multi-Agent Systems*, 2013
    8. ...
  - Safety

# Virtual crowds

- Realistic
  - Interaction between agents (agents must not collide with each other, follow gaze, adaptive)
  - Interaction with surroundings (walking around obstacles, groups of other people )
- Immersive
  - Elicit physical reactions akin to real environment (postural responses, collision avoidance)
  - Emotional and psychological reactions (presence questionnaires, EEG data)
    1. Pelechano et al., *Synthesis Lectures on Computer Graphics and Animation*, 2008
    2. Olivier et al., *Transportation Research Procedia*, Elsevier, 2014,
    3. Brunaeu, et al.. *IEEE Transactions on Visualization and Computer Graphics*, 2015
    4. Moussaïd et al., *Journal of the Royal Society interface*, 2016
    5. ...

# Psychological priming

“I immediately thought back to what happened the year before in Apeldoorn [the witness refers to the failed attack on the Royal Family the year before, when someone drove his car into the crowd towards the Royal Family ...]”  
—eyewitness account in the May 4th incident in Amsterdam

“the behavioral effect of an event or action in the past that have bearing on subsequent responses of an individual through an implicit memory recall”

- Increase presence in high-fidelity environments
- Alter the responses in visual exposure therapy
- Modify expectations about efficacy in aromatherapy (instructional priming)

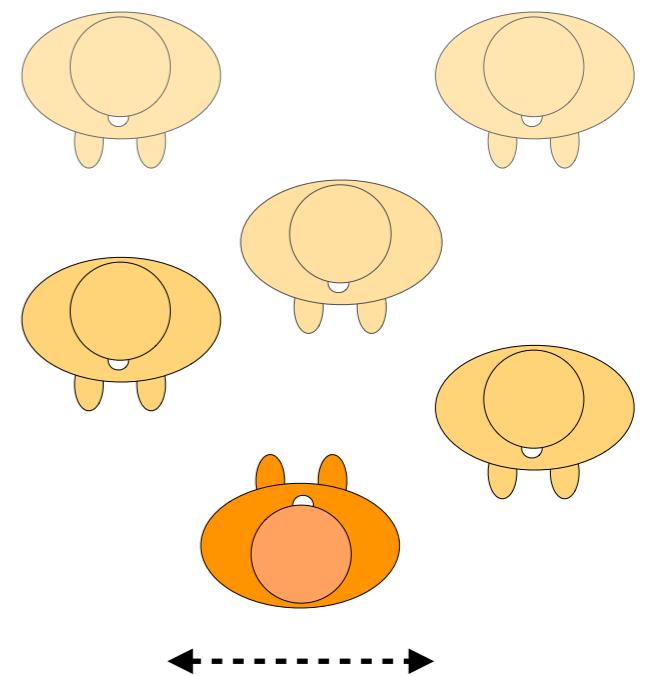
1. Tulving and Schacter, *Science*, 1990.
2. Nunez and Blake, in *Proceedings of the ACM International Conference on Computer graphics, Virtual Reality, Visualisation and Interaction*, 2003
3. Qu et al., *Presence*, 2013
4. ...

# Instructional priming (this study)

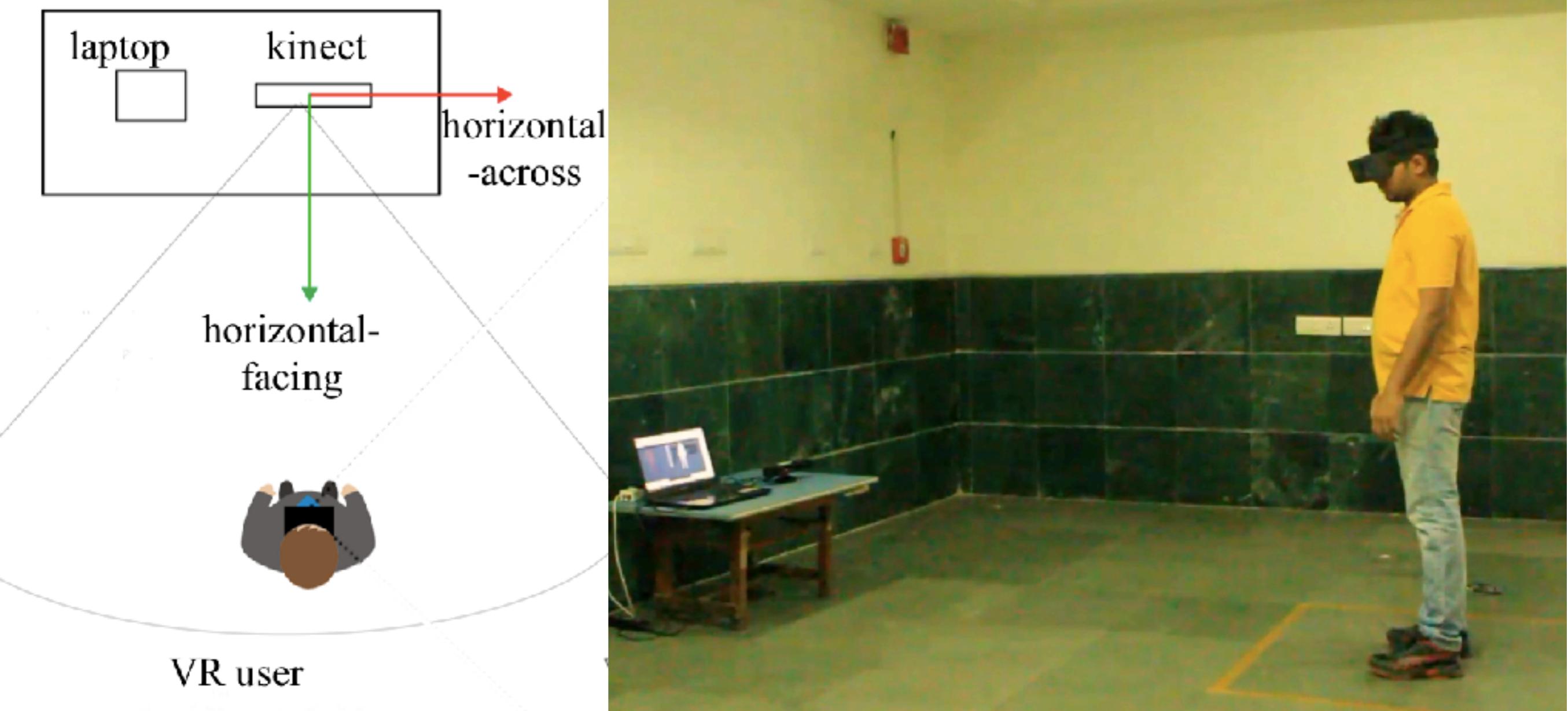
**Hypothesis 1:** Postural response will be enhanced for the participants who are primed with an instruction that one of the walking agents in the environment represents a real person



**Hypothesis 2:** Participants who are primed will respond by demonstrating increased collision avoidance maneuvers; these maneuvers will manifest themselves in the form of larger movements in the left-right direction perpendicular to the ambient virtual crowd flow



# Experimental setup



# Virtual environment

- Participant stands facing against an oncoming crowd
- The agents interact between themselves and with the participant based on the social force model
- Participant avatar is stationary

$$m_i \ddot{\mathbf{r}}_i = \mathbf{f}_g + \sum_{j=1, j \neq i}^N \mathbf{f}_{ij} + \sum_W \mathbf{f}_{iW}$$

acceleration

mass

goal force with a speed of 0.6 m/s

social force with standard parameter values

wall force replaced with reflective condition

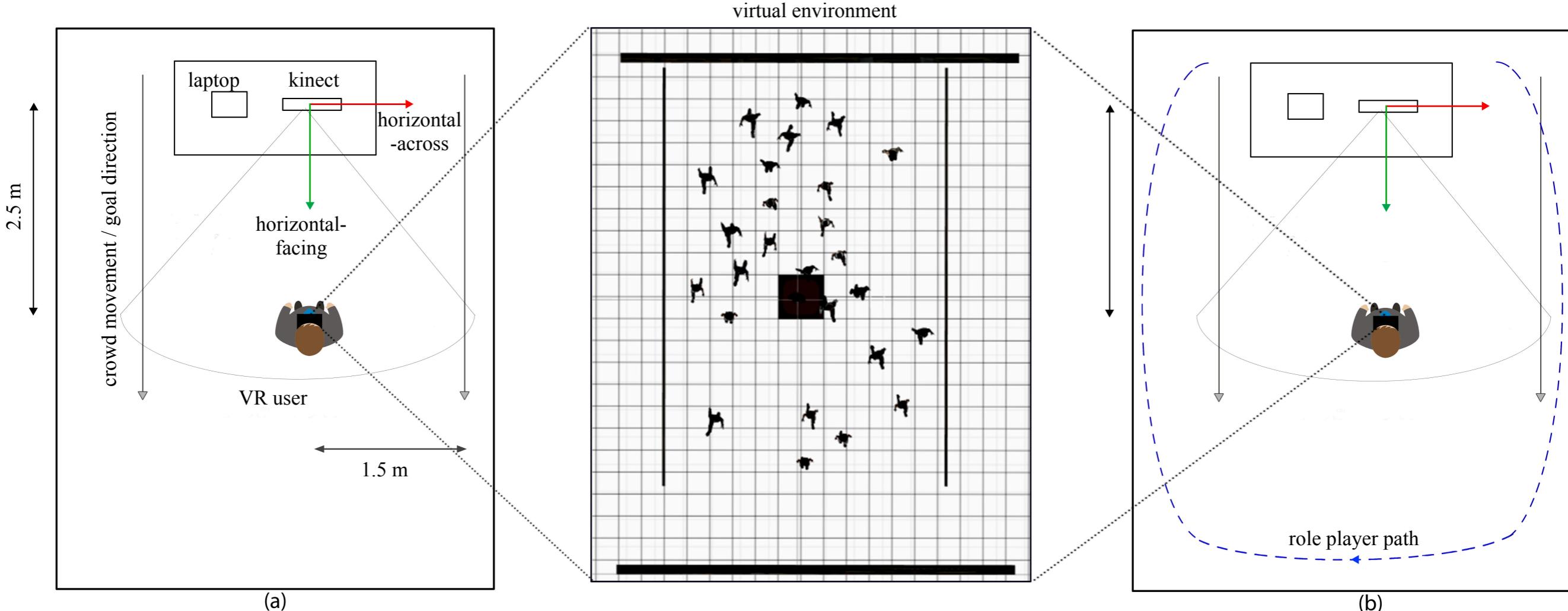


# Virtual environment



[https://youtu.be/5J-N\\_4zF4oo](https://youtu.be/5J-N_4zF4oo)

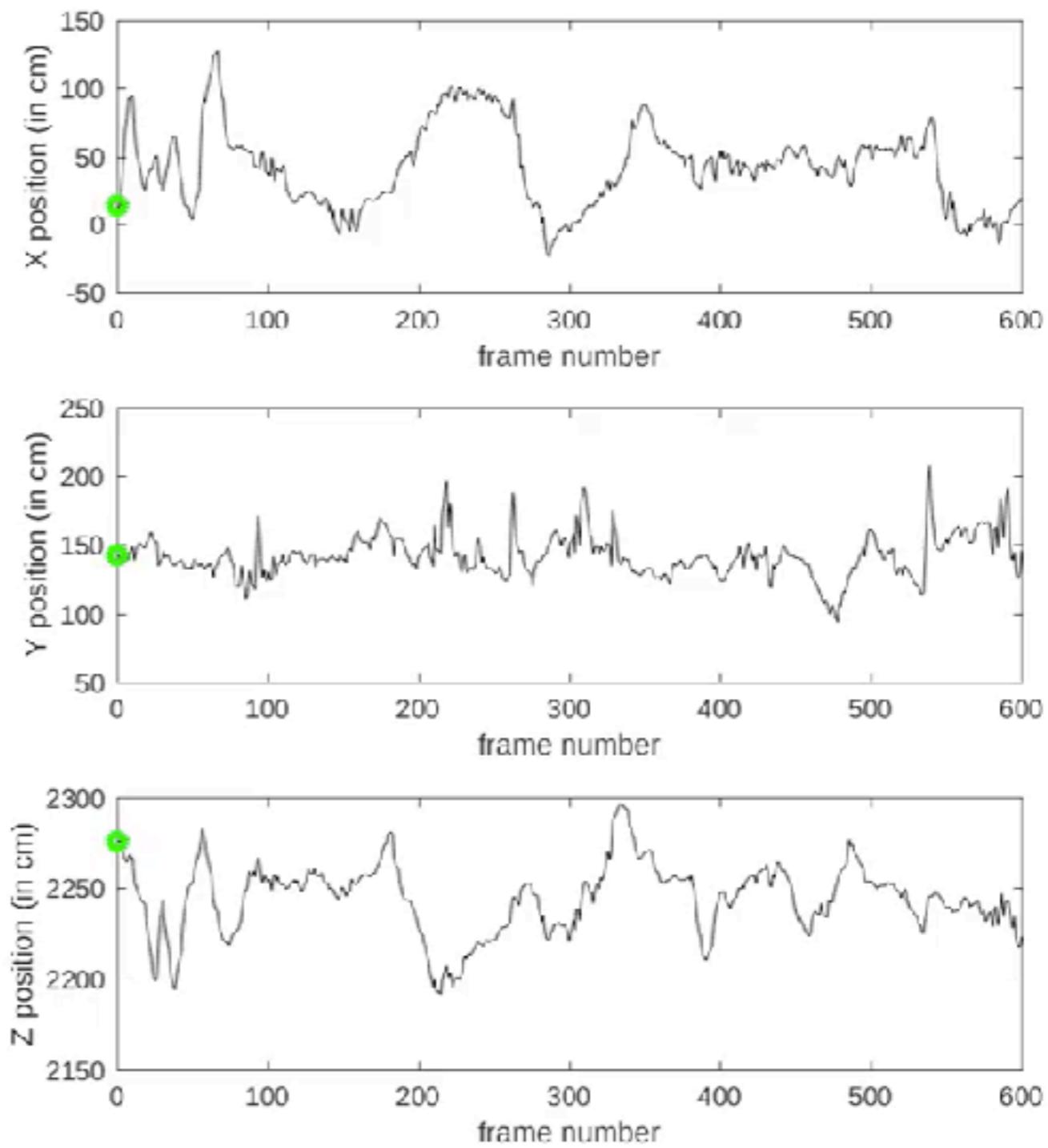
# Experimental procedure



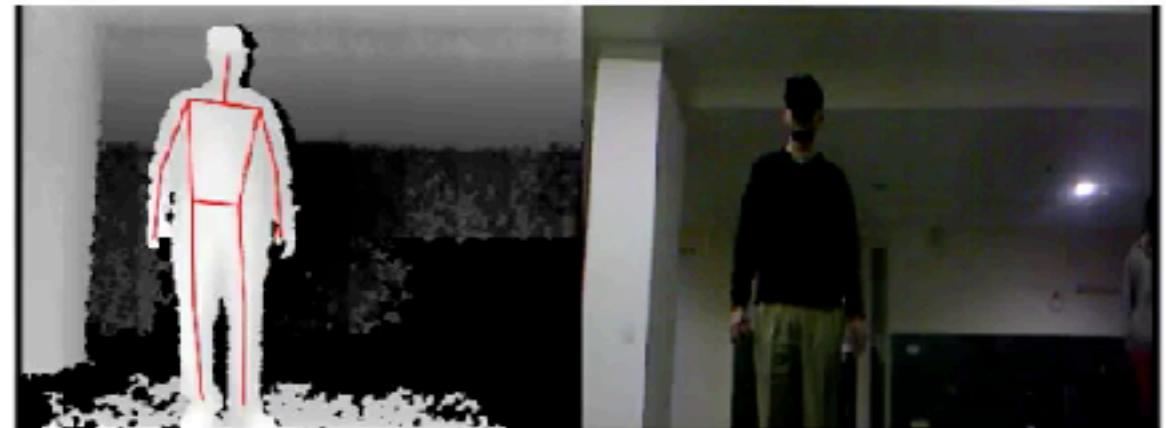
**noPrimeVR**  
“ ”

**primeVR**

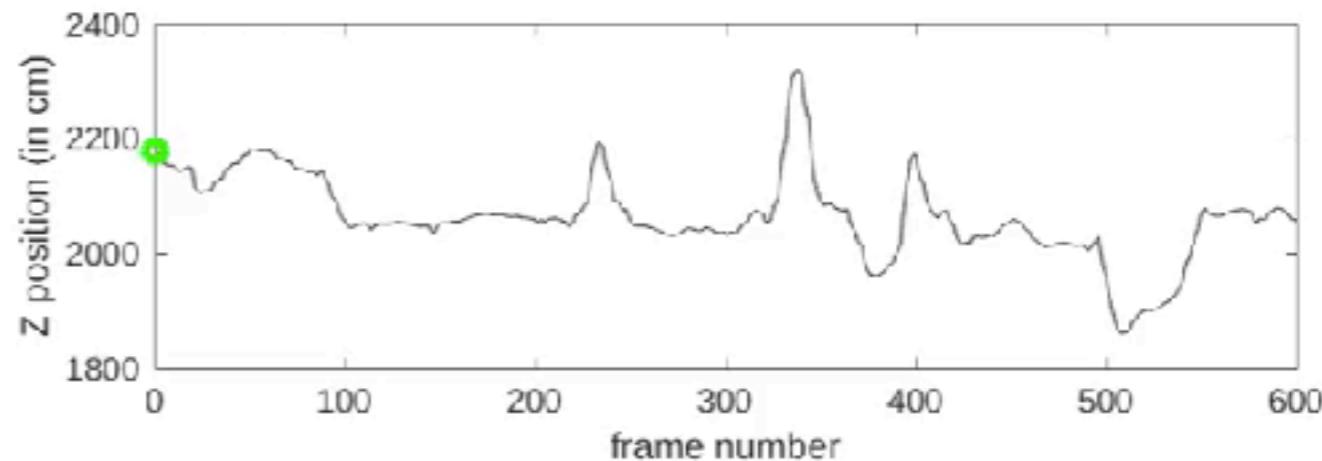
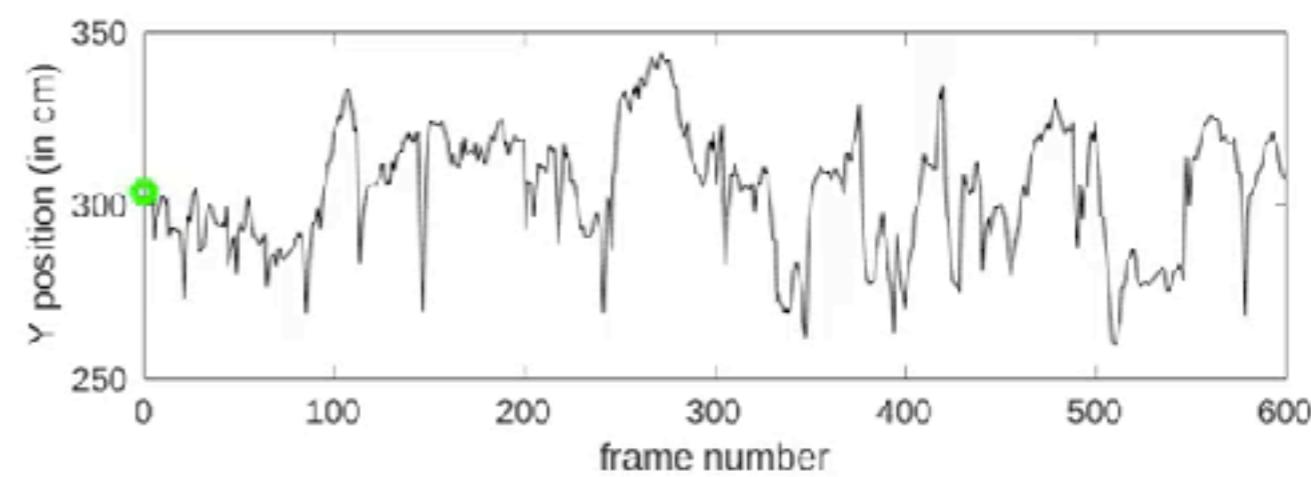
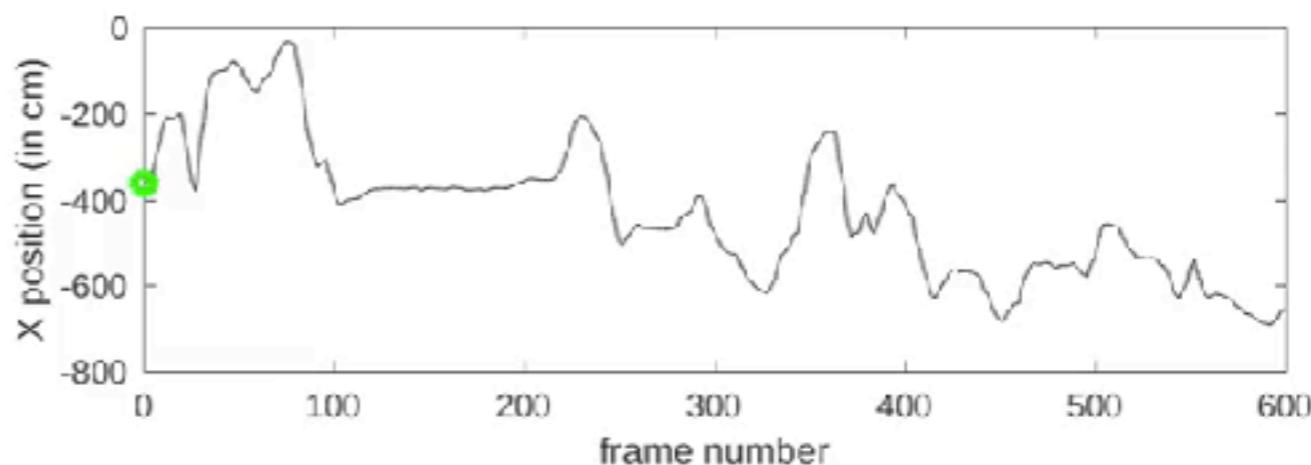
“During the experiment, one of the virtual people in the crowd will correspond to an actual person in the real world who will be moving in the experimental arena”



**noprimeVR**

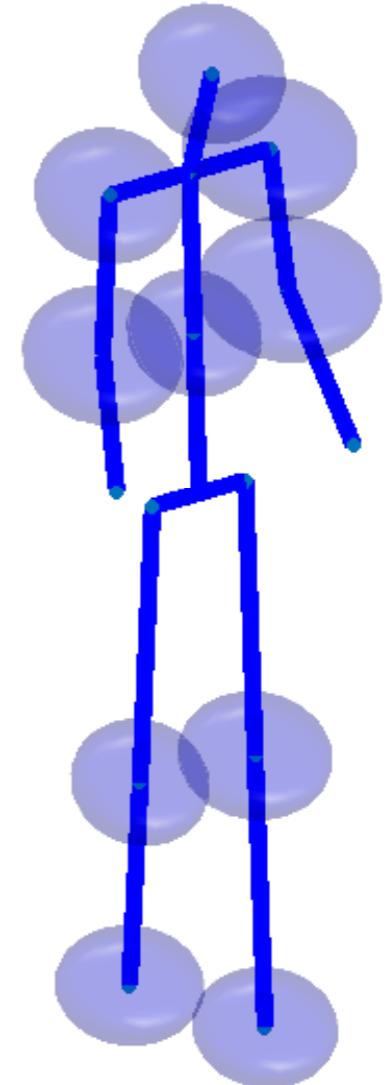


**primeVR**



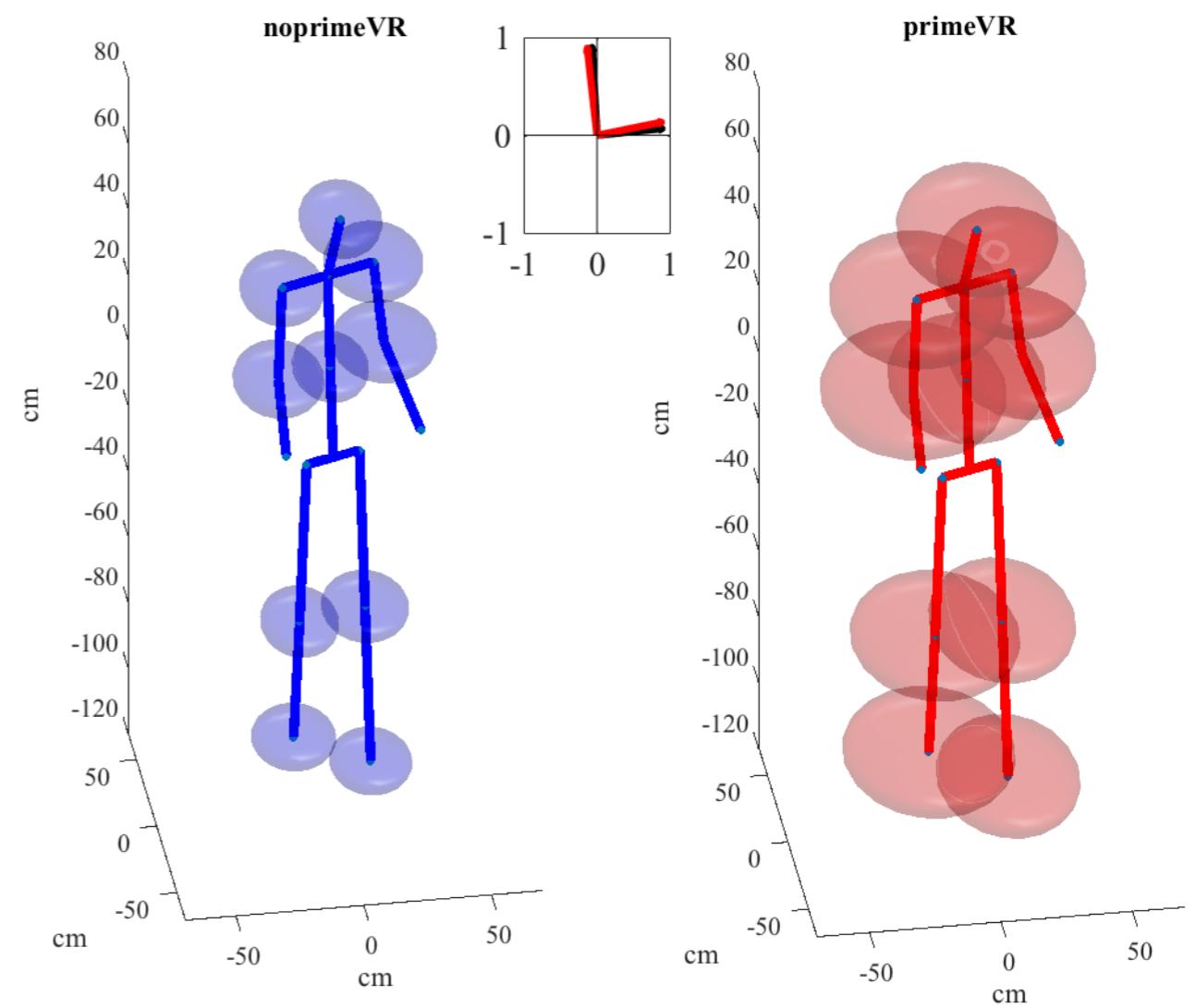
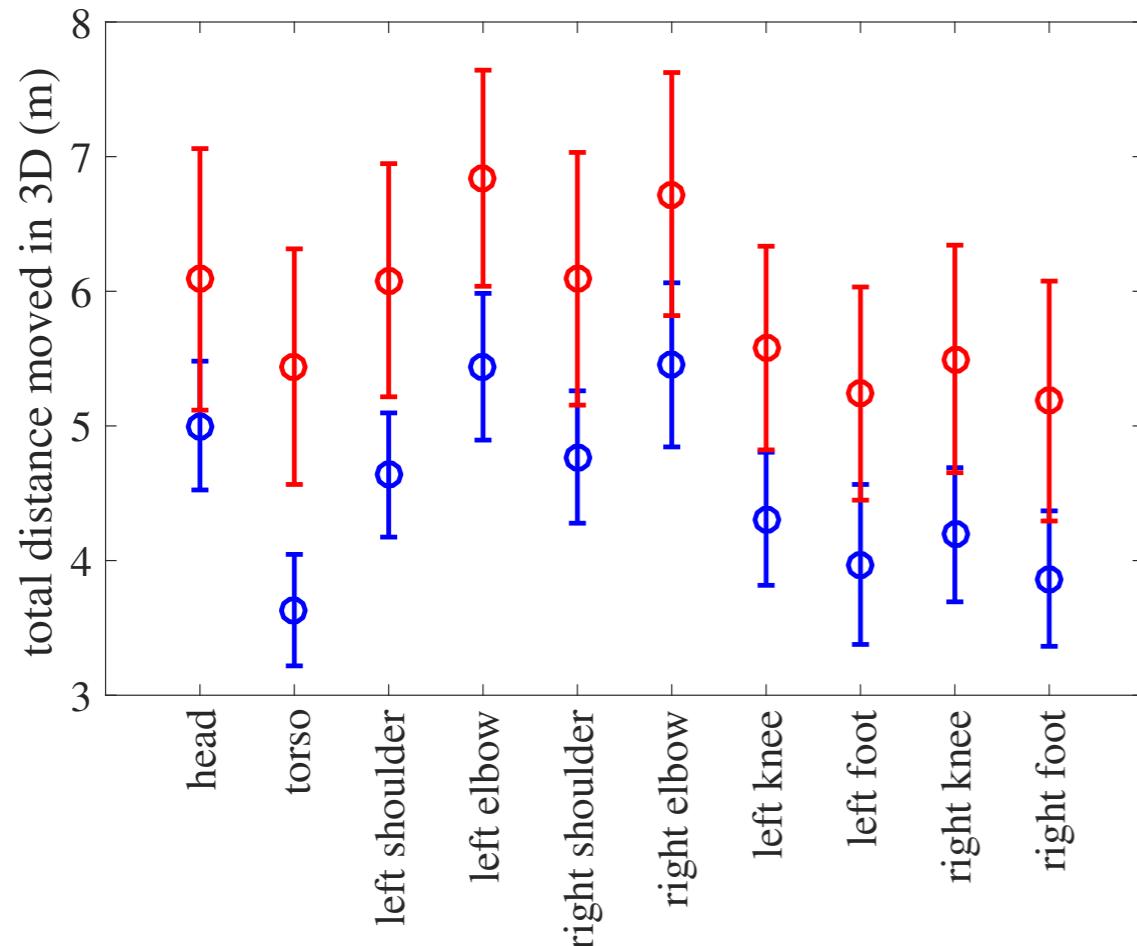
# Analysis

- Movement of 10 joints in three dimensions
- Smoothed raw trajectory data with a moving average filter (window size 4,8, and 16 frames)
- Distance moved by each joint for 60 seconds as the participant interacted with the virtual environment
  - Compare average between conditions for distance in 3D (H1) and in left-right direction with respect to the ambient crowd movement (H2)



# Results

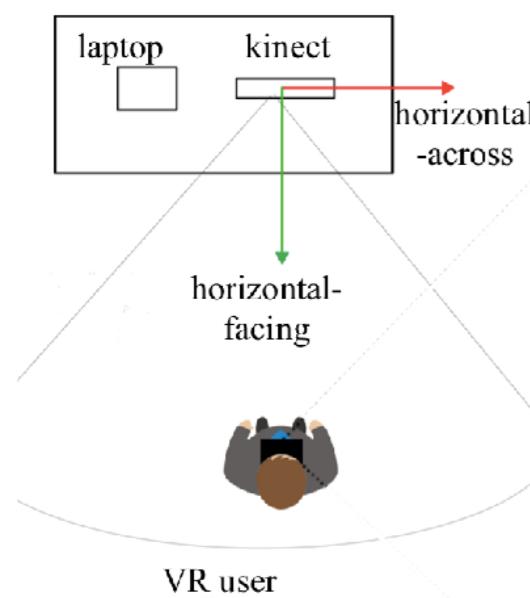
# Distance moved across joints



# Postural response was not different (H1)

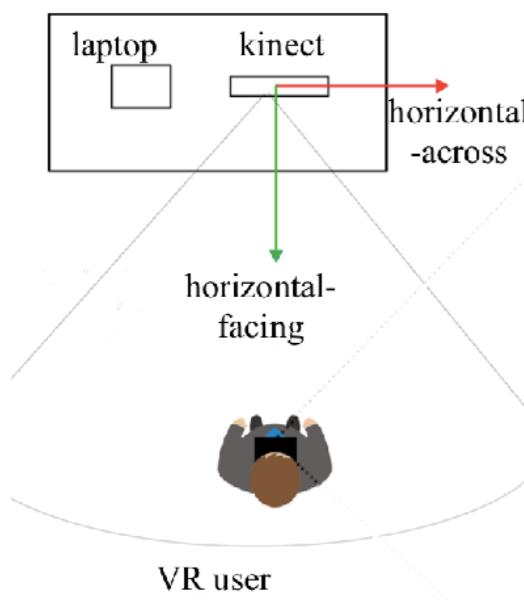
repeated measures joints x condition

window size	3D		2D		horizontal-across	
	p	F(1,20)	p	F(1,20)	p	F(1,20)
4	0.32	1.01	0.14	2.35	0.03	5.23
8	0.17	2.02	0.08	3.35	0.02	5.95
16	0.11	2.74	0.06	3.87	0.03	5.20



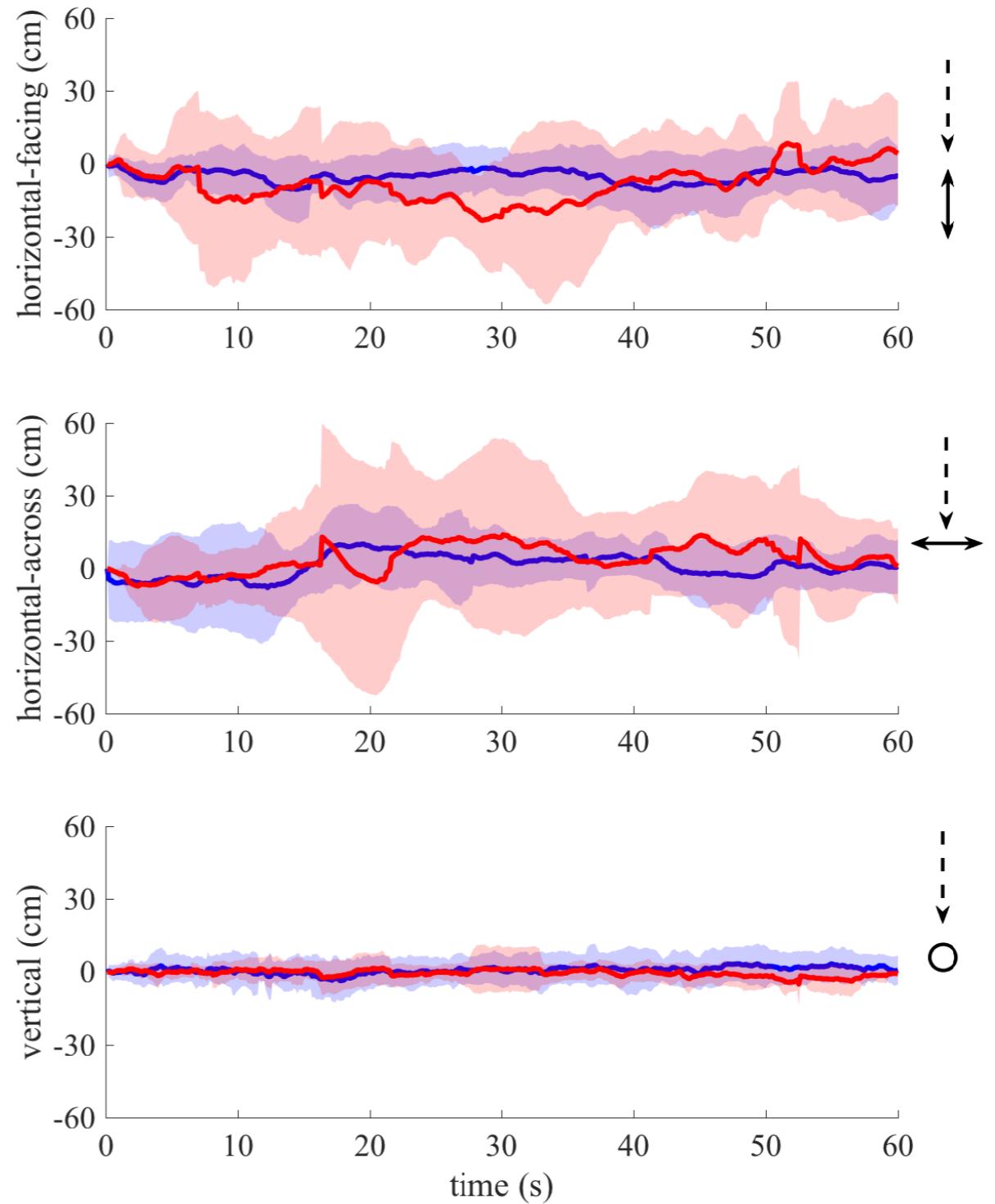
# Left-right movement was different (H2)

window size	3D		2D		horizontal-across	
	p	F(1,20)	p	F(1,20)	p	F(1,20)
4	0.32	1.01	0.14	2.35	0.03	5.23
8	0.17	2.02	0.08	3.35	0.02	5.95
16	0.11	2.74	0.06	3.87	0.03	5.20



# Variation in joint movements

- Two sample F-test with Bonferroni correction ( $p < 0.005$ )
- Torso movement along the horizontal plane had significantly different variation between conditions



# Observations/summary

- Postural responses displayed maximum difference in torso, which cannot be moved independently
- Instructional priming can serve to increase presence
- Distance based interaction could have elicited unrealistic avoidance—although participants in each condition interacted with the same type of simulation

# Ongoing work

- Other priming methods: videos, text, conversational
- Anticipatory collision model
- New environment to study individual response to crowds in different states
- Network of agents to simulate information transmission within a crowd
- Multiple measures of presence including questionnaires, EEG data, and distance from virtual characters in real time



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# Thank you!

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