



Gaze Behavior During 360° Naturalistic Scene-Viewing

Thomas L. Botch¹, Jeff Mentch^{1,2}, Caroline E. Robertson¹

¹Dartmouth College, Hanover, NH; ²McGovern Institute for Brain Research, MIT, Cambridge, MA



BACKGROUND

- Little is known about gaze behavior in 360° naturalistic scenes.
- Here, we tested whether three features of gaze behavior, previously observed in eye-tracking studies using fixed displays or mobile studies, extend to naturalistic 360° scene-viewing:
 - “Center bias” – Fixations are biased to the center of static [1] and dynamic images [2]
 - Relatively short saccade lengths (2.5 DVA) and fixation durations (~330 ms) during natural photograph viewing [3].
 - Head direction is, on average, coincident with eye-direction [4].

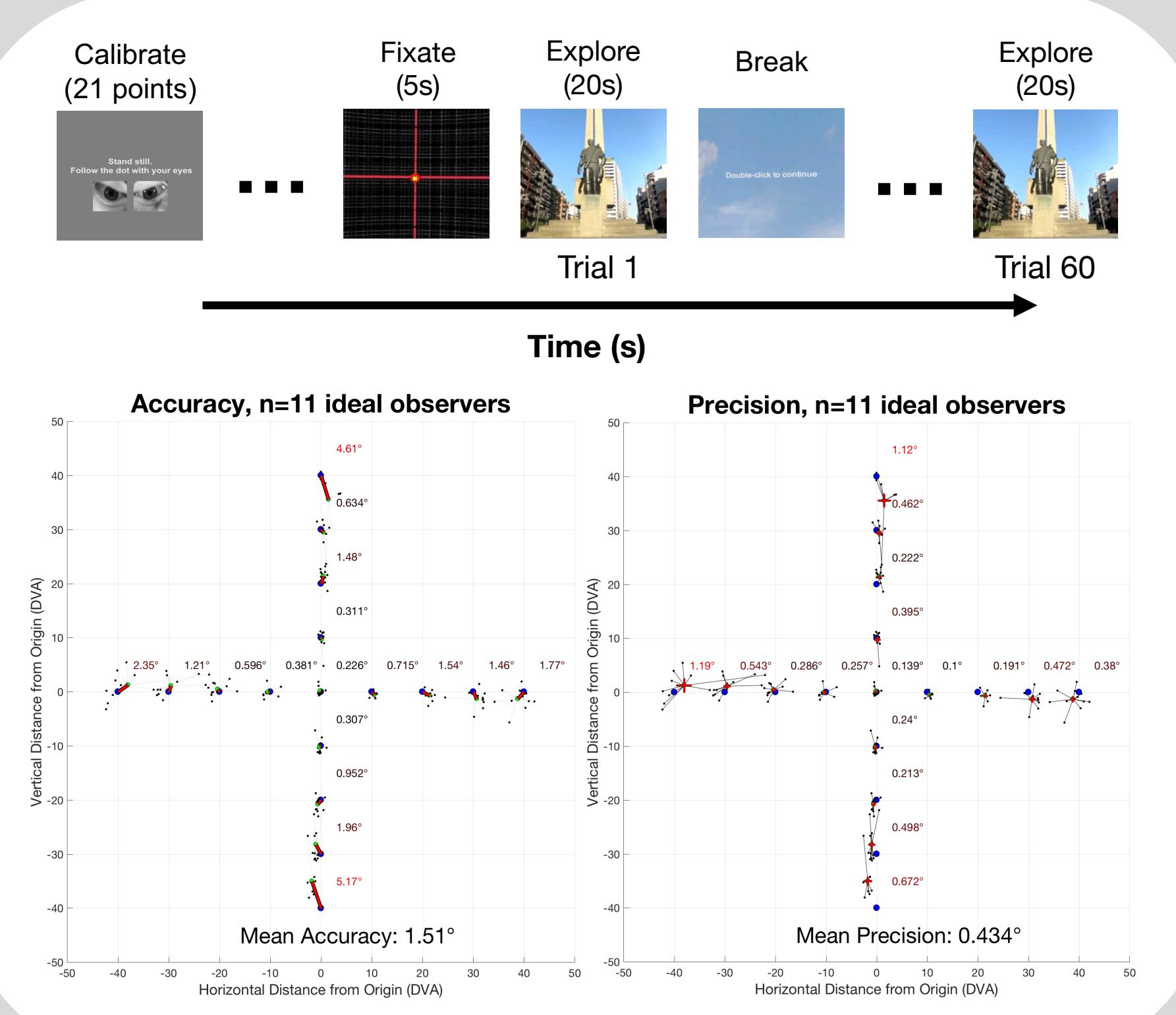
VR / Eye-tracking: Measuring Active Vision



- Wide visual field (100°)
- 360° real-world, complex scenes
- Active, first-person viewing

METHODS – DESIGN

Paradigm



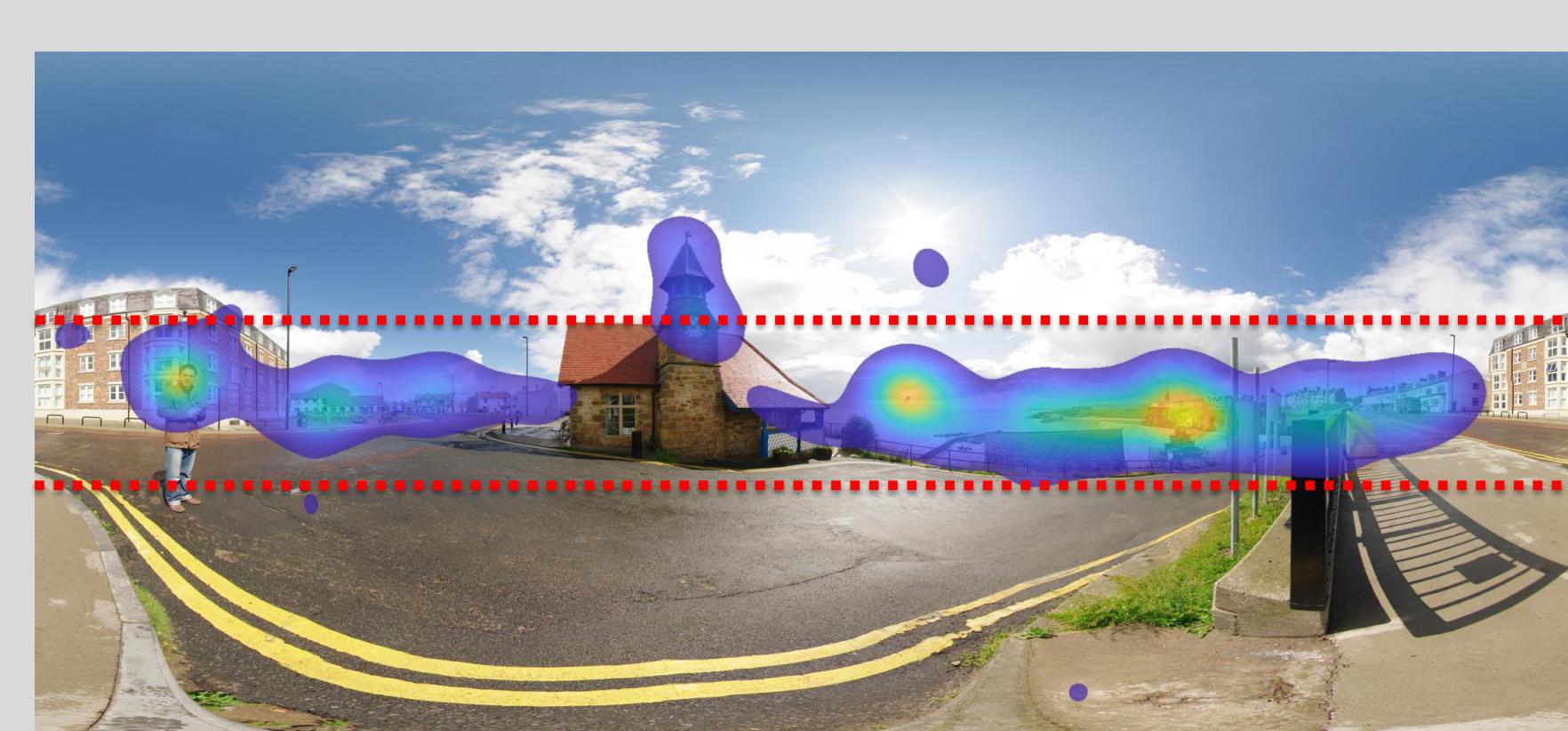
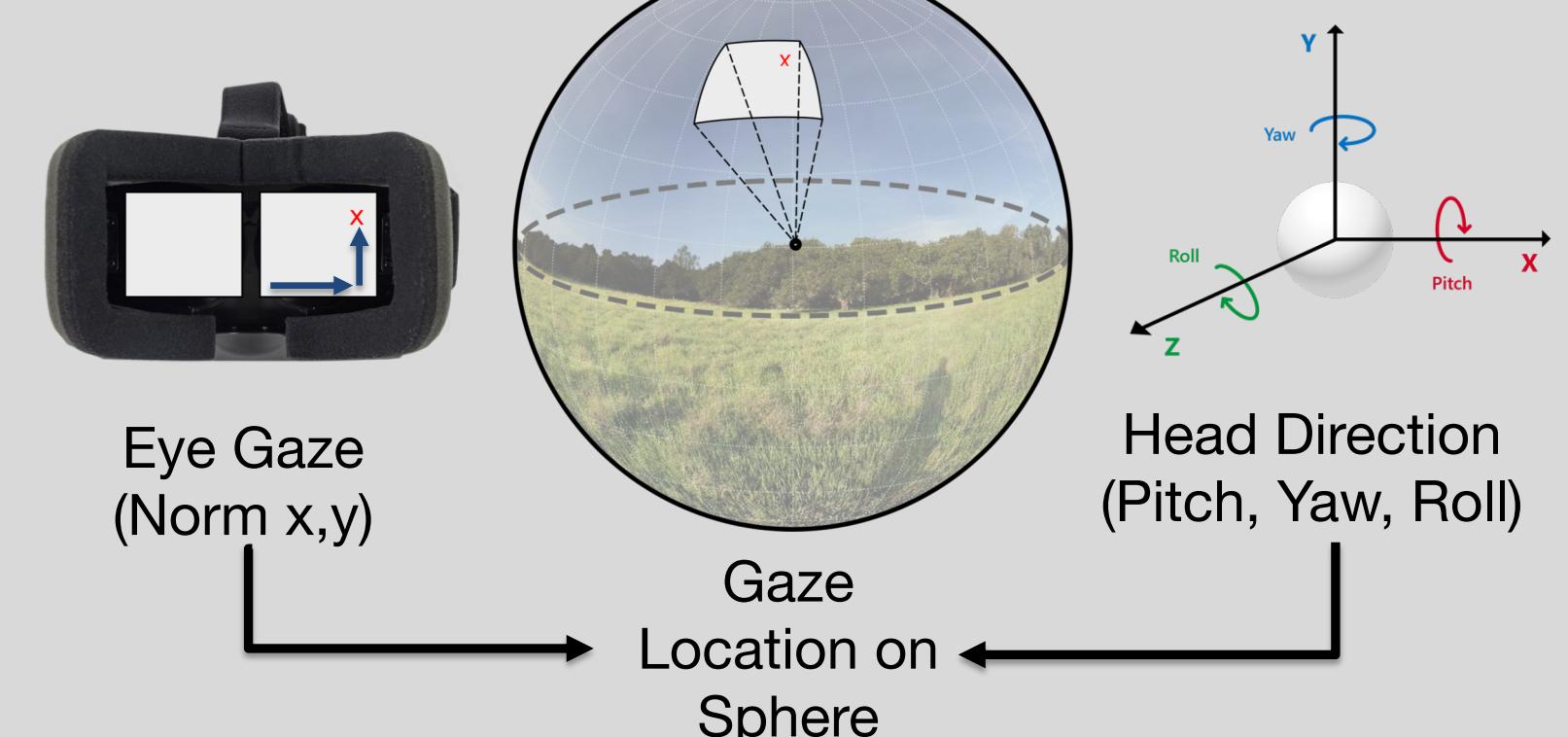
Gaze behavior in complex, real-world 360° panoramic scenes was measured in a head-mounted display.

- HMD specs: Oculus DK2: resolution: 960 x 1080; field-of-view: ~95 DVA; 75 Hz refresh).
- Eyetracker: (Pupil Labs. 120 Hz refresh; 5.7ms latency; 0.5 visual degrees accuracy). 1.51° mean accuracy and 0.434° mean precision measured in n=11 ideal observers.

12 adults observed 60 scenes (20s each). 21-point calibration preceded trial 1. Drift-correction fixation preceded each trial.

Data Processing

Gaze coordinates were rectified with head direction (pitch, yaw, roll), and transformed into latitude and longitude on the 360° panorama.

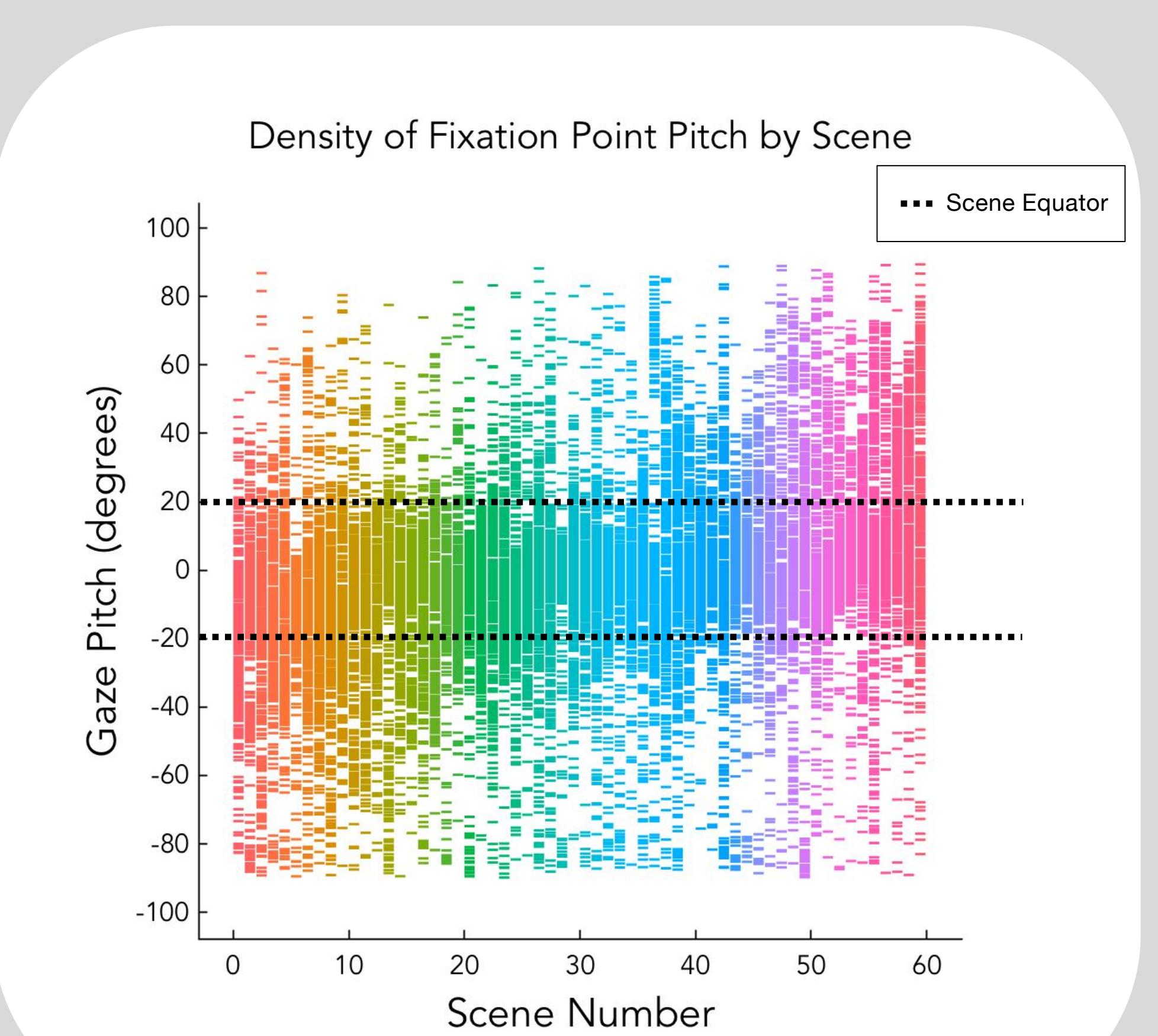
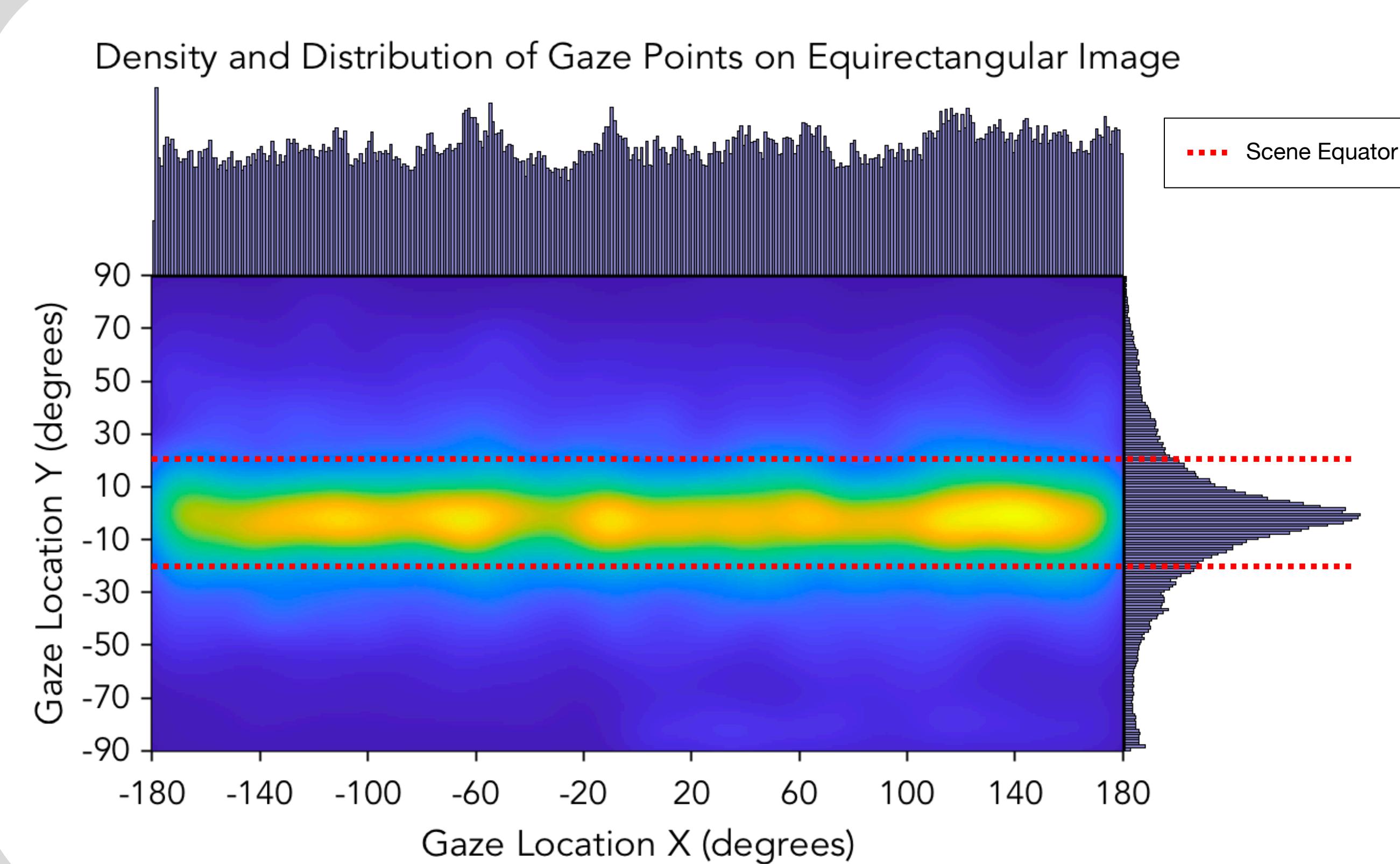


Heat maps were created by weighting fixations by duration and smoothing with a gaussian filter for all scenes for each participant.

RESULTS – VISUAL BEHAVIOR IN 360° REAL-WORLD SCENES

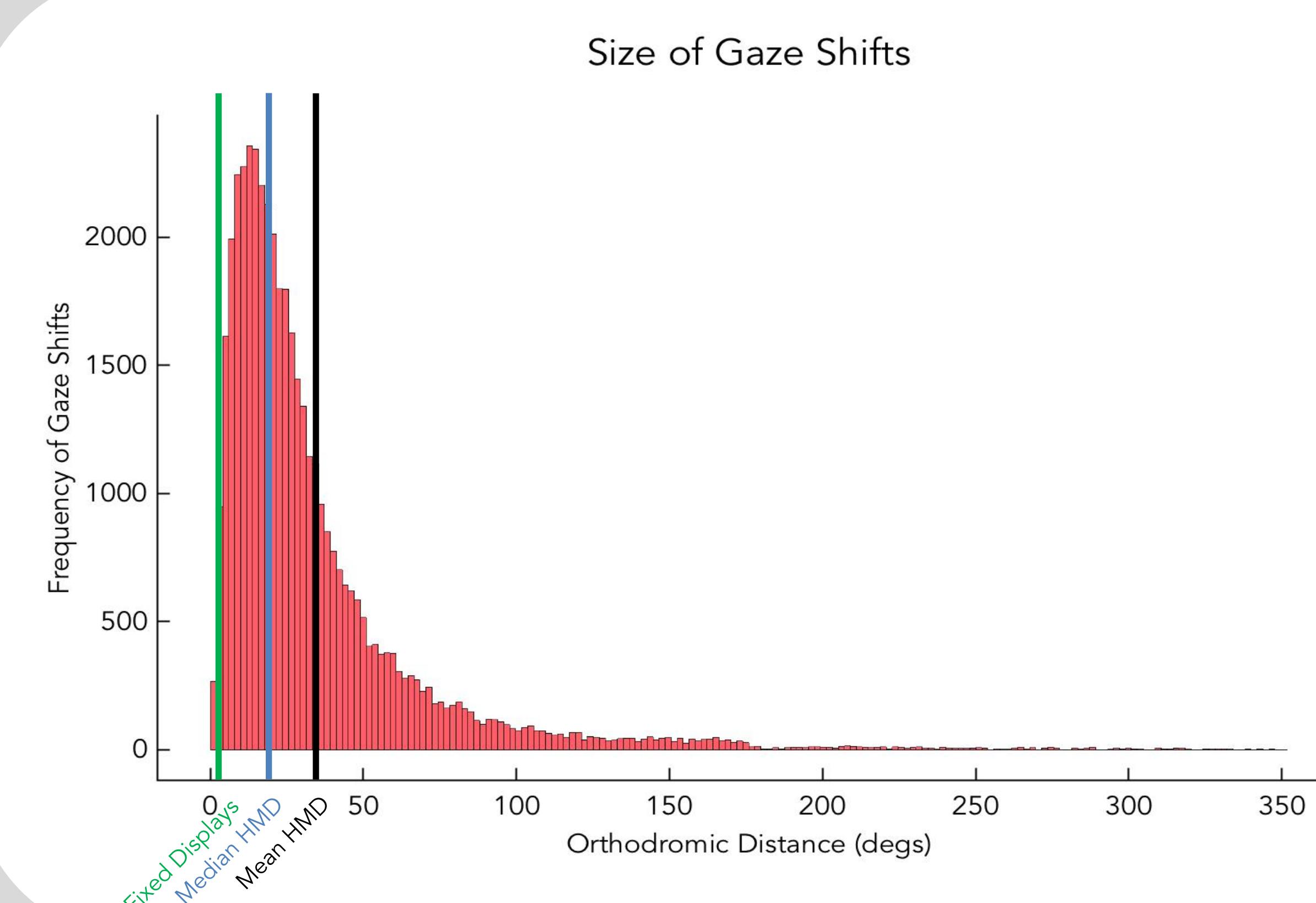
Where do people look relative to the equator of a scene?

Across participants, we observed an “equator bias”, rather than a “center bias”, in gaze behavior. The majority of fixations were often directed within +/- 20° of the equator of the panoramic scene: 62.94% +/- 3.45 STD of the trial.



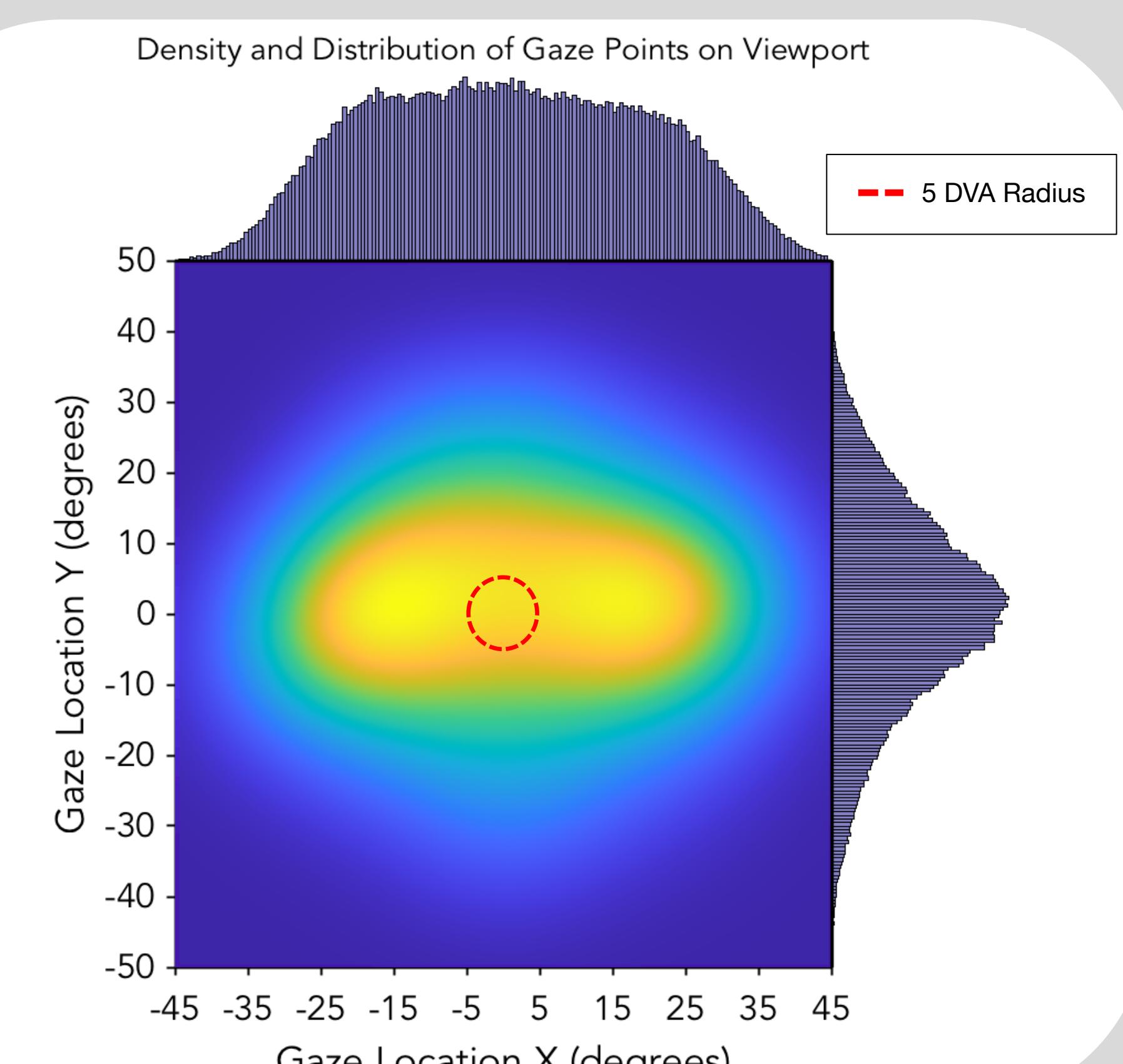
How big are gaze shifts and fixation durations?

Mean gaze shifts during 360° scene exploration were much larger than expected: 37.6° visual angle +/- 46.8 STD. Fixation durations were comparable to fixed-display studies: 332 ms +/- 2.53 STD.



Where do people look relative to head center?

Surprisingly, gaze was rarely at head center: on average, only 3.01% +/- 0.901 STD of gaze points fell within a 5° radius of head center.



REFERENCES

- Busswell, G. T. (1935). *How people look at pictures: A study of the psychology of perception in art*. Chicago: University of Chicago Press.
- Itti, L. (2004). Automatic foveation for video compression using a neurobiological model of visual attention. *IEEE Transactions on Image Processing*, 13, 1304–1318.
- Henderson, J. M., & Hollingworth, A. (1998). Eye movements during scene viewing: An overview. In Eye guidance in reading and scene perception.
- Linda B. Smith, Chen Yu, Hanako Yoshida & Caitlin M. Fausey (2015) Contributions of Head-Mounted Cameras to Studying the Visual Environments of Infants and Young Children, *Journal of Cognition and Development*, 16:3, 407-419

CONCLUSIONS

- Gaze in 360° real-world scenes tends to be concentrated around the “equator” of scenes, rather than the center of the screen or initial FOV, suggesting that “center bias” may be an artifact of fixed-display presentations.
- Gaze shifts during 360° active viewing are larger than what is typically reported in fixed display and mobile eye-tracking studies.
- Gaze is often directed away from head center, suggesting that head direction is not a good proxy for eye-direction (as is often assumed in infant research).