

Head movements during visual exploration of natural images in virtual reality

Brian Hu

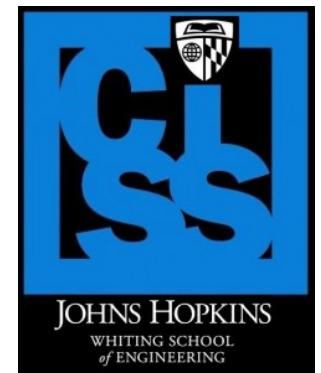
Ishmael Johnson-Bey

Mansi Sharma

Ernst Niebur

Johns Hopkins University

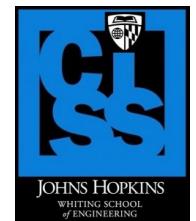
March 24th, 2017



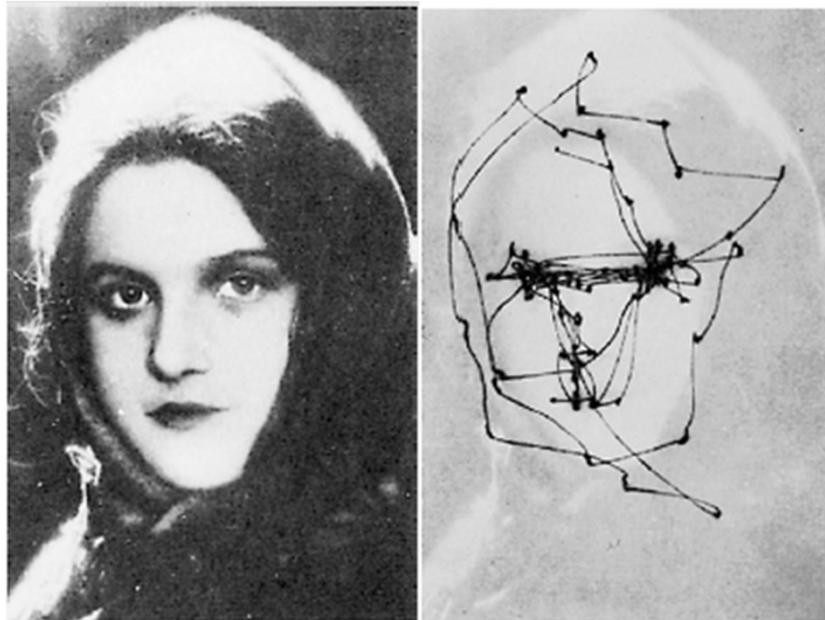
Eye movements are a window into the mind



Yarbus, 1967



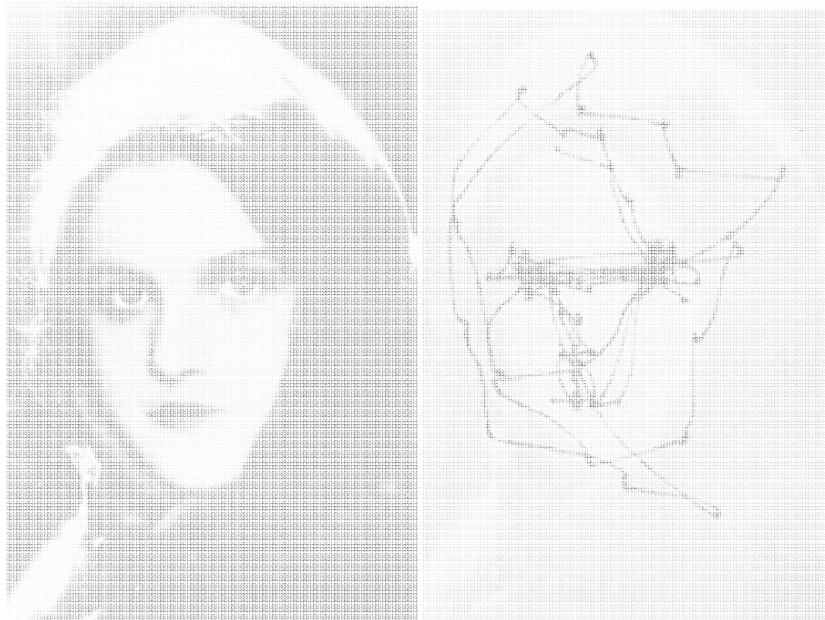
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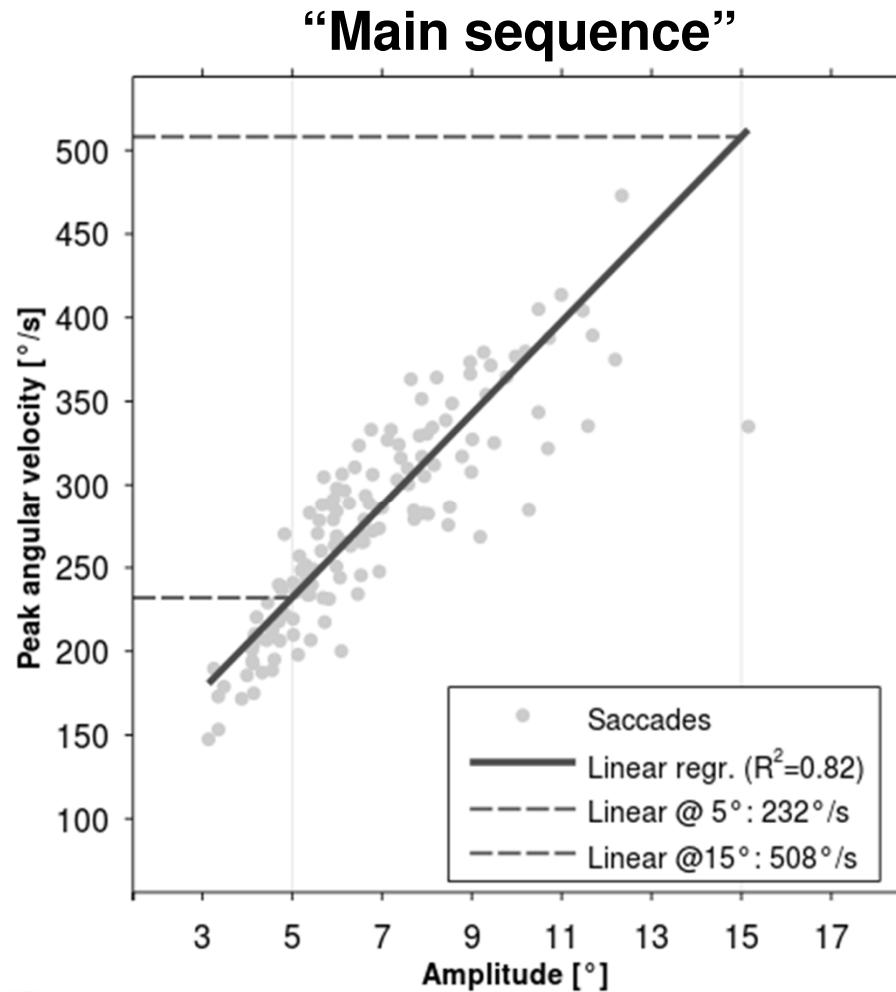
Eye movements are influenced by task demands



Yarbus, 1967



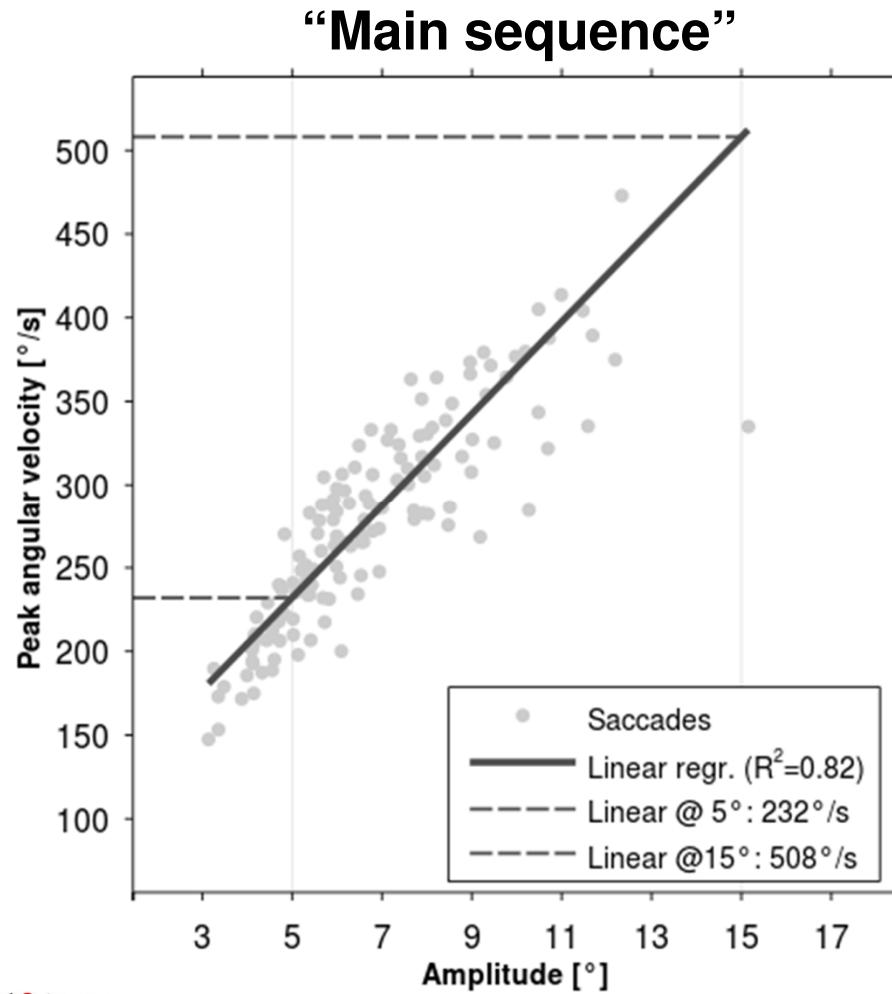
Eye movements are stereotyped



Original image by InkassoSchroeder
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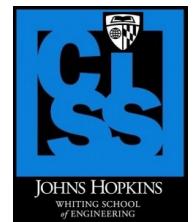
Eye movements are stereotyped



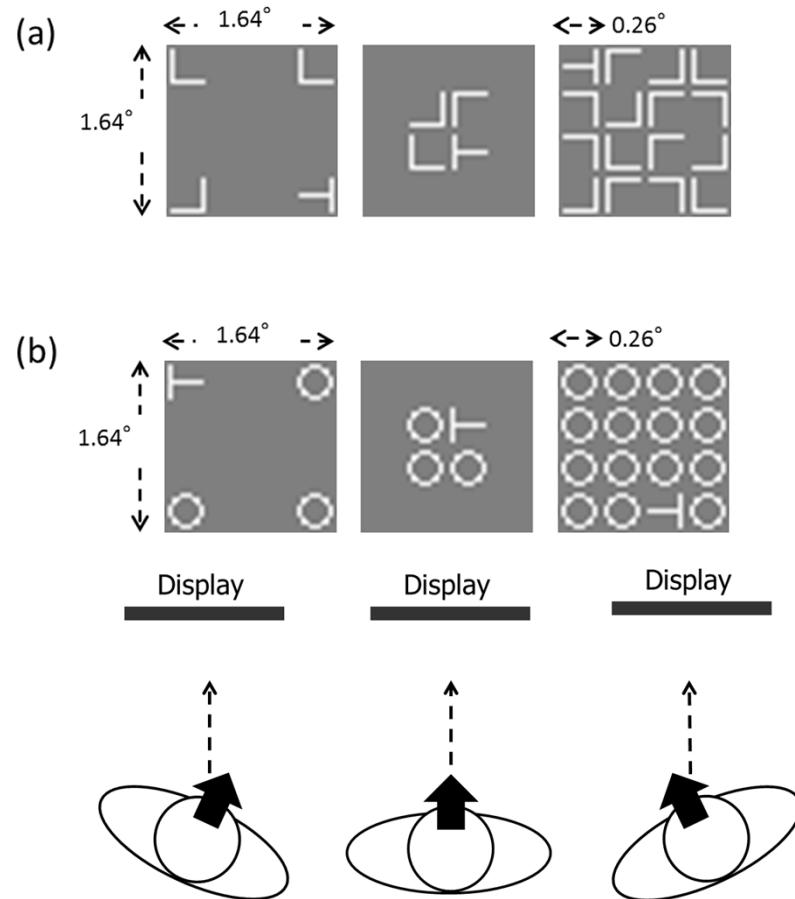
What is the role of head movements during natural visual exploration?

How can we study this?

Original image by InkassoSchroeder
via Wikimedia Commons



Well-controlled experiments may not translate to the real world

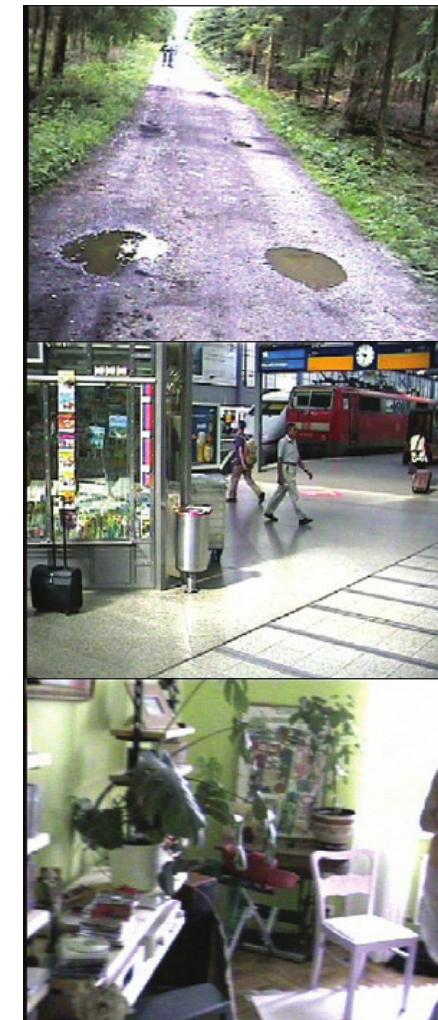


Nakashima and Shiori, 2014

Unconstrained visual exploration is difficult to reproduce



Einhauer et al., 2007



Virtual reality (VR) as a novel experimental paradigm

- Combine Google Cardboard + Unity game engine to record head movements while subjects view natural images in VR
 - **Advantages:** cost-effective, can present the same set of images to subjects
 - **Disadvantages:** cannot record eye movements, have to deal with “drift”



Source: i.ytimg.com/vi/eT9vmpE8WcY/maxresdefault.jpg



Methods

- Participants viewed 70 images drawn from 5 categories (buildings, fractals, “old” home interiors, landscapes, and “new” home interiors)
 - 65 unique images, 5 repeat images (shown only at the end of the experiment)
 - Parkhurst et al., '02 image dataset + 25 new images
- 1-second image preview, 10-second viewing time
- Participants were recorded verbally describing the image after each viewing



Data Analysis

- Exclude trials where head movements went outside the image area (<2% of the data)
- Resample/interpolate position data at 50 Hz and convert pixel locations to visual degrees
- Compute velocity (deg/sec) by convolving with derivative of Gaussian filter ($sd = 100$ ms)
- Separate **head “fixations”** from **head movements** with a velocity threshold (≤ 25 deg/sec), and use the centroid of fixation points as the “fixation” center
- Record fixation location/duration and movement amplitude/duration/angle/velocity

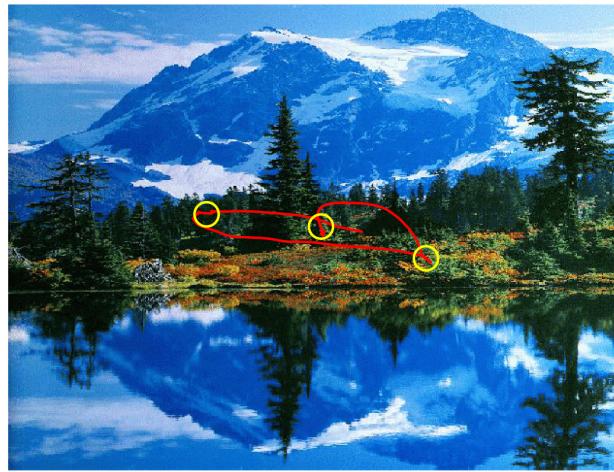
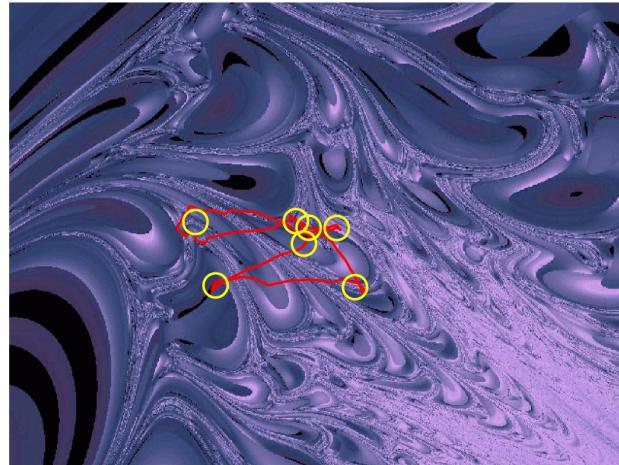
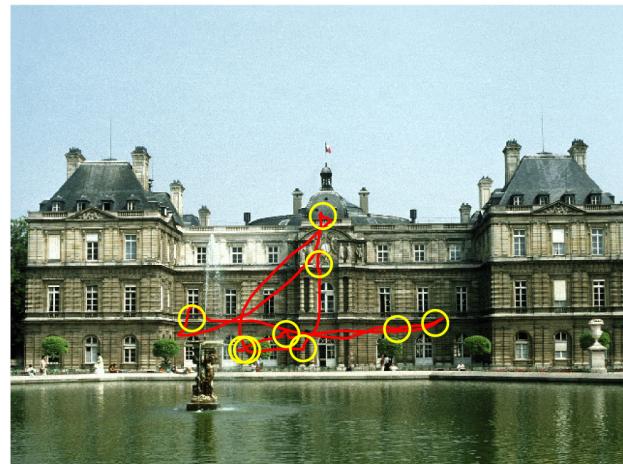


Participant Demographics

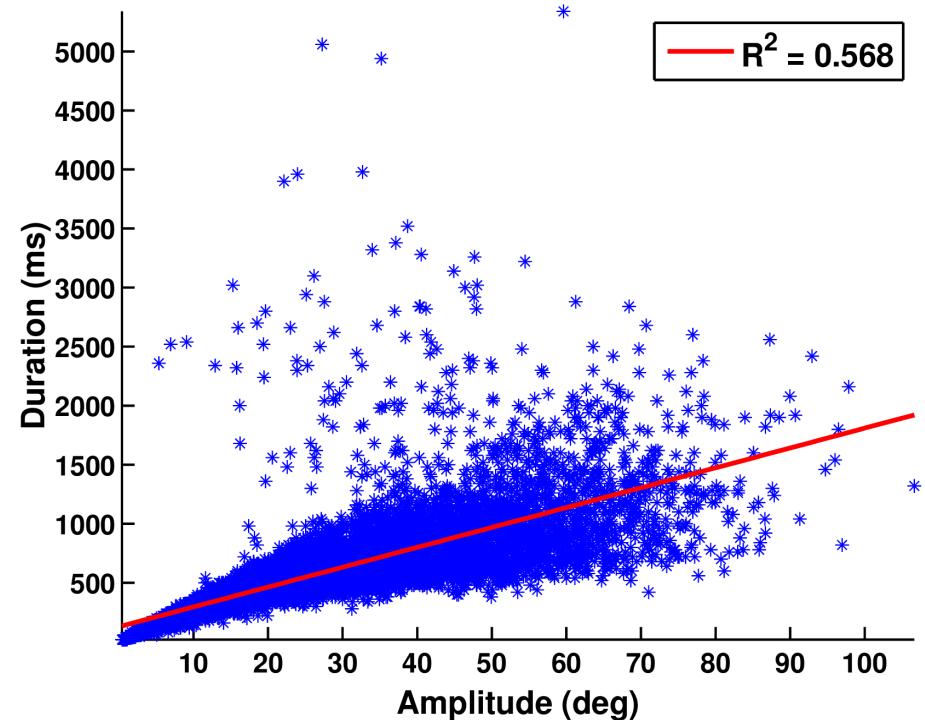
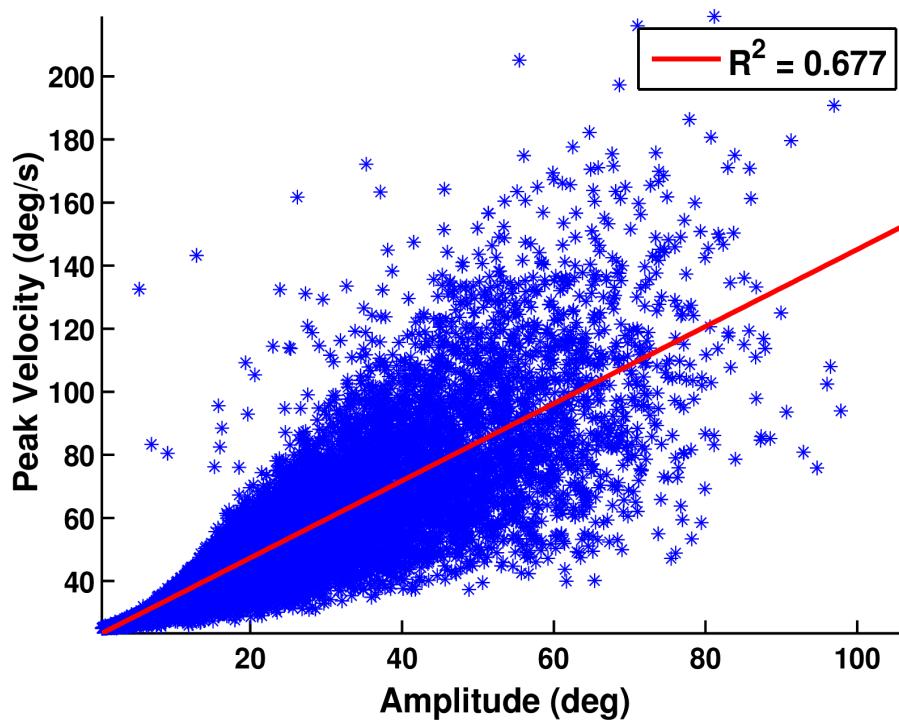
- N = 27 total participants (**15 M, 12 F**)
- Age: 18-26 y.o. (Mean: **20.1 y.o.**)
- Gaming experience (1: little to no, 5: a lot): **3.8**
 - **7/27** participants used some VR system before
- Nausea/dizziness (1: little to no, 5: a lot): **1.5**
- Ease of use (1: very, 5: not at all): **2.4**
- **20/27** participants used the smaller “preview” image to guide visual exploration



Head movements are diverse



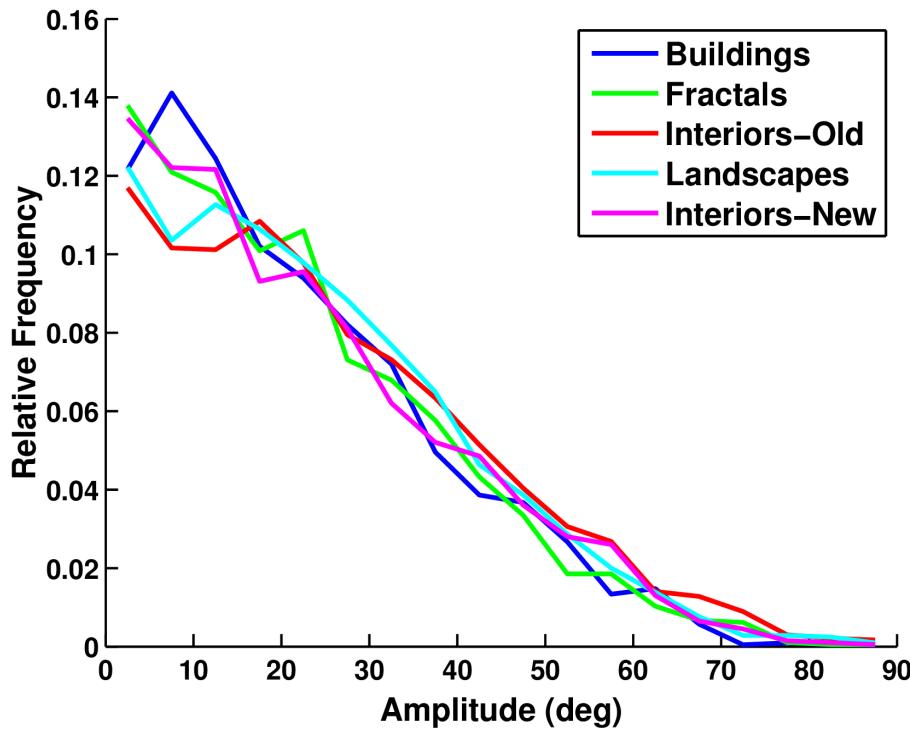
Head movements also follow a main sequence



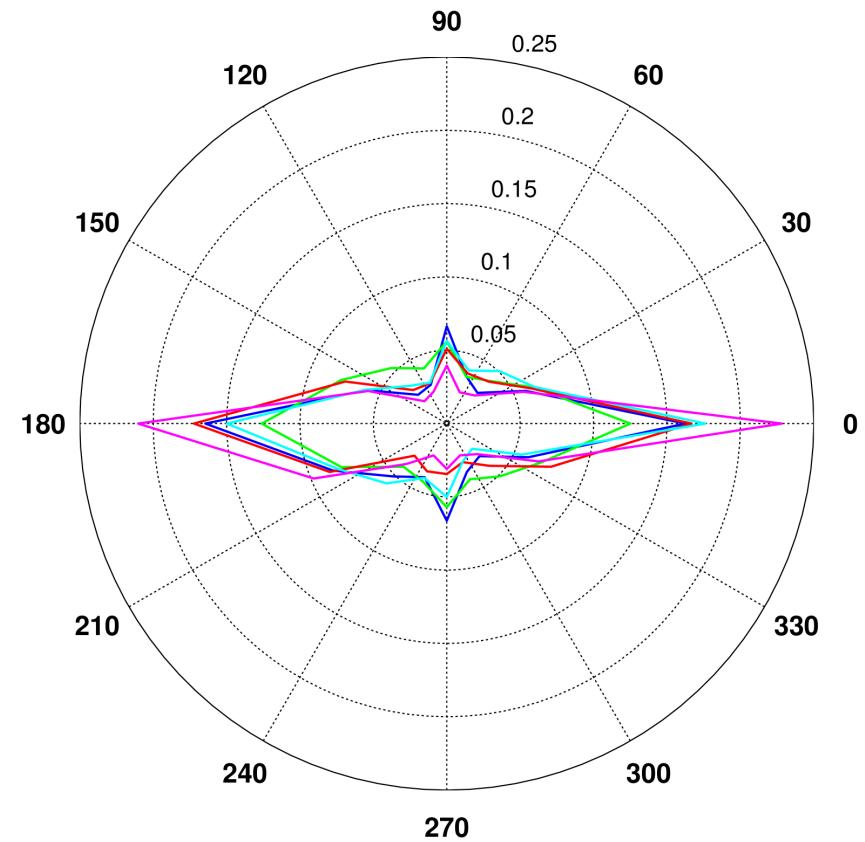
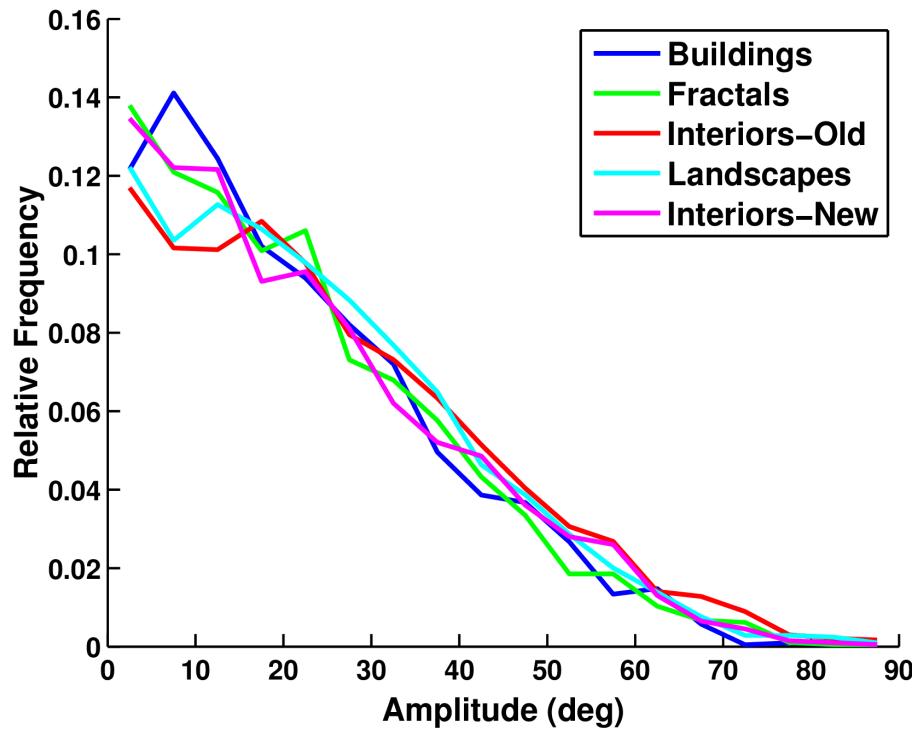
Note: Head movements are not analogous to eye movements!



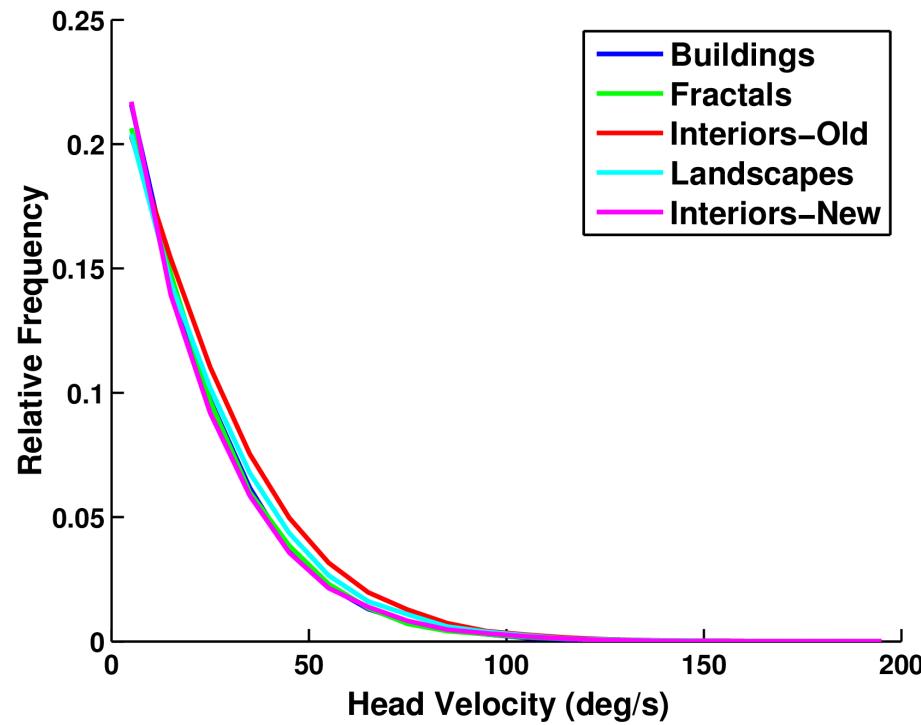
Head movement amplitudes are typically small



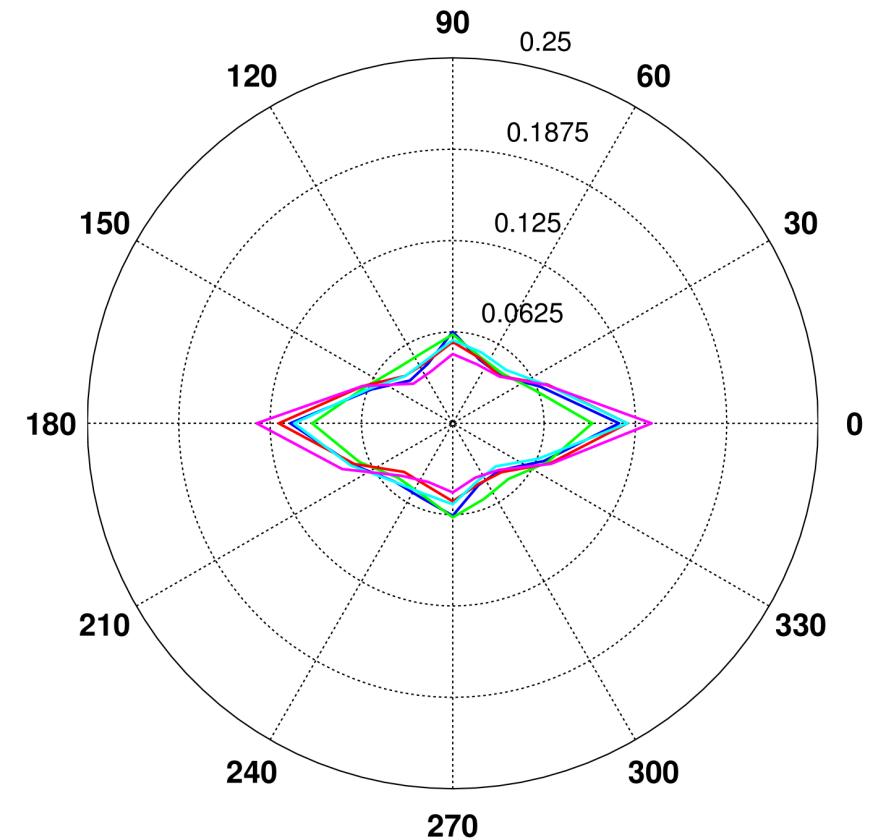
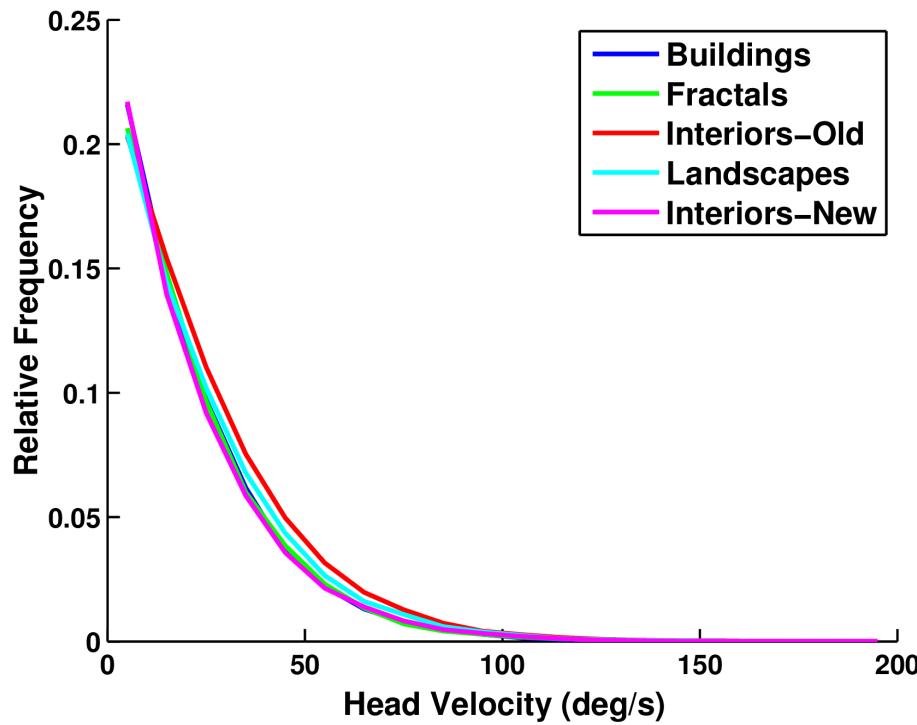
Head movements mainly occur along the cardinal axes



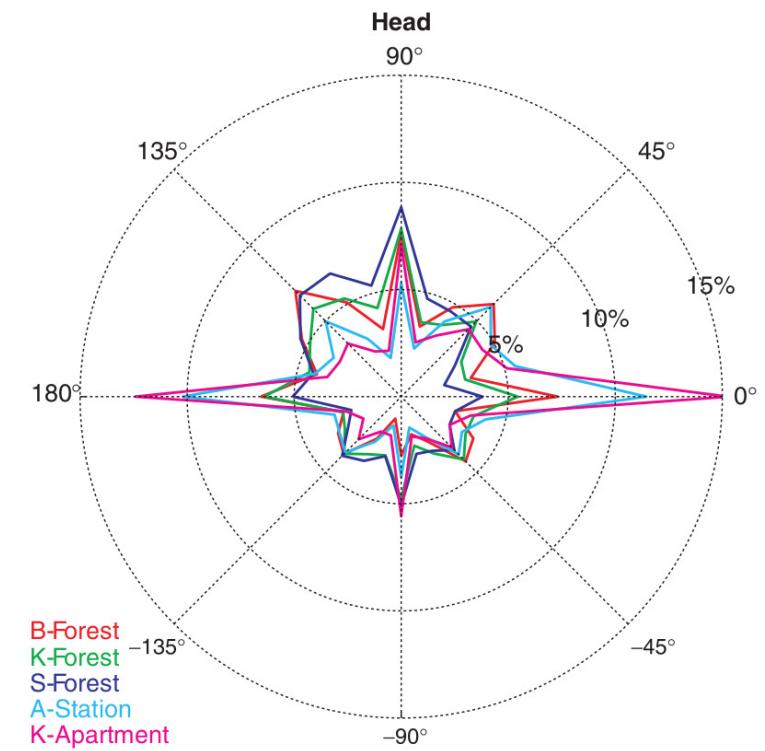
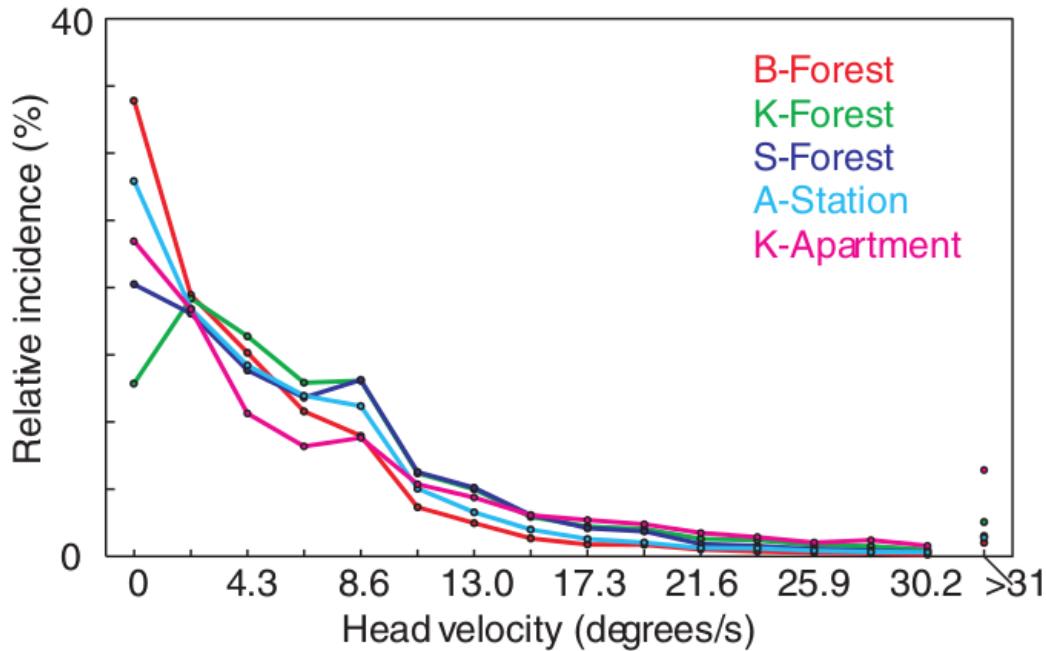
Head velocities have a different distribution



Head velocities also show strong anisotropy



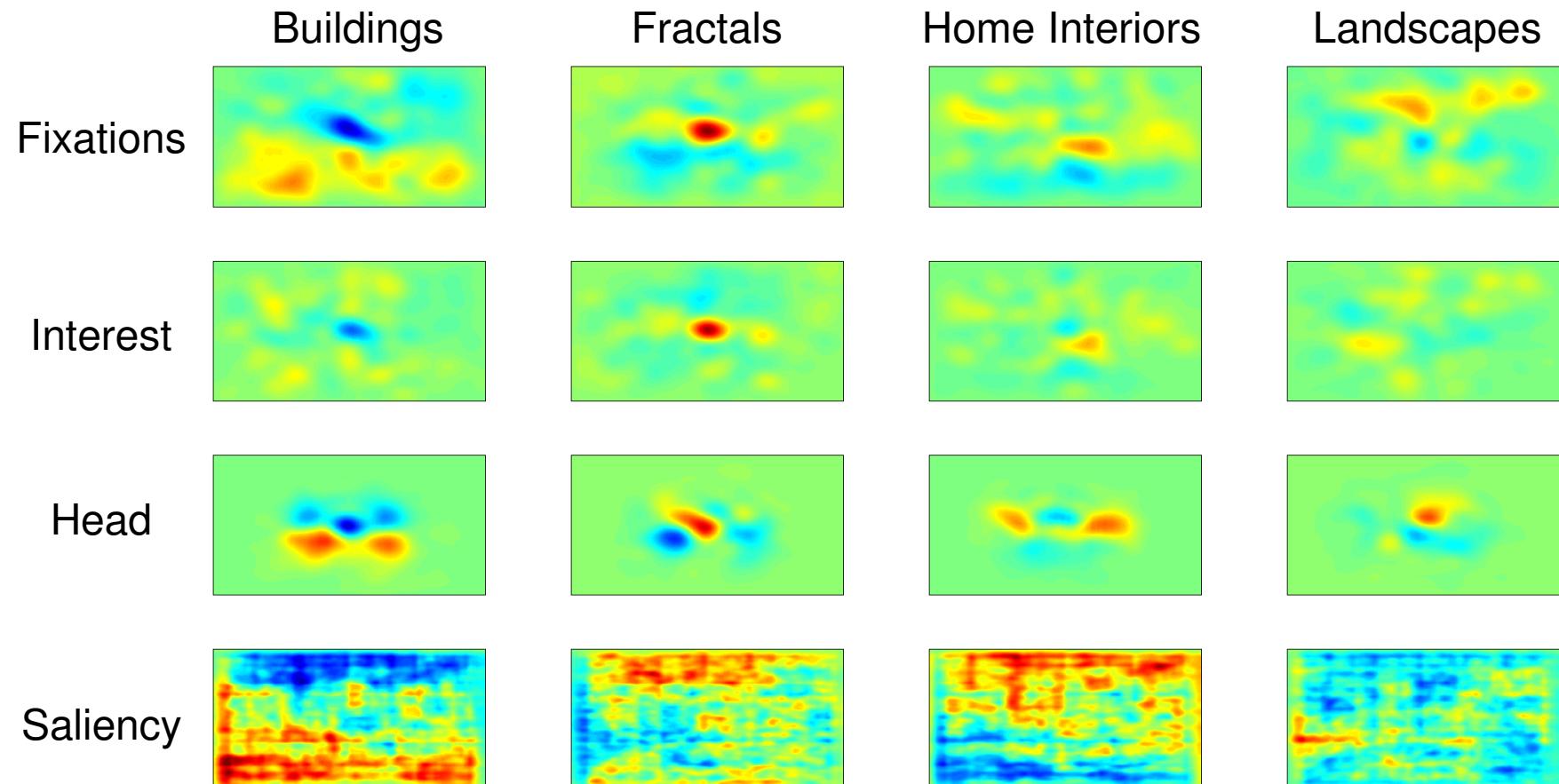
Head velocities are consistent with previous findings



Einhauser et al., 2007



Head fixations may be correlated with visual attention



Positive regions (red) fixated more than the overall average across categories



Conclusion

- We recorded head movements during natural image exploration in a VR environment
- Our results give insight into head movement kinematics during natural visual exploration
- Future work will include simultaneous recording of eye and head movements



Acknowledgement

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Code and data available at:
https://github.com/brianhhu/VR_HeadMovements

Questions?



References

- [1] Yarbus, Alfred L. Eye movements during perception of complex objects. Springer US, 1967.
- [2] Nakashima, Ryoichi, and Satoshi Shioiri. "Why do we move our head to look at an object in our peripheral region? Lateral viewing interferes with attentive search." PloS one 9.3 (2014): e92284.
- [3] Einhäuser, Wolfgang, et al. "Human eye-head co-ordination in natural exploration." Network: Computation in Neural Systems 18.3 (2007): 267-297.
- [4] Parkhurst, Derrick, Clinton Law, and Ernst Niebur. "Modeling the role of salience in the allocation of overt visual attention." Vision research 42.1 (2002): 107-123.

