Fixational eye drift adapts to the history of eye positions

Terence L. Tyson[1,2,3], Leland S. Stone[3], & Jorge Otero-Millan[1,2,4]

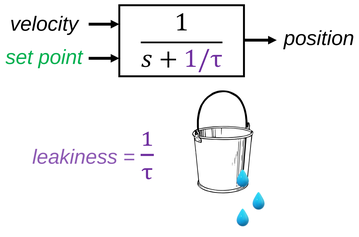
[1]Herbert Wertheim School of Optometry and Vision Science, University of California, Berkeley, Berkeley, CA;
[2]Redwood Center for Theoretical Neuroscience, University of California, Berkeley, Berkeley, CA;
[3]Human Systems Integration Division, NASA Ames Research Center, Moffett Field, CA;
[4]Department of Neurology, Johns Hopkins University, Baltimore, MD

Introduction

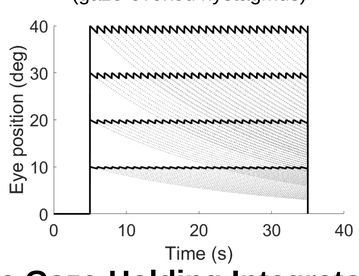
- Fixational drift velocities in the dark depend on eye position[1] and have been shown to adapt, for example, after prolonged eccentric gaze[2].
- The neural mechanism of **adaptation** can either be:
  1. a change in the **leakiness** of the gaze-holding integrator measured as the increase of drift velocity with eccentricity
  2. or a change in the gaze-holding **set point** measured as the eye position with a zero amount of drift.
- We examined baseline drift velocity across different eye positions and the adaptation of that relationship after prolonged eccentric gaze to the far left or the far right (± 40 deg). For each participant, we recorded the left eye at 250 Hz with a custom infrared video-based eye tracker. 18 participants completed the study.

Gaze-Holding (leaky) Integrator

Leaky Integrator

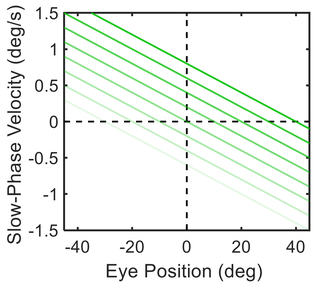


Drift during eccentric gaze (gaze-evoked nystagmus)

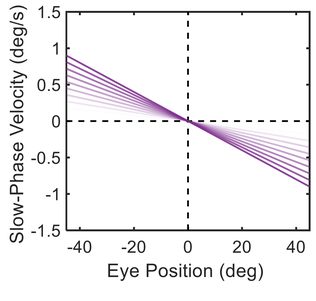


Possible Adaptations in the Gaze-Holding Integrator

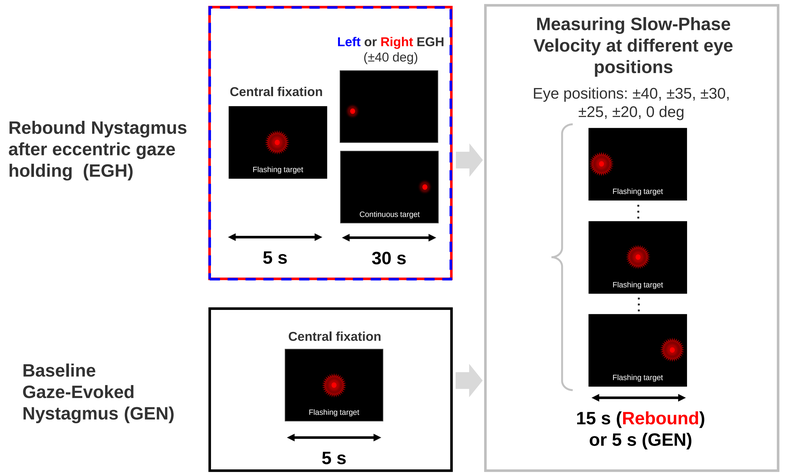
Change in **Set Point**



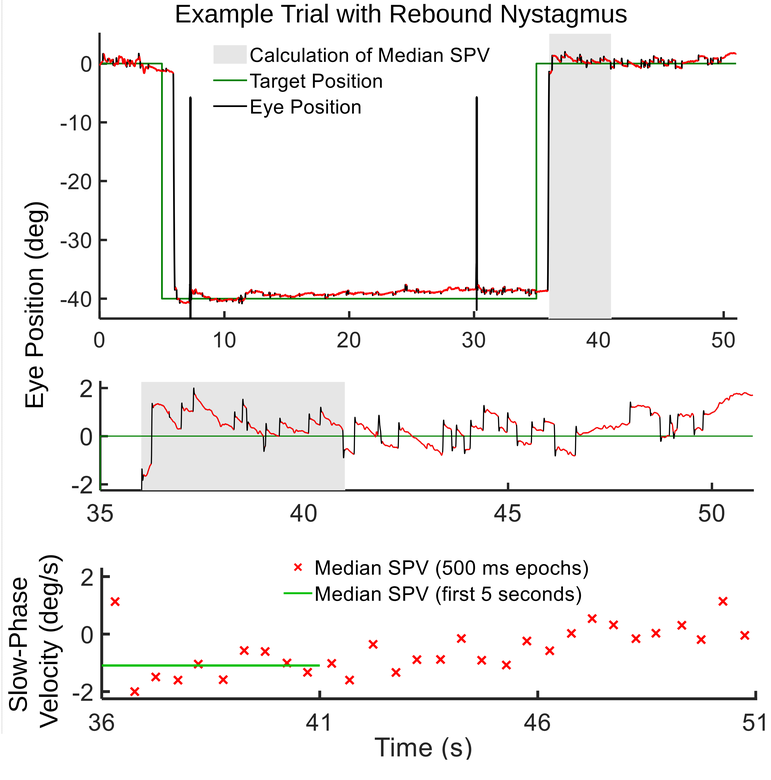
Change in **Leakiness**



Rebound Nystagmus Paradigm



Example Trial with Rebound Nystagmus

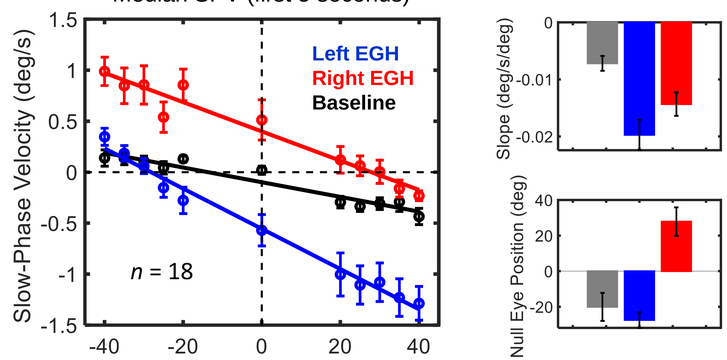


Drift Adapts After Prolonged Gaze Holding

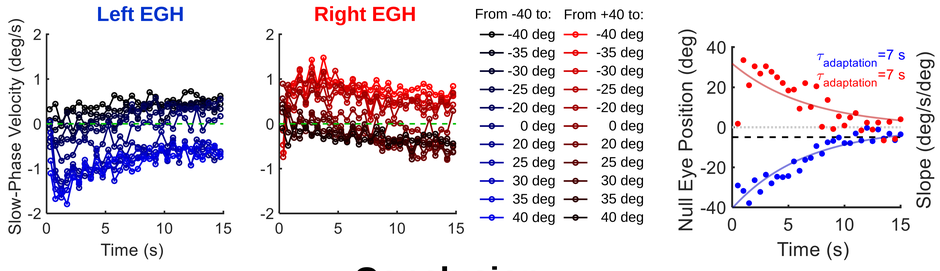
Two changes were found after prolonged eccentric gaze holding:

- **Slope increase** of the velocity-position curve relative to gaze-evoked nystagmus (control).
- **Shift of the zero-velocity eye position** away from central gaze (0 deg).

Median SPV (first 5 seconds)



Time Course of Set-Point Adaptation



Conclusion

- After prolonged eccentric gaze holding, the relationship between drift or slow-phase velocity and eye position changes.
- These changes are consistent with a combined change of the leakiness and the set point of the gaze-holding integrator.

References

1. Bertolini, G., Tarnutzer, A. A., Olasagasti, I., Khojasteh, E., Weber, K. P., Bockisch, C. J., ... & Marti, S. (2013). Gaze holding in healthy subjects. PLoS One, 8(4), e61389.
2. Otero-Millan, J., Colpak, A. I., Kheradmand, A., & Zee, D. S. (2019). Rebound nystagmus, a window into the oculomotor integrator. Progress in brain research, 249, 197-209.

Funding Acknowledgments: NASA Ames Graduate Fellowship, NASA Ames Center Innovation Fund, NIH R00EY027846

QR code for PDF copy