



Evaluation of Tablet-Based Methods for Assessment of Contrast Sensitivity on Mobile Touch-Screens

Jeffrey B. Mulligan

NASA Ames Research Center

Human Vision and Electronic Imaging - January 2020



Motivation: SANS

Risk of Spaceflight Associated Neuro-ocular Syndrome (SANS)

Short Title: SANS

Last Published: 07/31/19 10:05:29 AM (Central)

Element: Human Health Countermeasures (HHC)

Evidence: [Report](#)

Risk Master Logic Diagram: Not Available

Point of Contact: [Michael Stenger](#)

Risk Ratings and Dispositions per Design Reference Mission (DRM) Category

DRM Categories	Mission Duration	Operations		Long-Term Health	
		LxC	Risk Disposition *	LxC	Risk Disposition *
Low Earth Orbit	6 months	3x2	Accepted	3x2	Accepted
	1 year	3x2	Accepted	3x3	Accepted
Deep Space Sortie	1 month	3x1	Accepted	3x1	Accepted
Lunar Visit/ Habitation	1 year	3x2	Accepted	3x3	Accepted
Deep Space Journey/Habitation	1 year	3x4	Requires Mitigation	3x4	Requires Mitigation
Planetary	3 years	3x4	Requires Mitigation	3x4	Requires Mitigation

From <https://humanresearchroadmap.nasa.gov/Risks/risk.aspx?i=105>



Orthostatic pressure and gravity

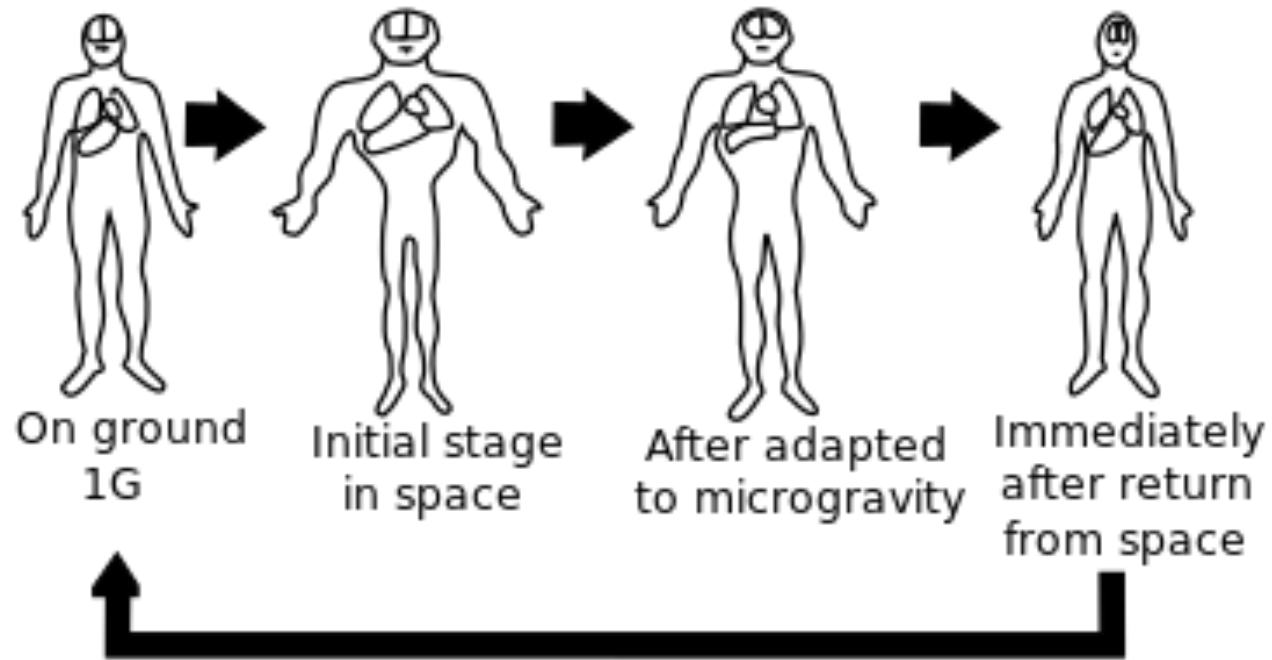


Figure from wikipedia page "Space Medicine," attributed to NASA.



Effects on the eye

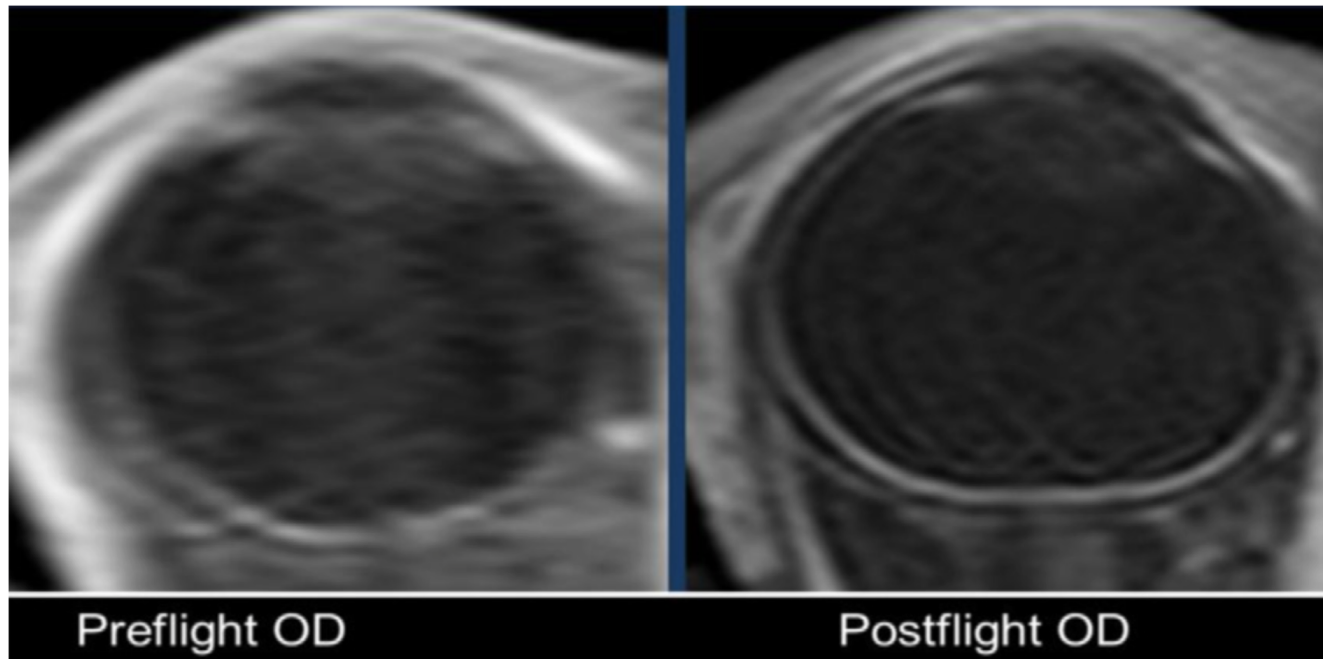


Figure from Marshall-Bowman, K., Barratt, M. R., and Gibson, C. R. (2013). "Ophthalmic changes and increased intracranial pressure associated with long duration spaceflight: An emerging understanding." *Acta Astronautica*, v. 87, pp. 77-87.



Effects on the eye

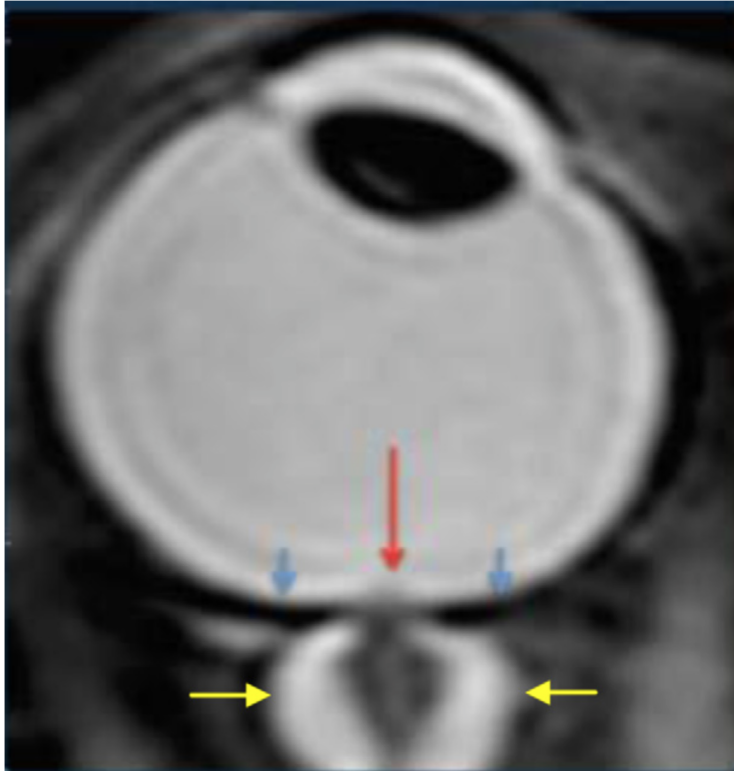


Fig. 4. Post-flight MRI picture of the eye showing optic disc edema (central vertical arrow), globe flattening (short vertical arrows) and optic nerve sheath distension (horizontal arrows).
Source: NASA.

Figure from Marshall-Bowman, K., Barratt, M. R., and Gibson, C. R. (2013). "Ophthalmic changes and increased intracranial pressure associated with long duration spaceflight: An emerging understanding." *Acta Astronautica*, v. 87, pp. 77-87.

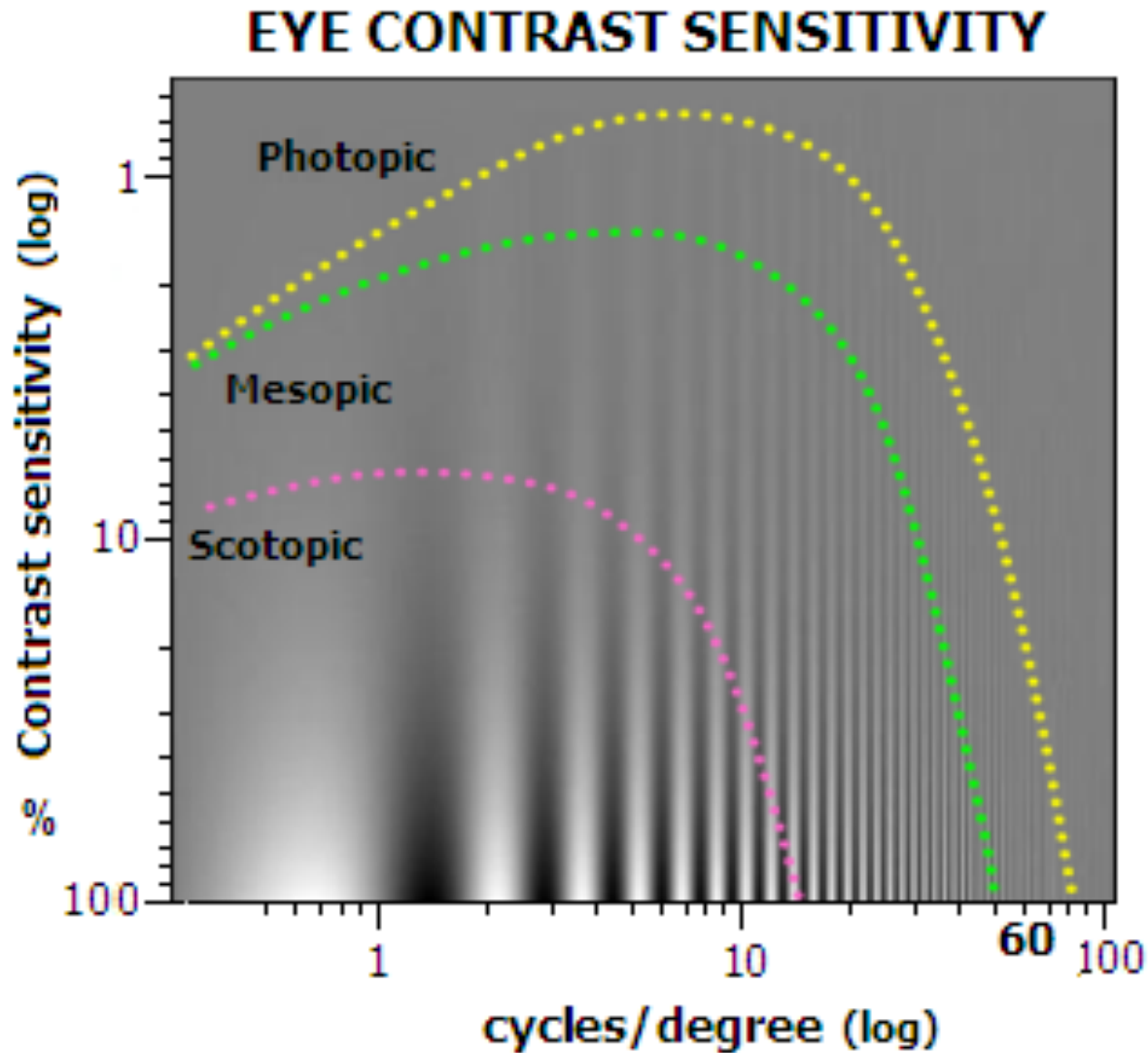


Goals

- Rapid vision assessment for daily use
- Simple hardware with low up-mass
- Approach: contrast sensitivity on Apple iPad



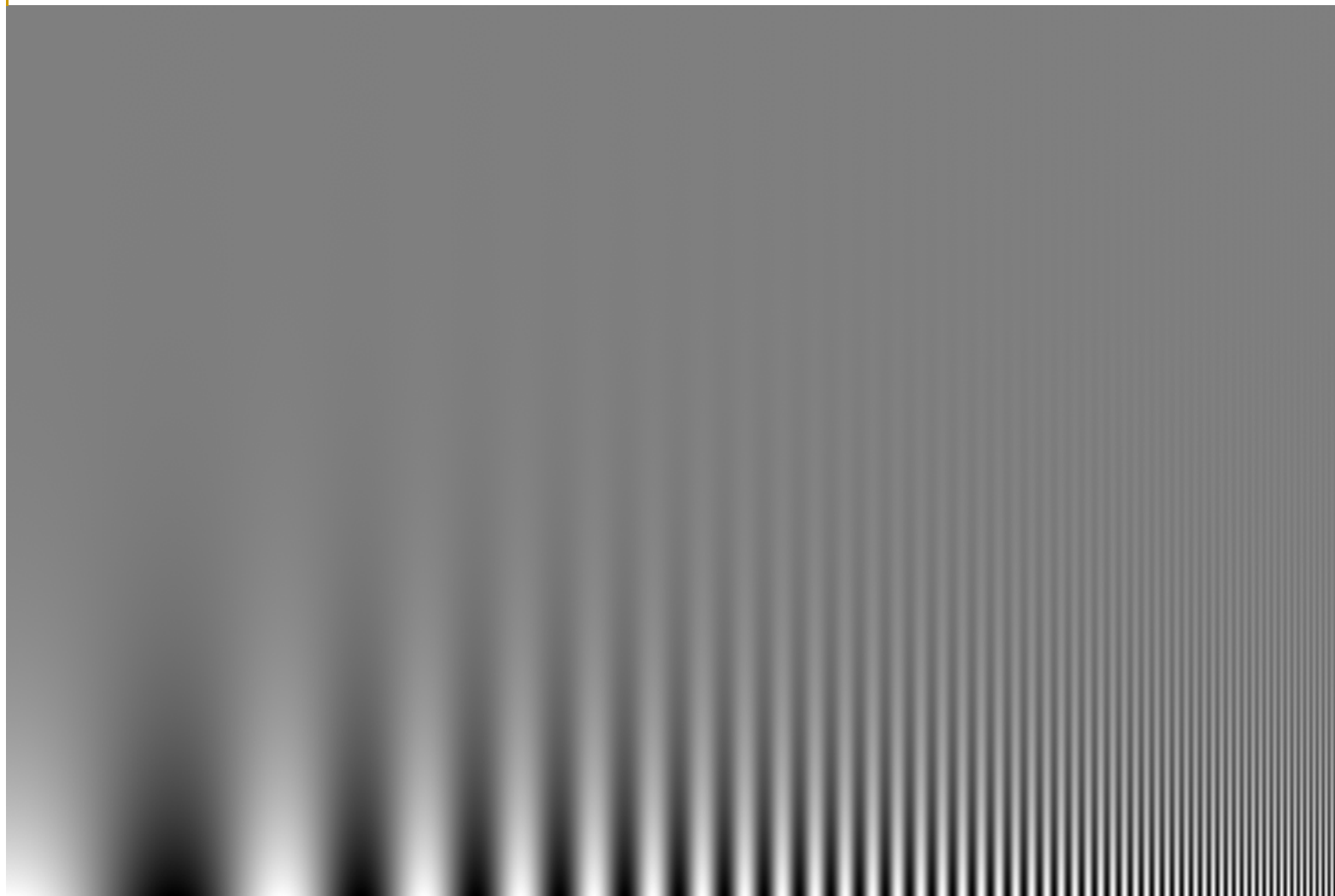
What is Contrast Sensitivity?



From http://www.telescope-optics.net/aberrations_extended.htm



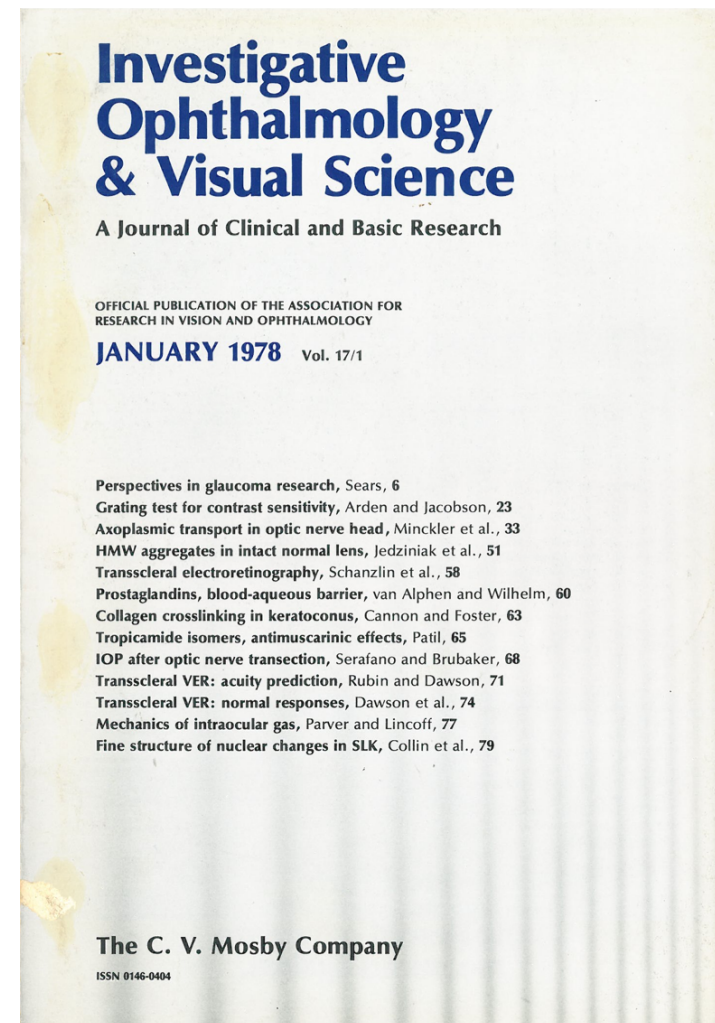
The double-sweep grating





Early public appearances

- Described for use in optical testing (Washer & Rosberry, 1951)
- Shown at 1964 OSA meeting (Robson & Campbell)
- Appeared in "Mach Bands" by F. Ratliff (1965)
- Appeared in "Visual Perception" by T. N. Cornsweet (1970)
- IOVS cover image, 1978-1982

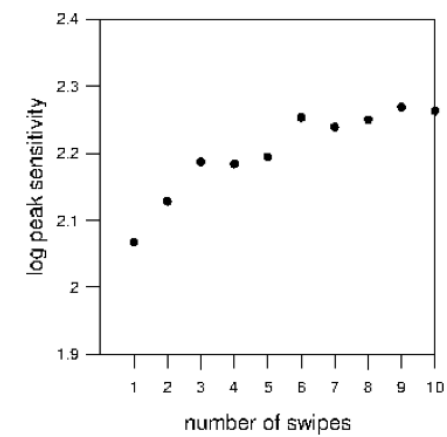
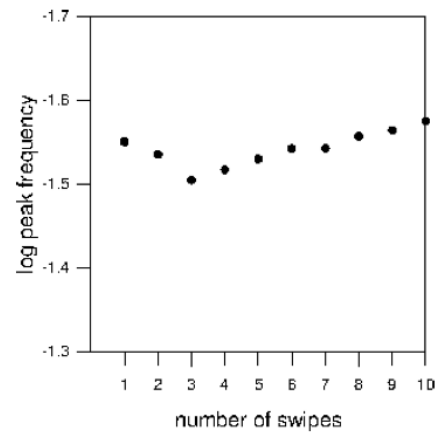
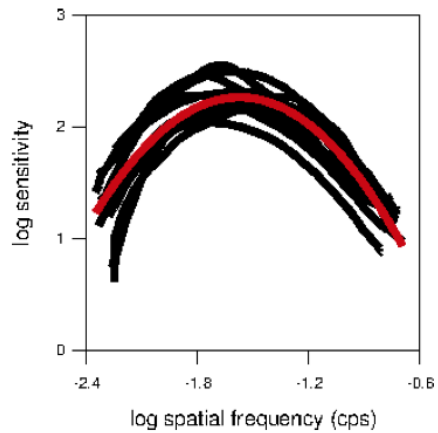
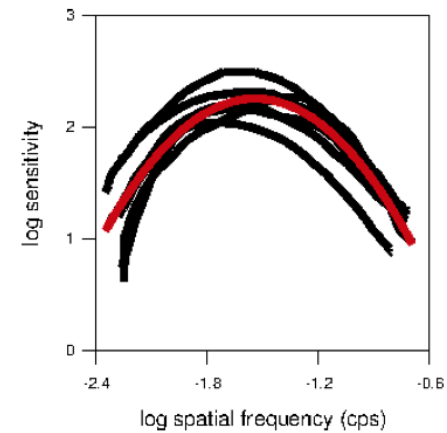
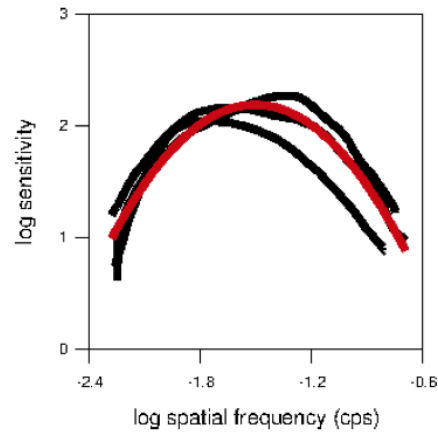
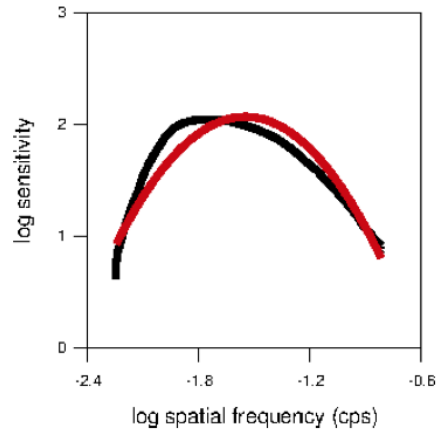




Jeff's idea for a rapid test

- Display sweep grating on touch screen
- Use finger to indicate edge of visibility
- Advantages: portable, fast (1-2 seconds for entire curve)
- Problems: unknown criterion, motor noise, cheating, reduction of phase uncertainty
- Mulligan, J. B. (2016). "A method for rapid measurement of contrast sensitivity on mobile touch-screens." Proc. HVEI.

Repeatability





The present study: validate against other methods

- Traditional quick-and-dirty: method of adjustment
- The gold standard: 2AFC
- Gabor patch stimuli

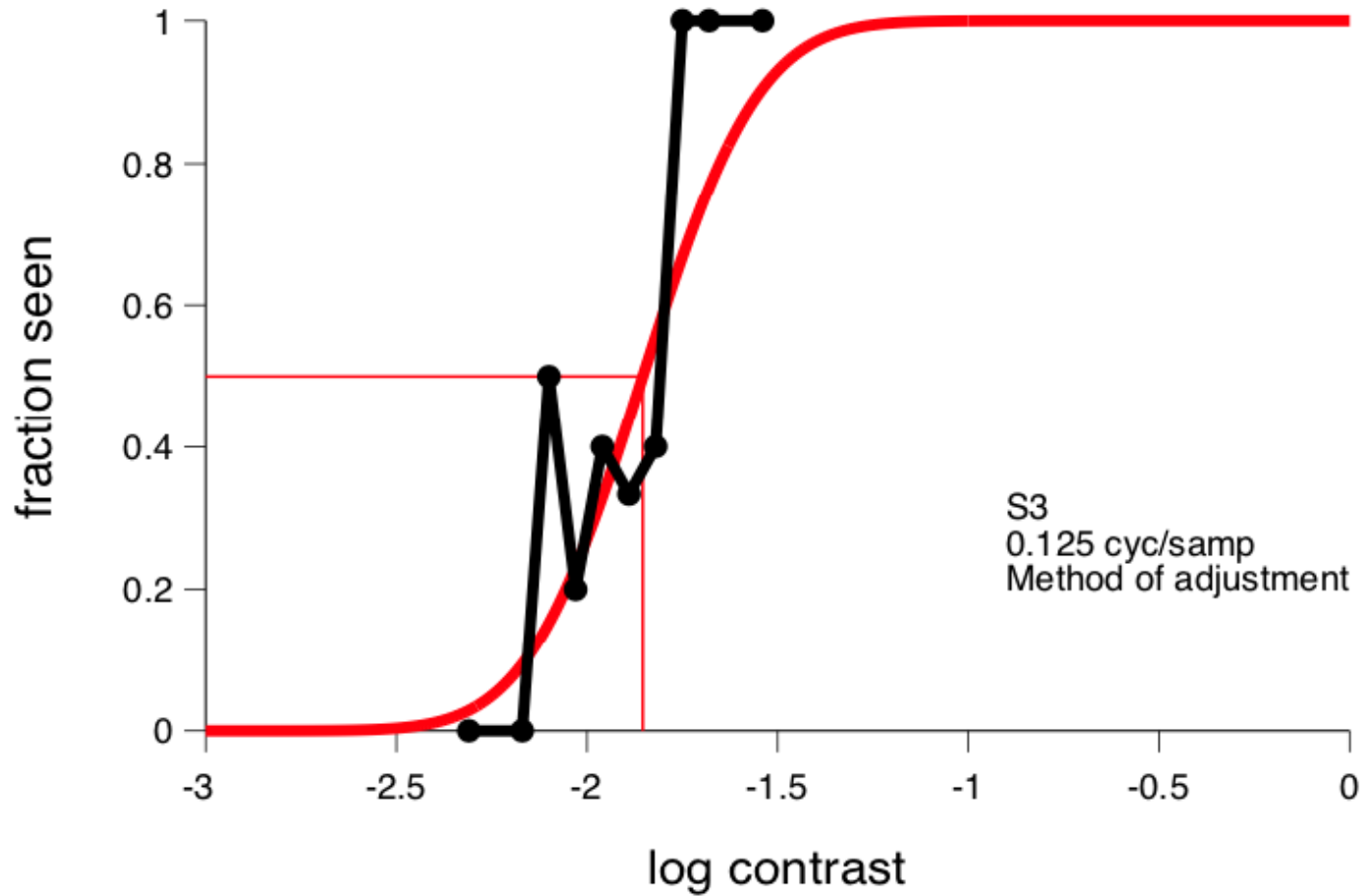


Method of adjustment

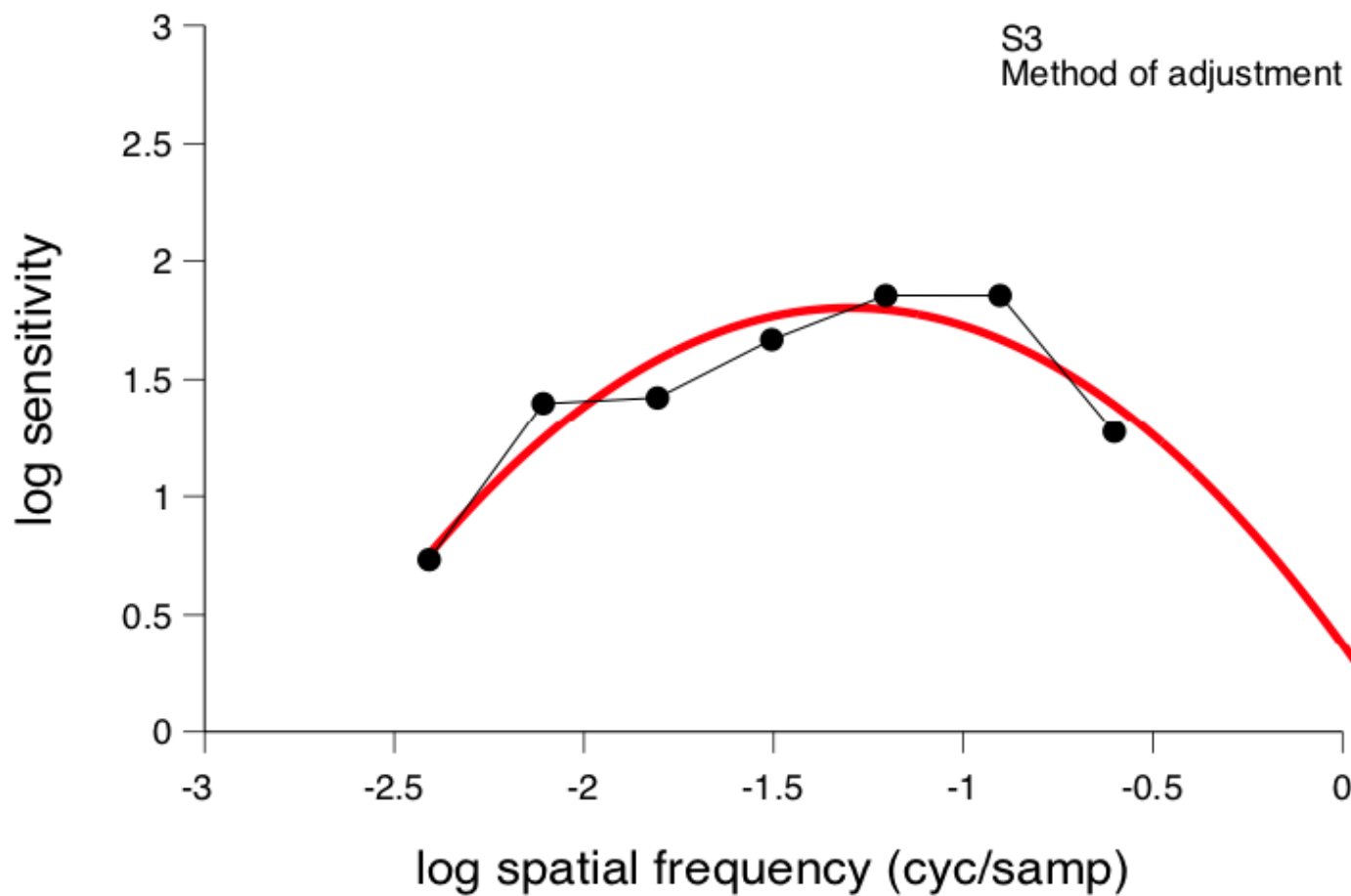
- Variable-contrast static Gabor patch
- Subject swipes up or down to increase or decrease contrast
- Adaptive contrast increment/decrement
- Effectively a yes/no experiment with 50 trials
- DEMO



Adjustment data psychometric function



Parabolic fit to adjustment thresholds



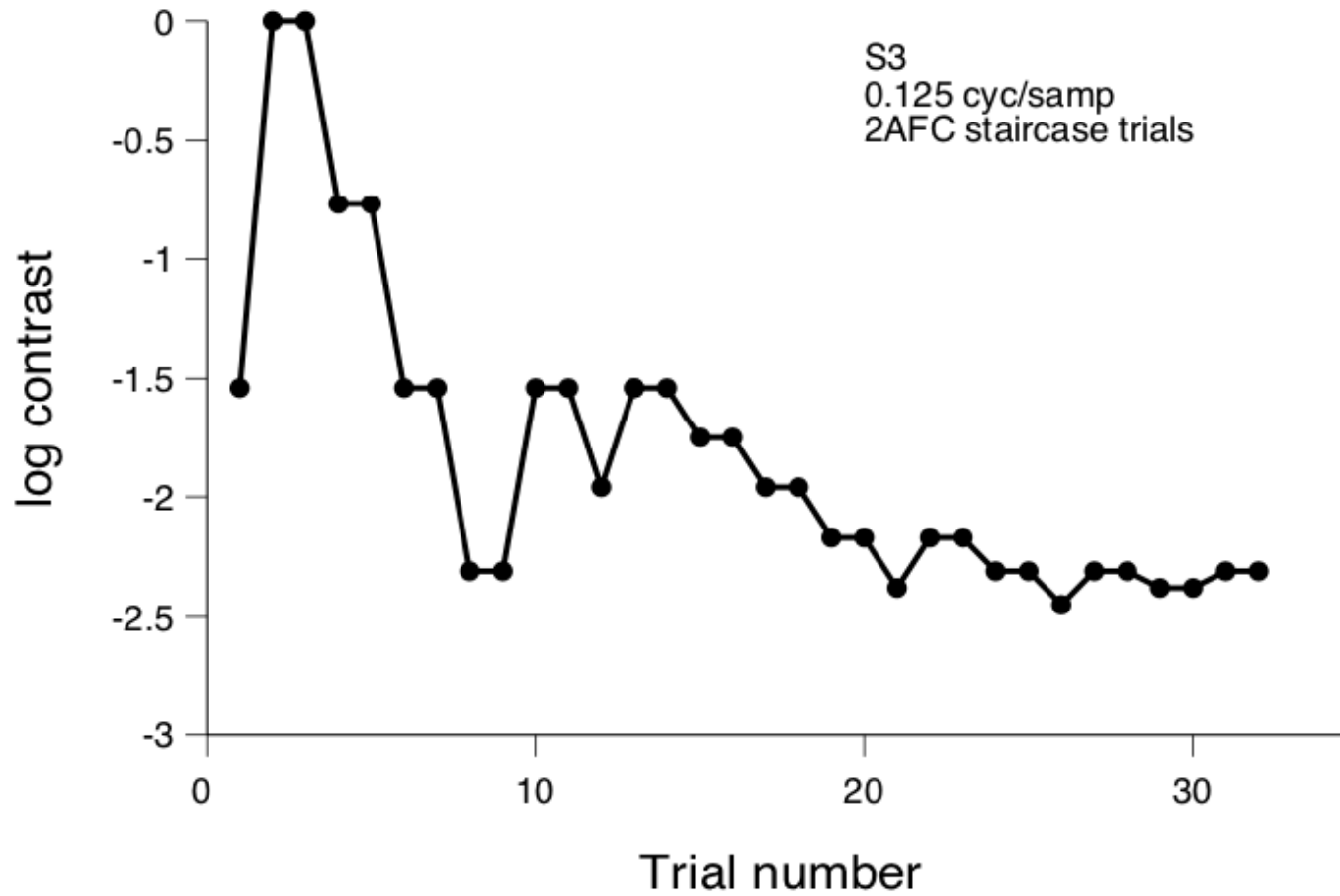


Two-alternative forced choice (2AFC)

- Gabor patch pulsed with a Gaussian temporal contrast window
- Two temporal intervals indicated by audio tones
- Stimulus presented in one of the two intervals
- Subject indicates stimulus interval with response buttons
- 2-to-1 staircase with adaptive step size
- DEMO

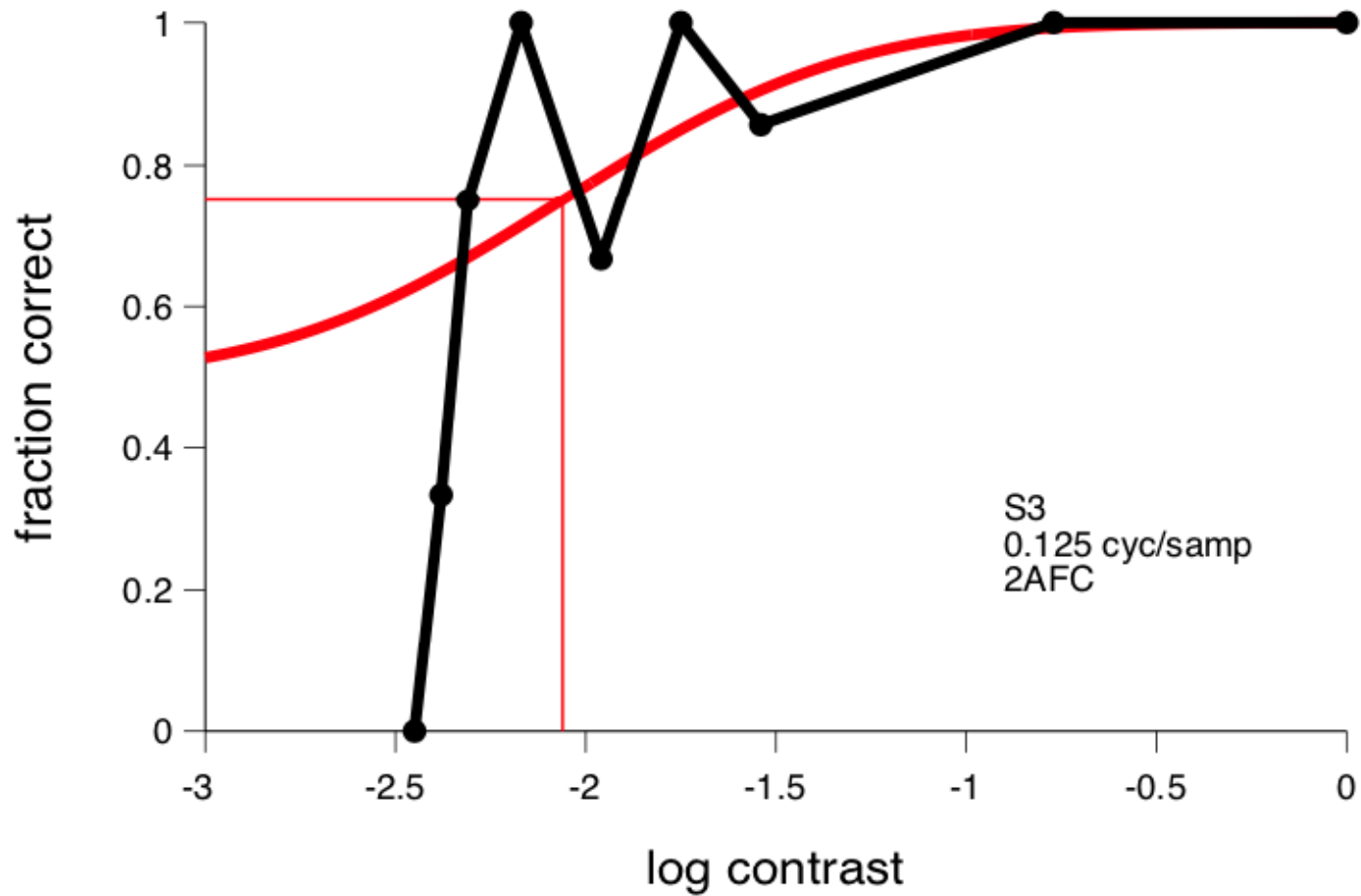


Staircase raw data



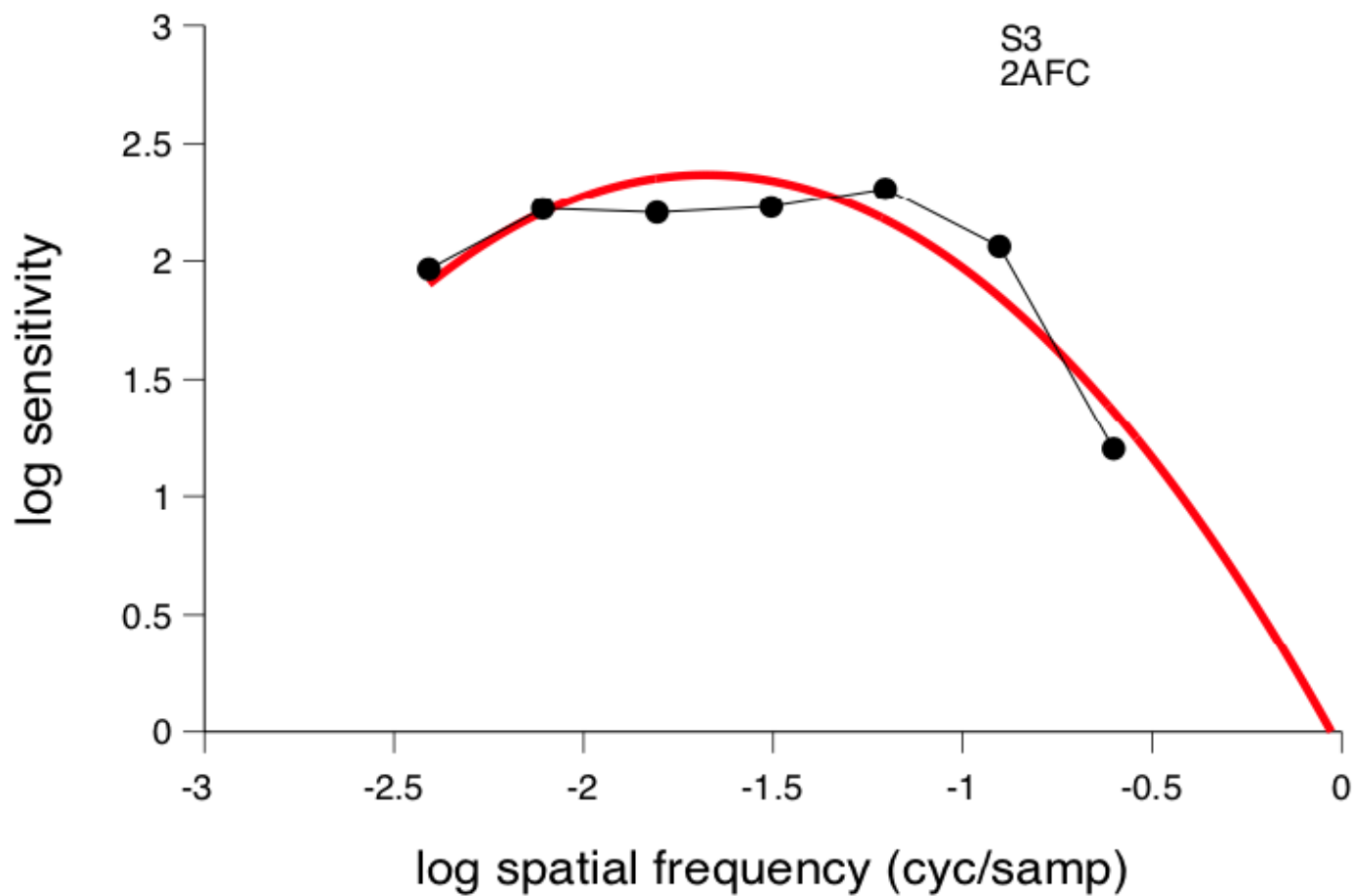


2AFC data psychometric function





Parabolic fit to 2AFC thresholds



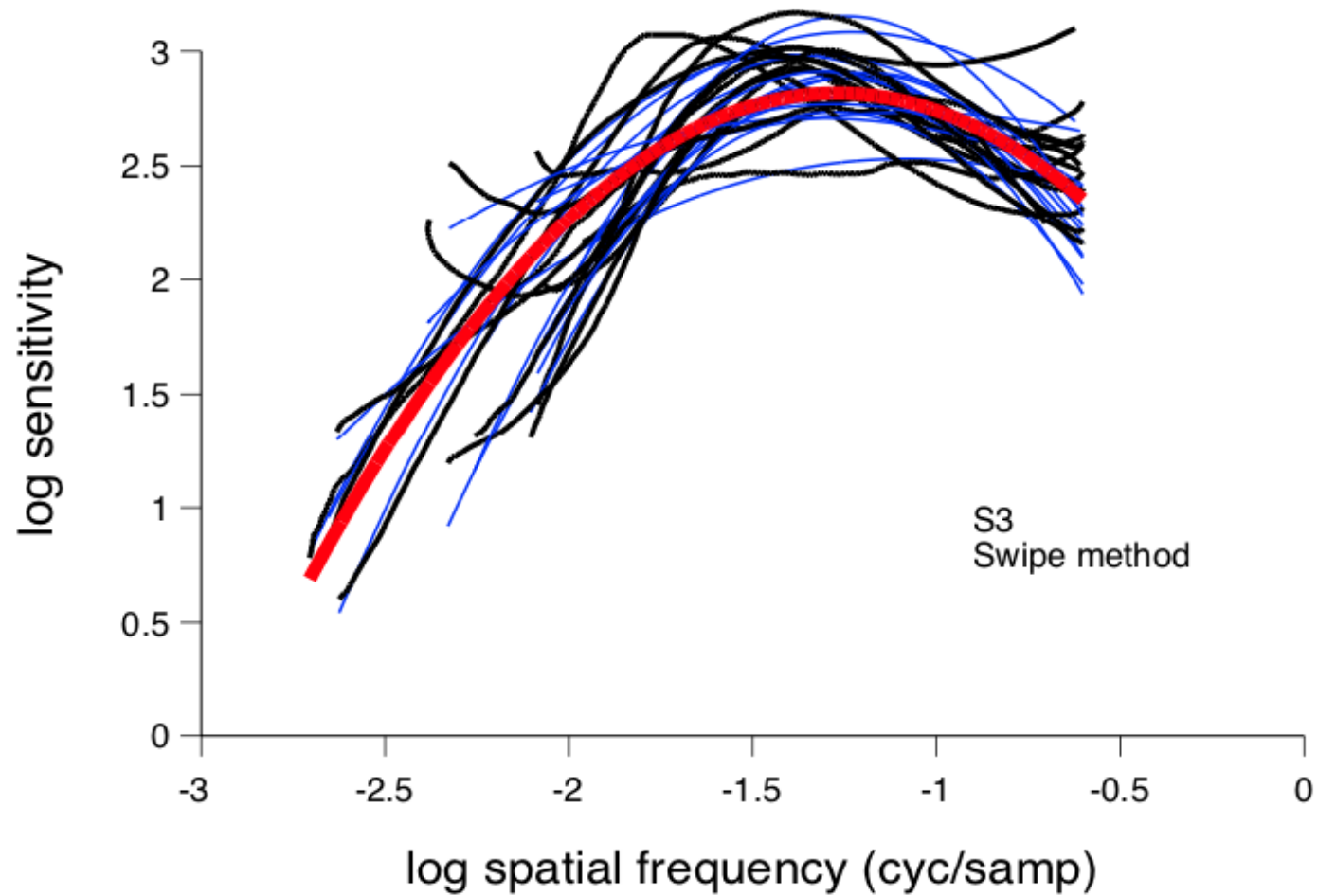


The updated swipe method

- 15 slightly different images presented
- Subject is shown swipe, can accept or redo
- DEMO

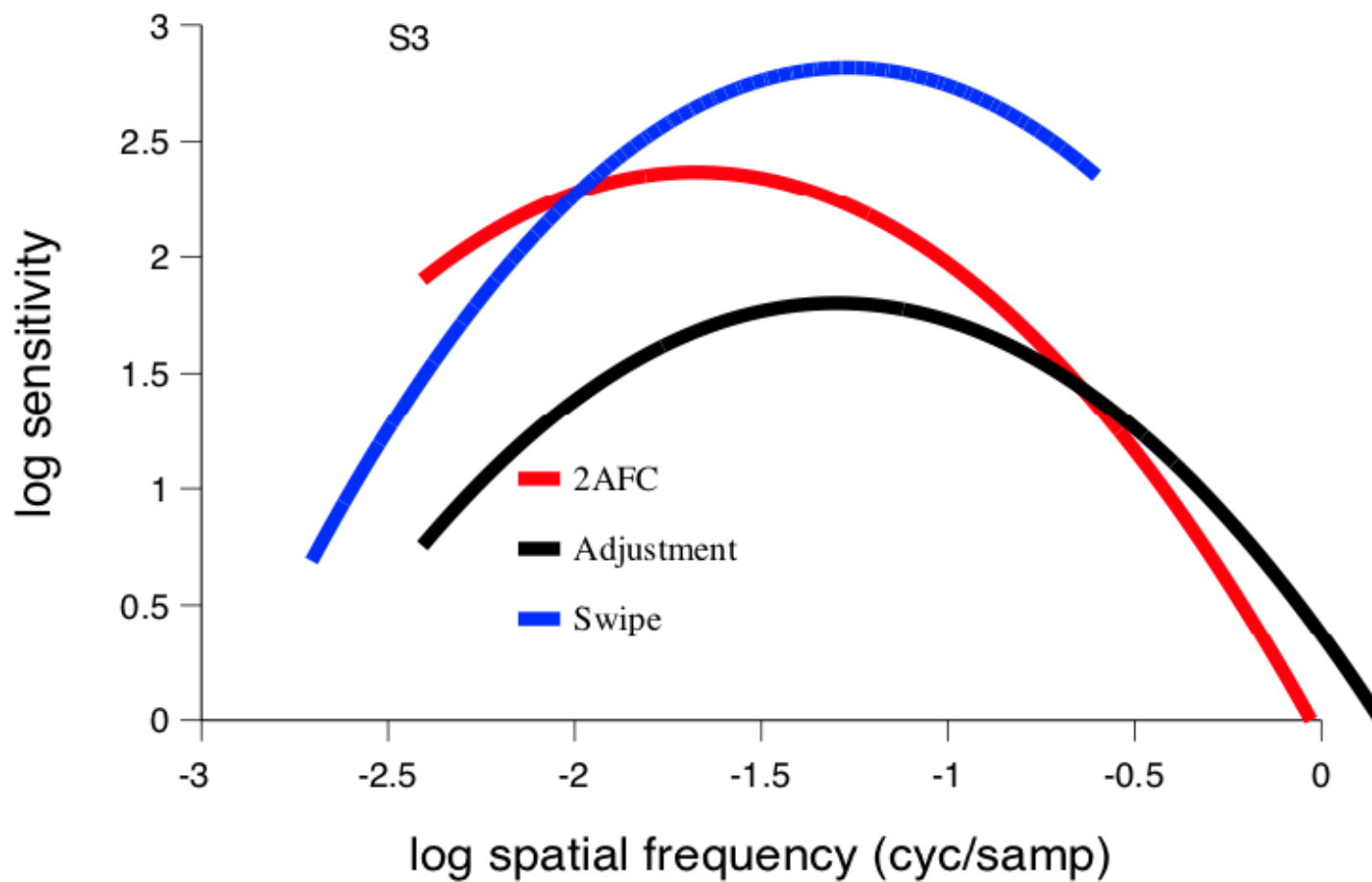


Parabolic fit to swipes



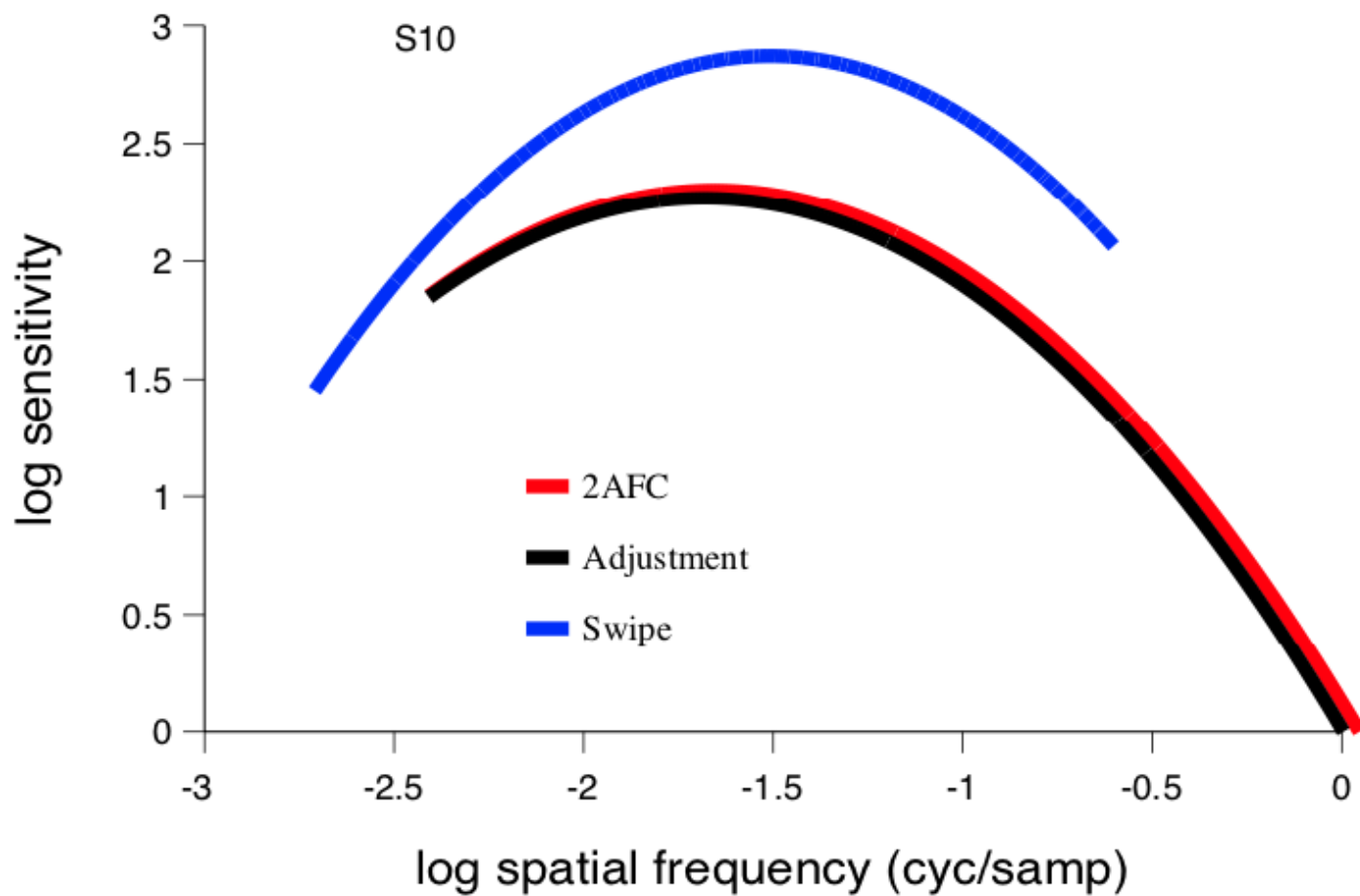


Comparing the methods



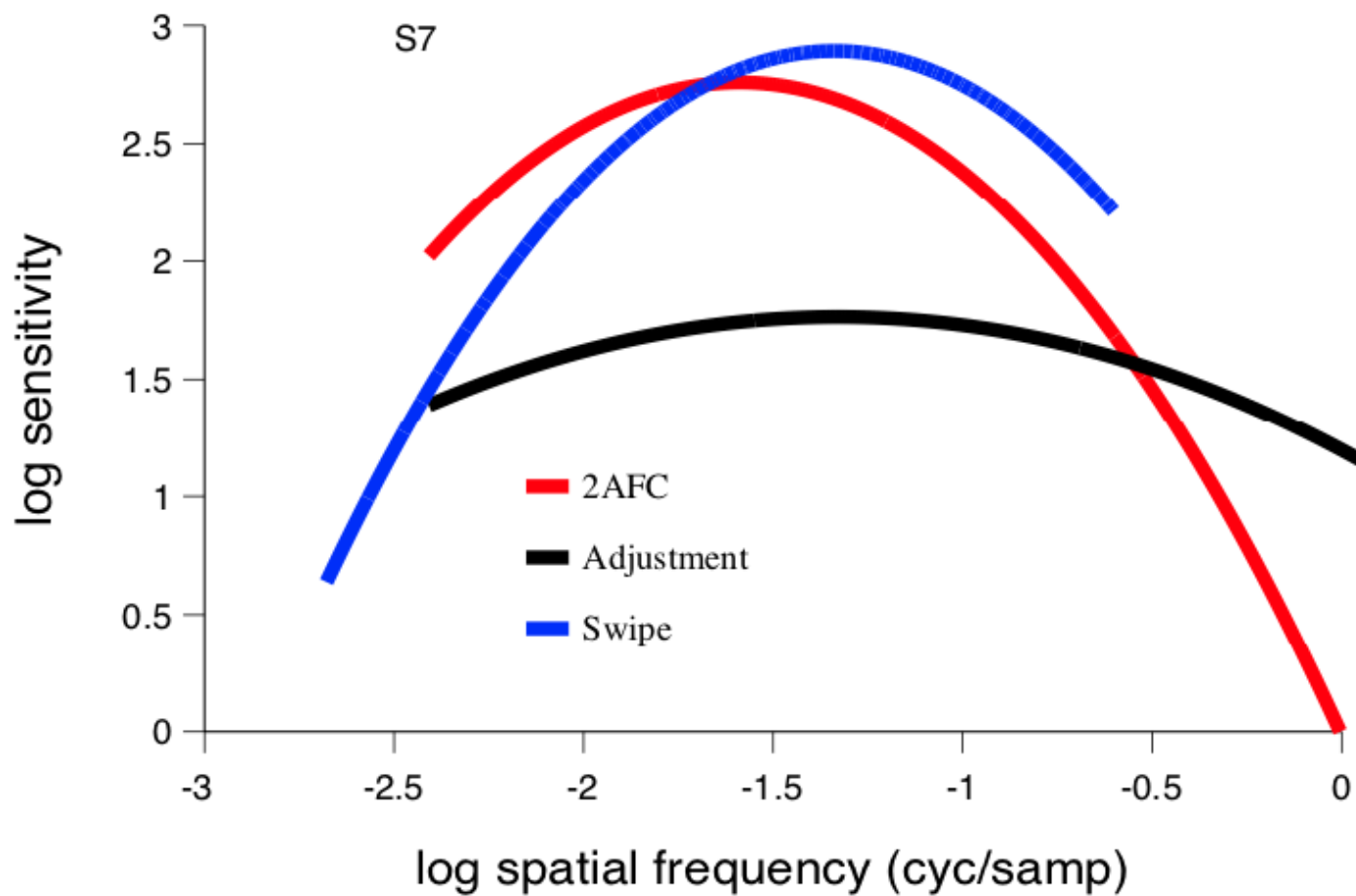


Comparing the methods



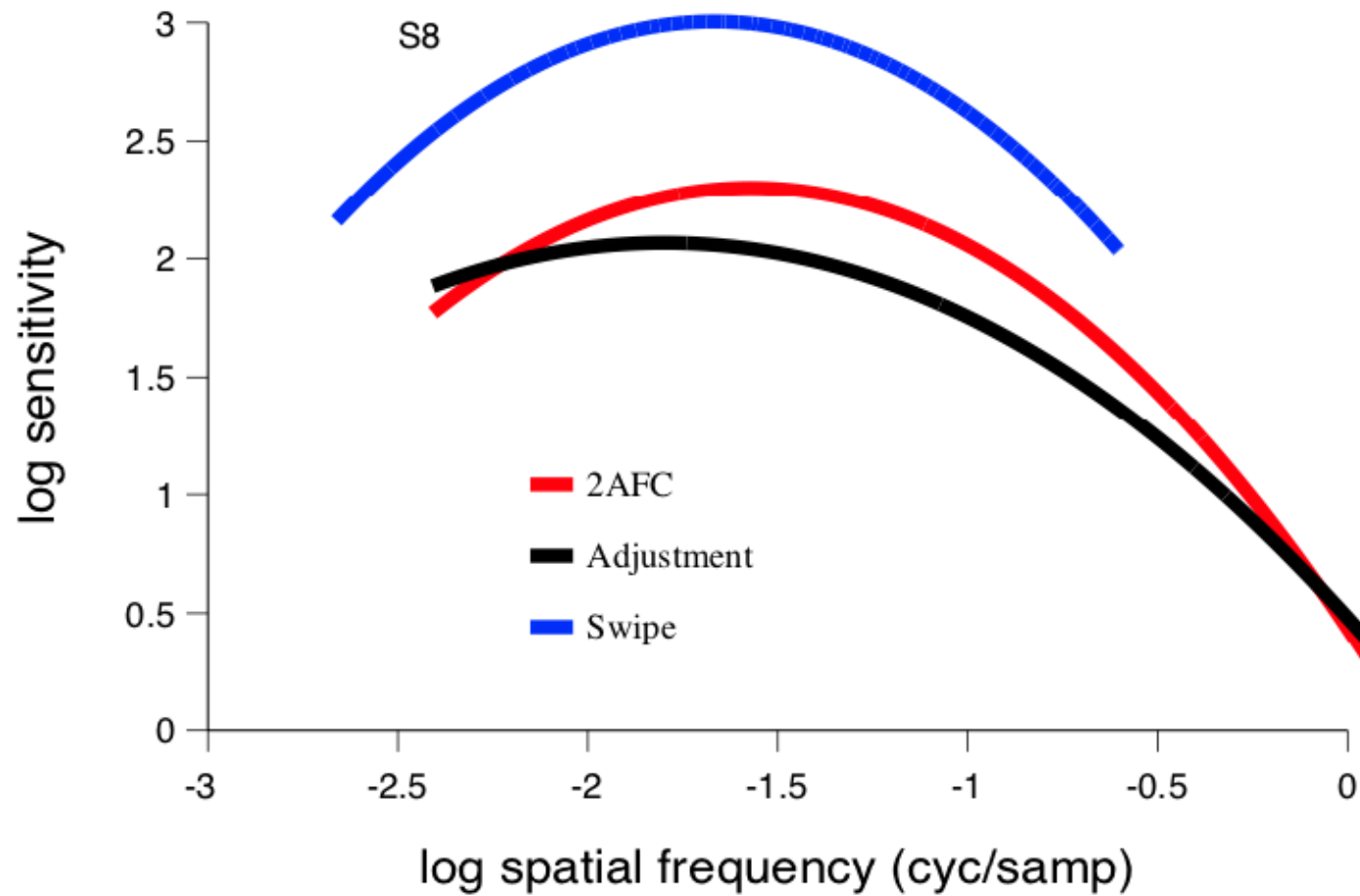


Comparing the methods



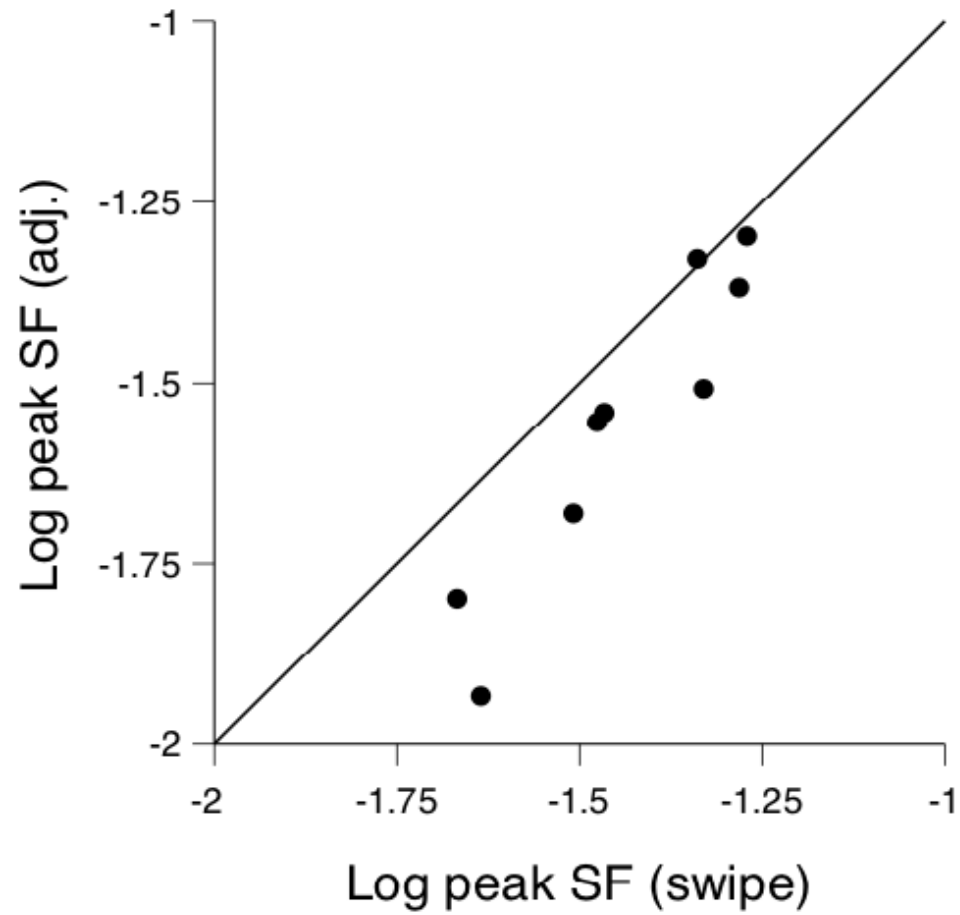


Comparing the methods



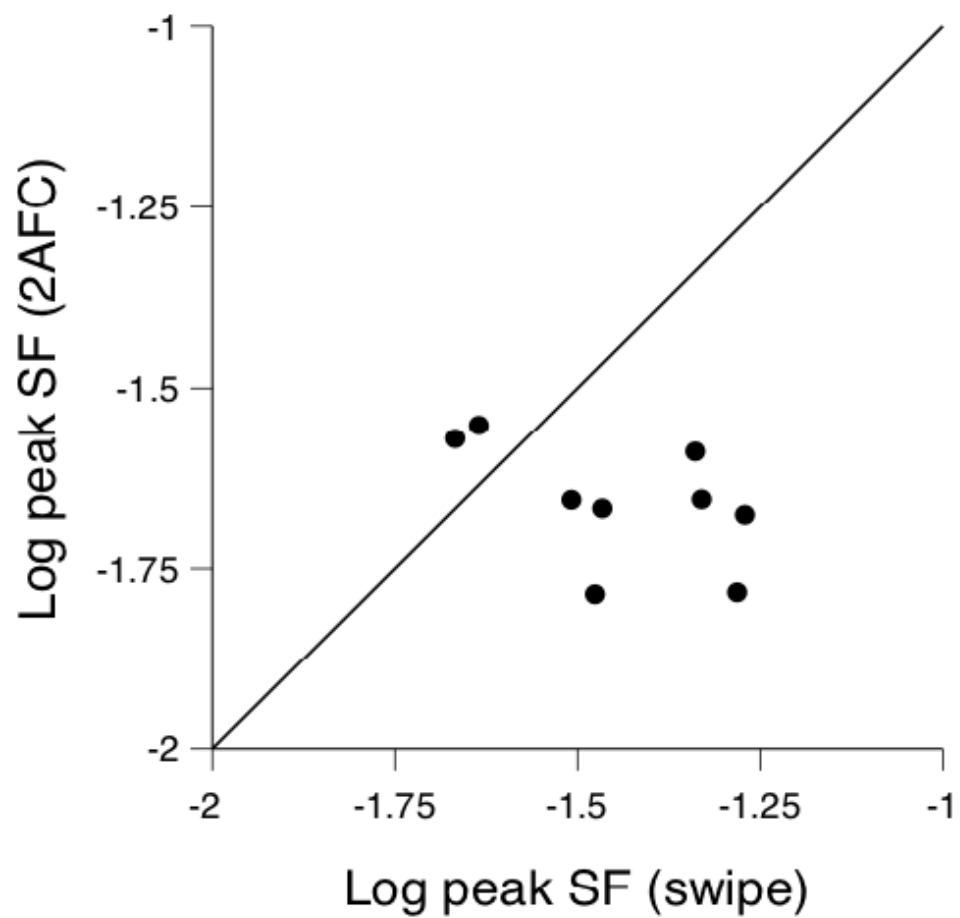


Comparing the methods



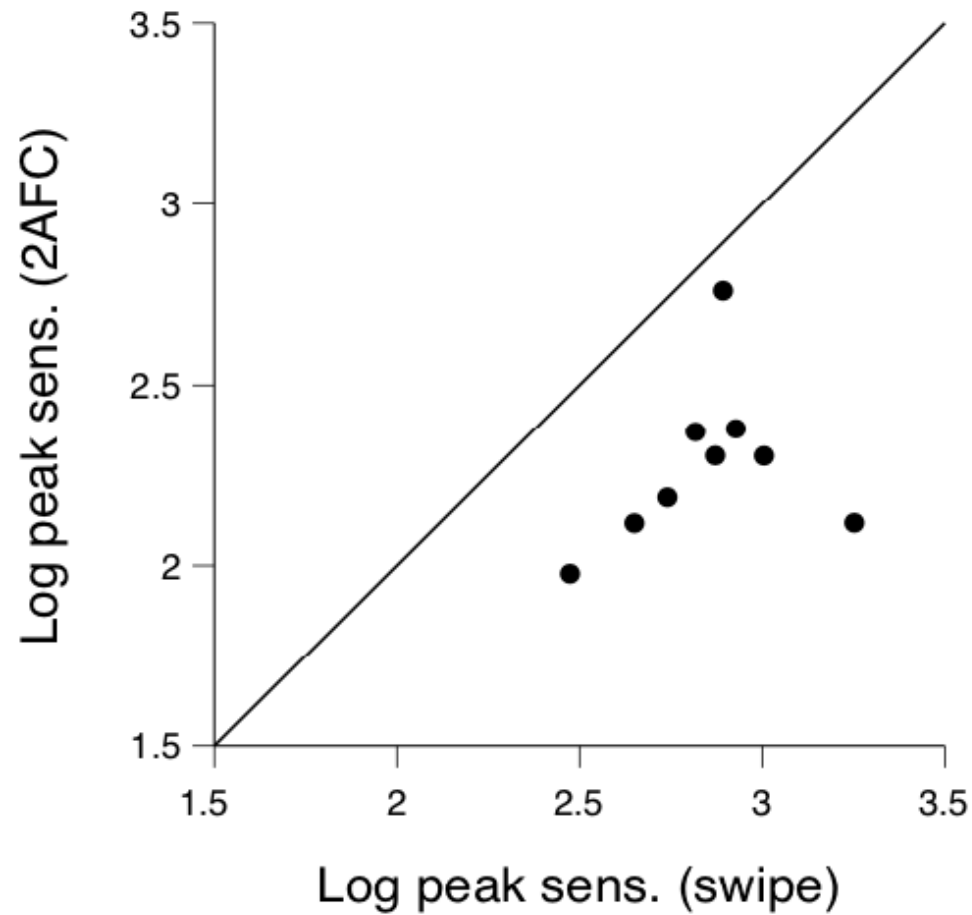


Comparing the methods



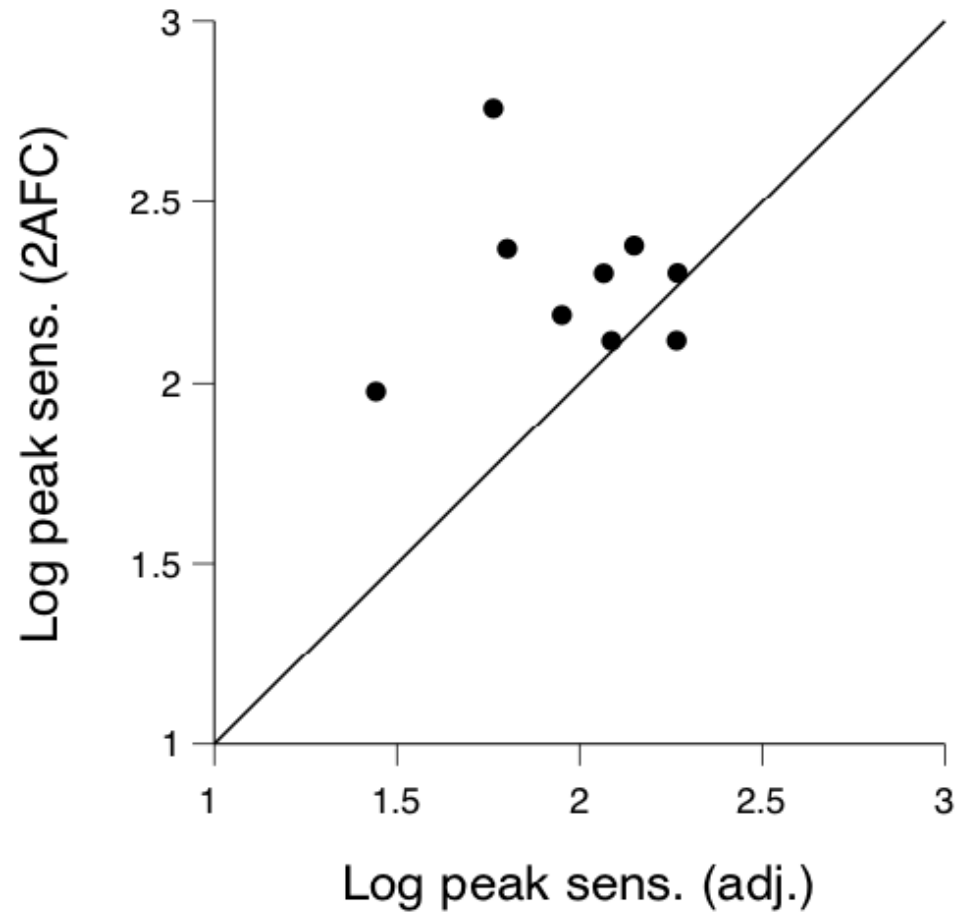


Comparing the methods





Comparing the methods





Summary

- 2AFC estimates greater sensitivity than adjustment
- Swipe method estimates more sensitivity still?
- SF differences may be explained by temporal factors
- Swipe method variability comparable to 2AFC
- Caveat: more efficient 2AFC methods available
e.g. QuickCSF, Lesmes et al.



Conclusions

- The swipe method is a viable choice for CSF estimation
- Accuracy probably sufficient for longitudinal monitoring
- Gamification?
- THANKS FOR LISTENING!