



School of Optometry
INDIANA UNIVERSITY

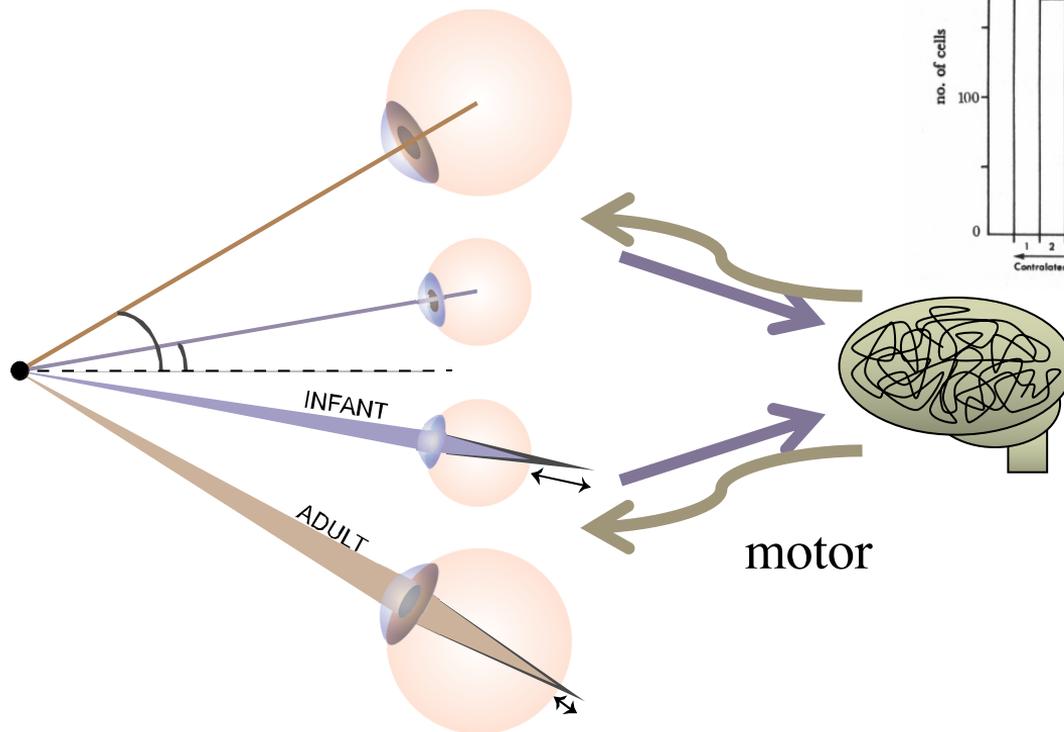
How well do infants and young children control their own visual experience?

T. Rowan Candy PhD FARVO

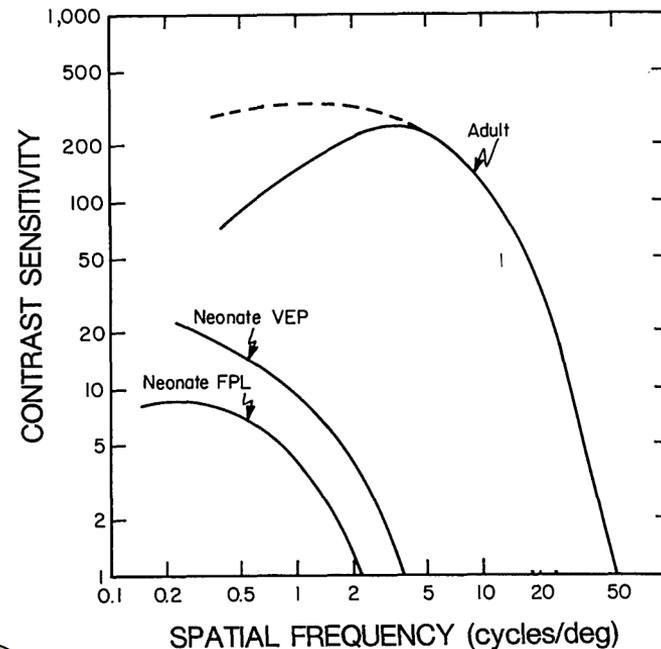
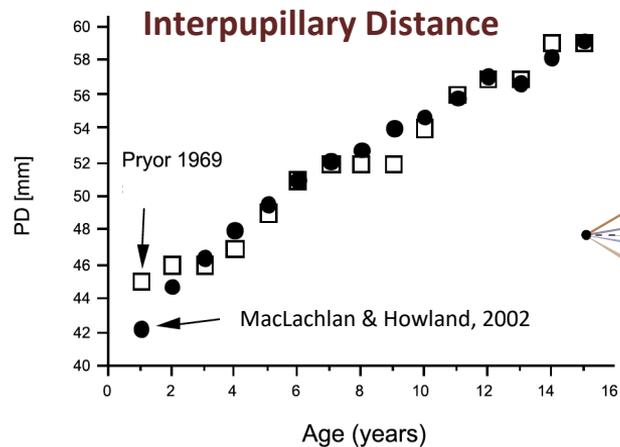
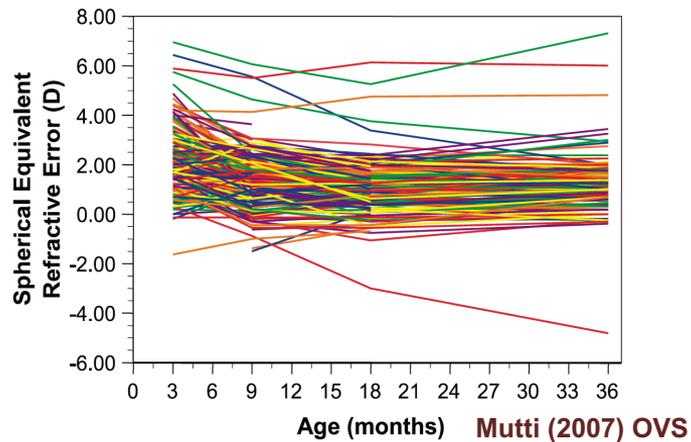
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Funding: NEI: ROI EY014460 EY032897, P30 EY019008, T35 EY090137. **Fight For Sight:** Postdoctoral Fellowship

Hubel DH, Wiesel TN & LeVay S (1977).

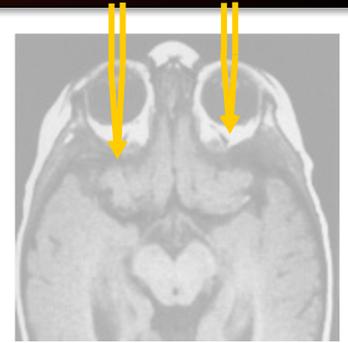
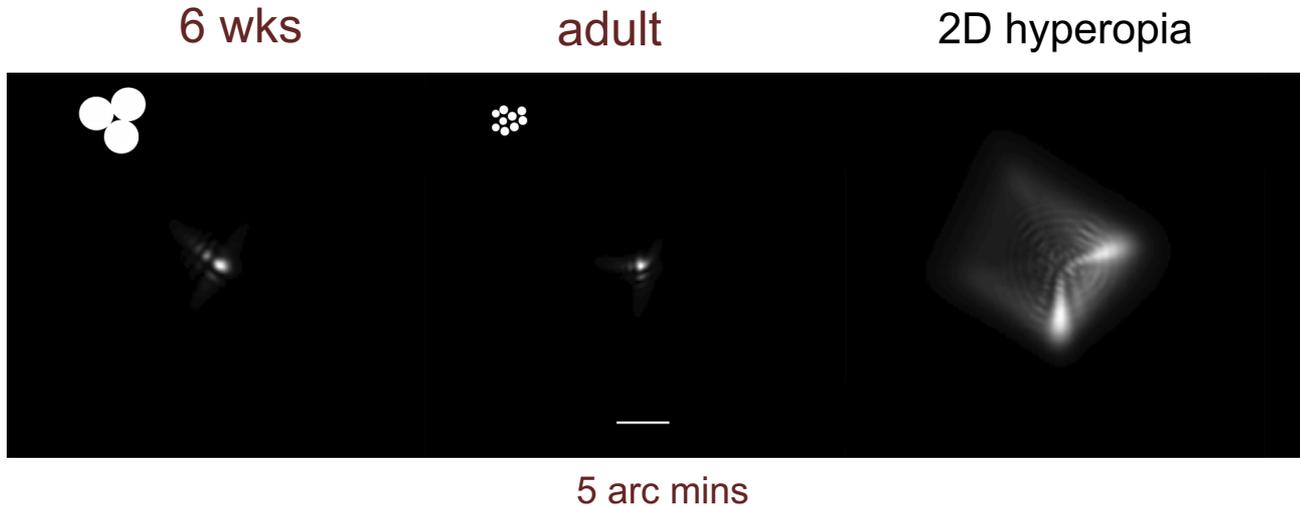
**Monocular deprivation**

Refractive error



Banks & Salapatek, 1978 Norcia, Tyler & Hamer, 1990

Does this refractive error impact retinal image quality?



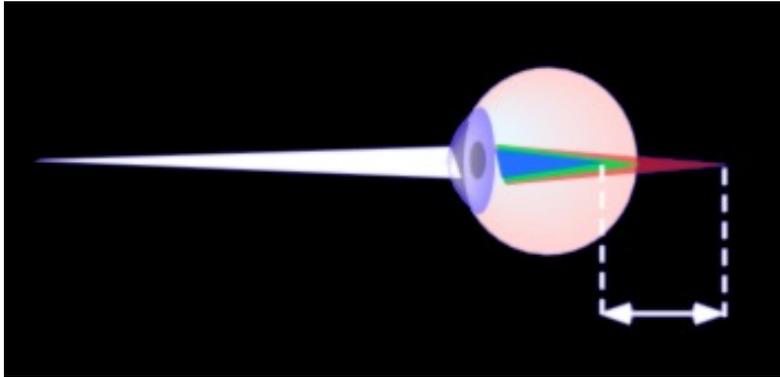
Accommodation is required to achieve a focused retinal image

The visual system controls its own postnatal retinal image defocus

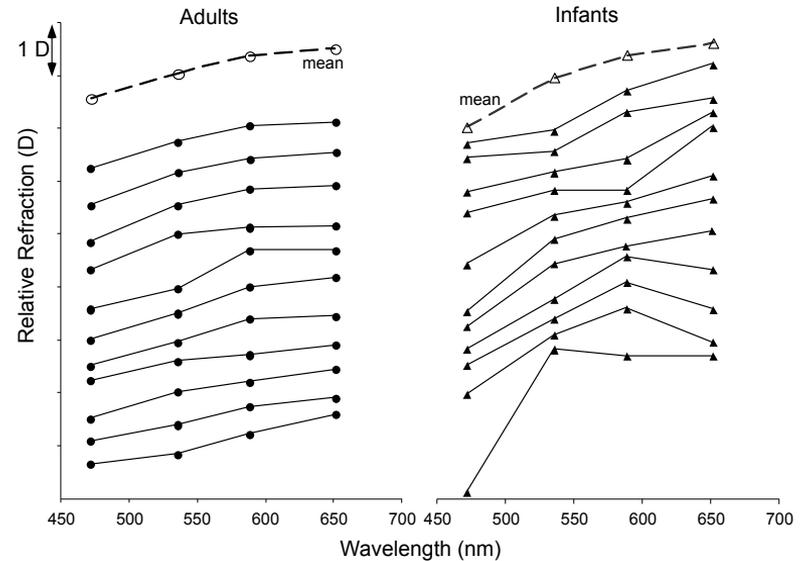
Candy, Wang & Ravikumar, 2009; Wang, Candy, Teel & Jacobs 2008; Wang & Candy, 2005; Howland, 2005; Candy & Banks 1999; Hendrickson & Drucker, 1992

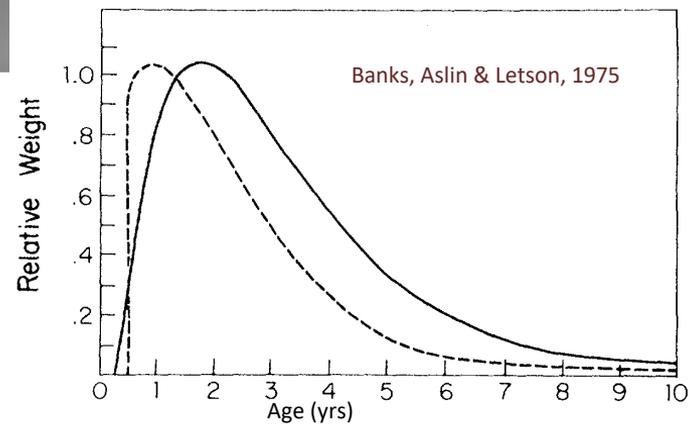
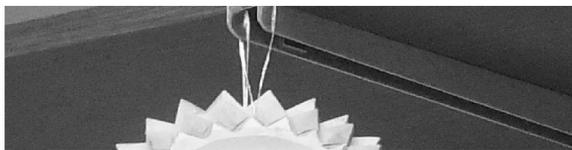


The 'sign of defocus' problem for accommodation and emmetropization?

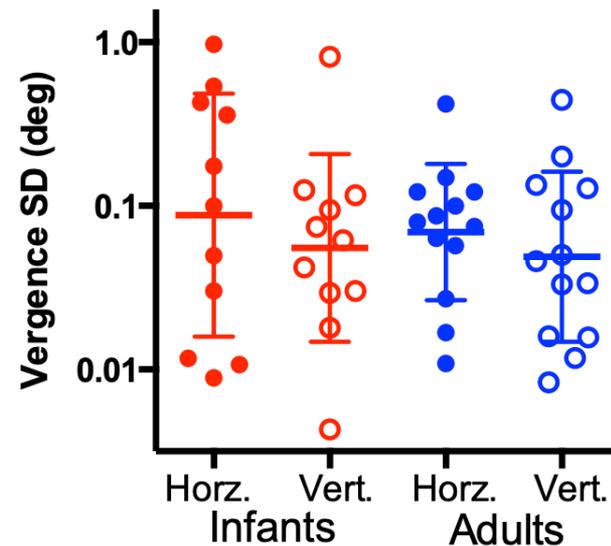
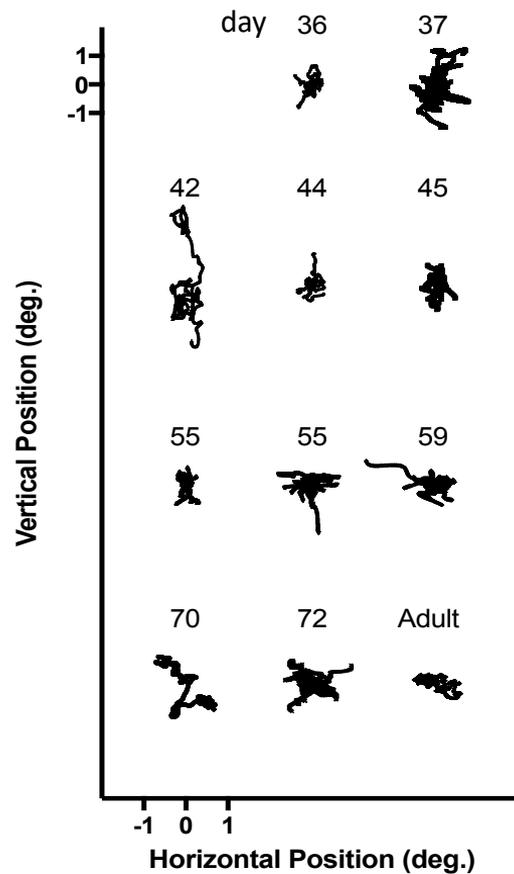


3-month-olds & adults
LCA 1.7 x greater in infants
Consistent with the difference in eye size

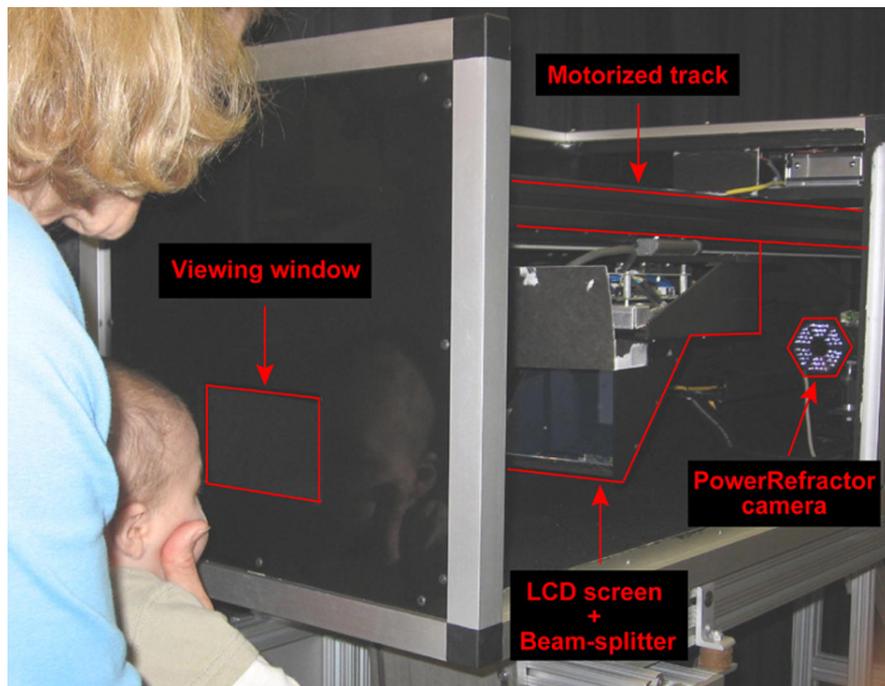




Gaze stability?

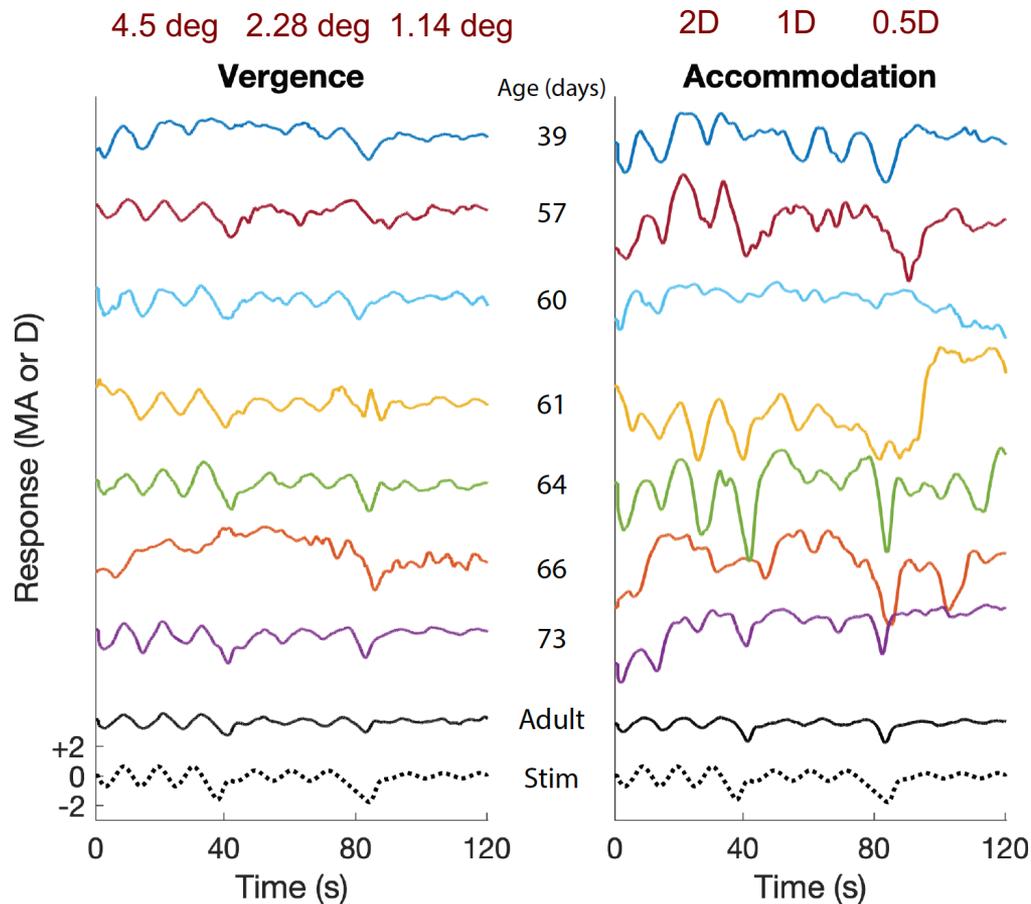


How sensitive are the developing accommodation and vergence systems?



Eccentric photorefraction and Purkinje image eye tracking, at 25Hz or 50Hz. (PowerRefractor 1 or 3)

0.1 Hz



T. Rowan Candy

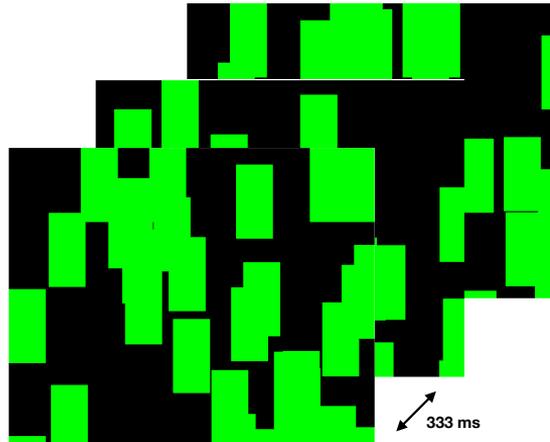
Seemiller, Wang & Candy (2016) JoV

Candy (2019) ARVS

Wang & Candy (2010) IOVS



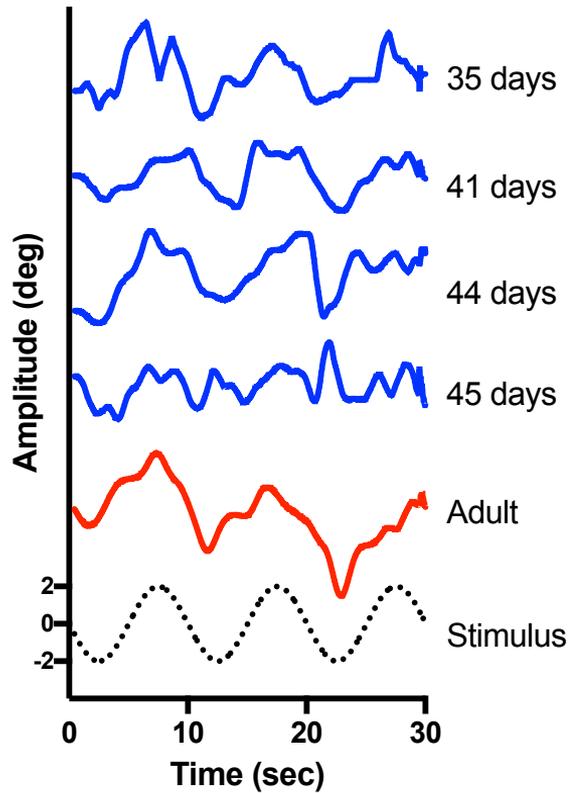
Disparity?



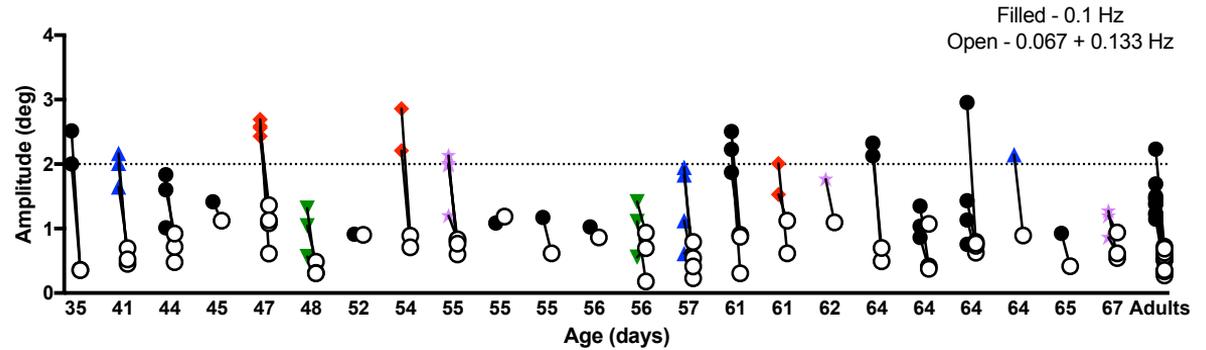
e.g. Atkinson & Braddick (1975); Fox, Aslin, Shea & Dumais (1979);
Held, Birch & Gwiazda (1980); Petrig, Julsez, Kropfl, Baumgartner,
Anliker (1981)



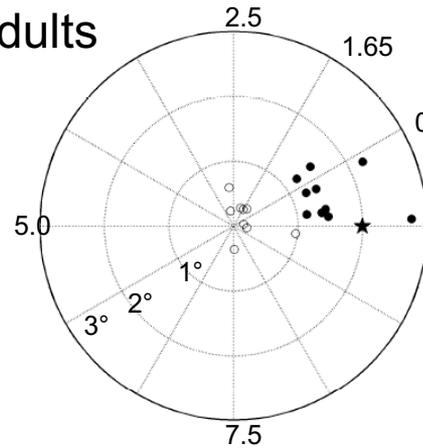
Disparity?



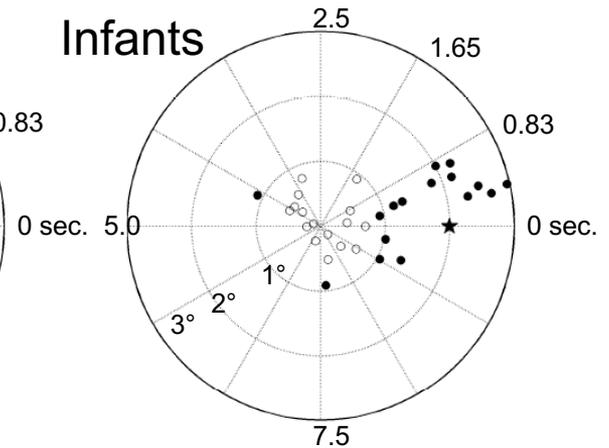
0.1 Hz



Adults

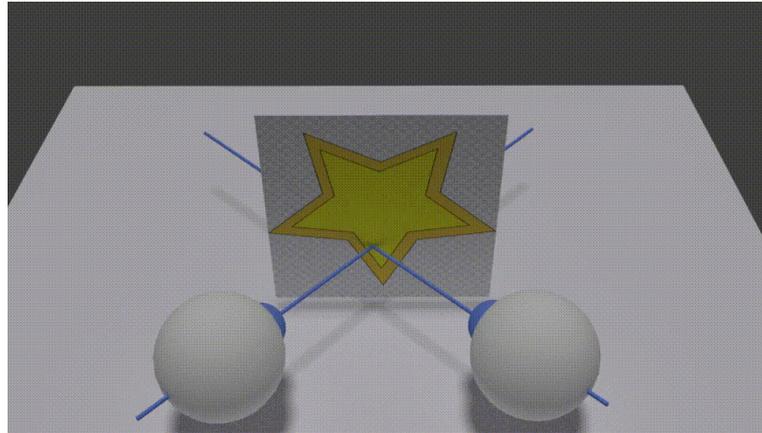


Infants



Tracking a Random Walk

- Mulligan, Stevenson & Cormack (2013)
 - Correlation between a random stimulus and responses
 - Gaussian low-pass filtered velocity noise





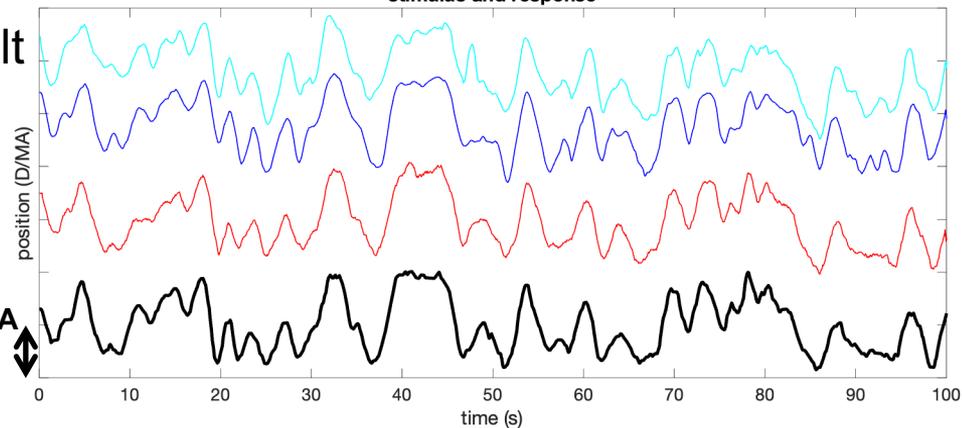
- Screen moving between 33 & 80cm
- 4 Hz velocity update rate
- Spatially/temporally broadband cartoon movie
- Ecc. photorefraction & eye tracking at 50Hz (PowerRefractor 3, Plusoptix)



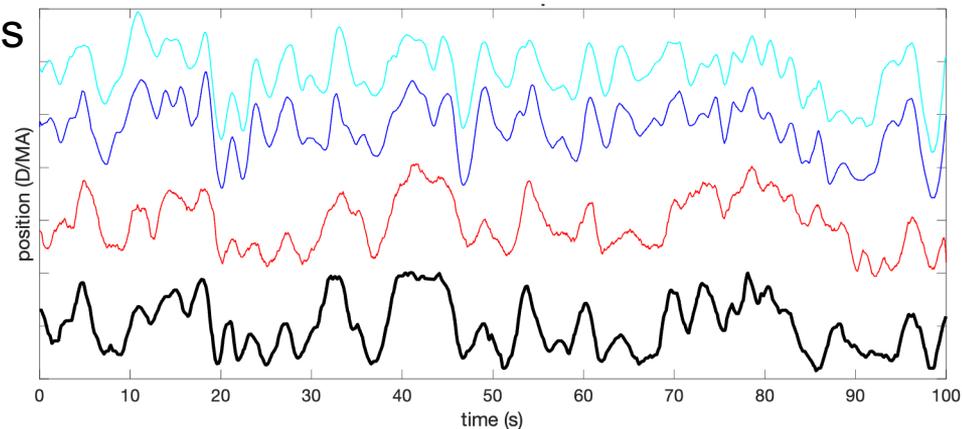
Single 100s Trial examples

stimulus and response

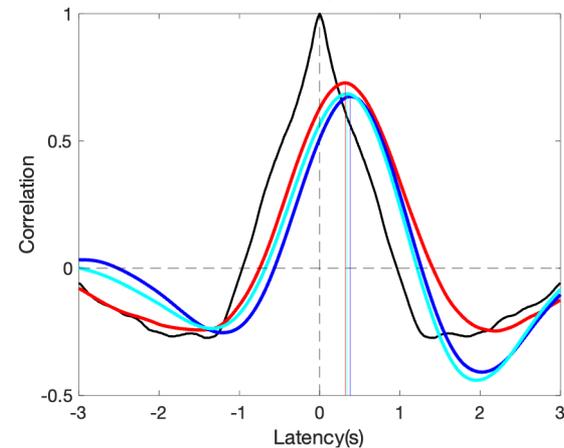
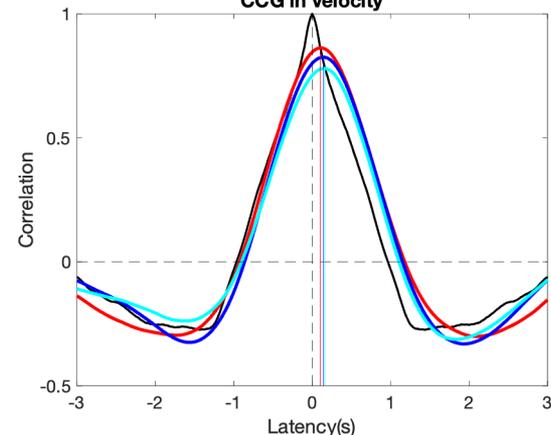
Adult



8wks

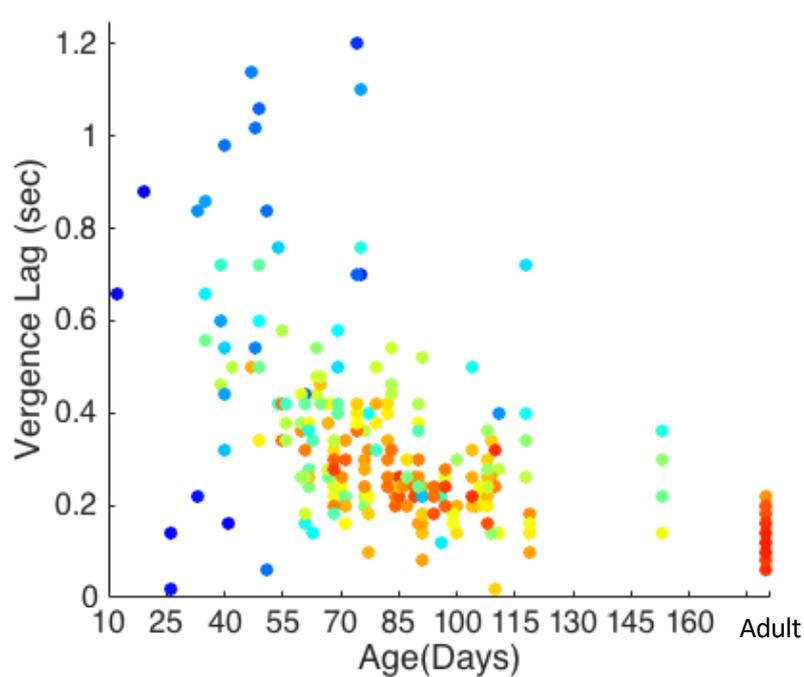


CCG in velocity

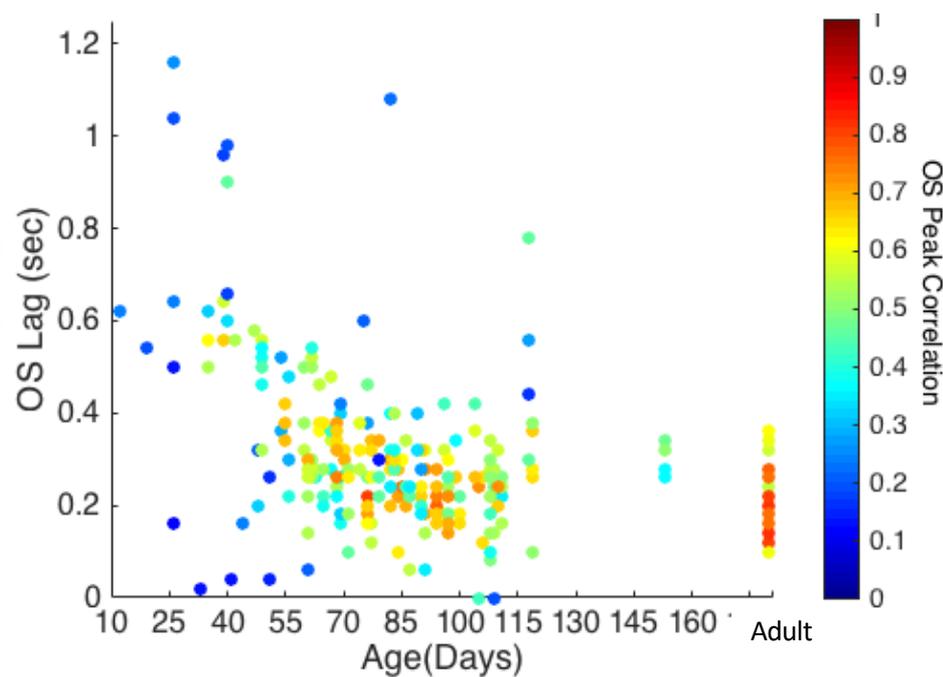


22/23 full-term, typical birthweight infants gave usable data (48/269 trials excluded)

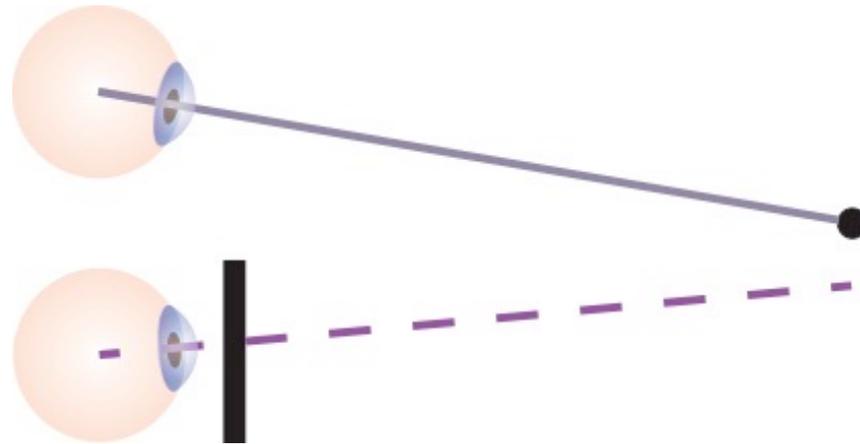
Vergence



Left Eye Accommodation



How robust is their eye alignment?

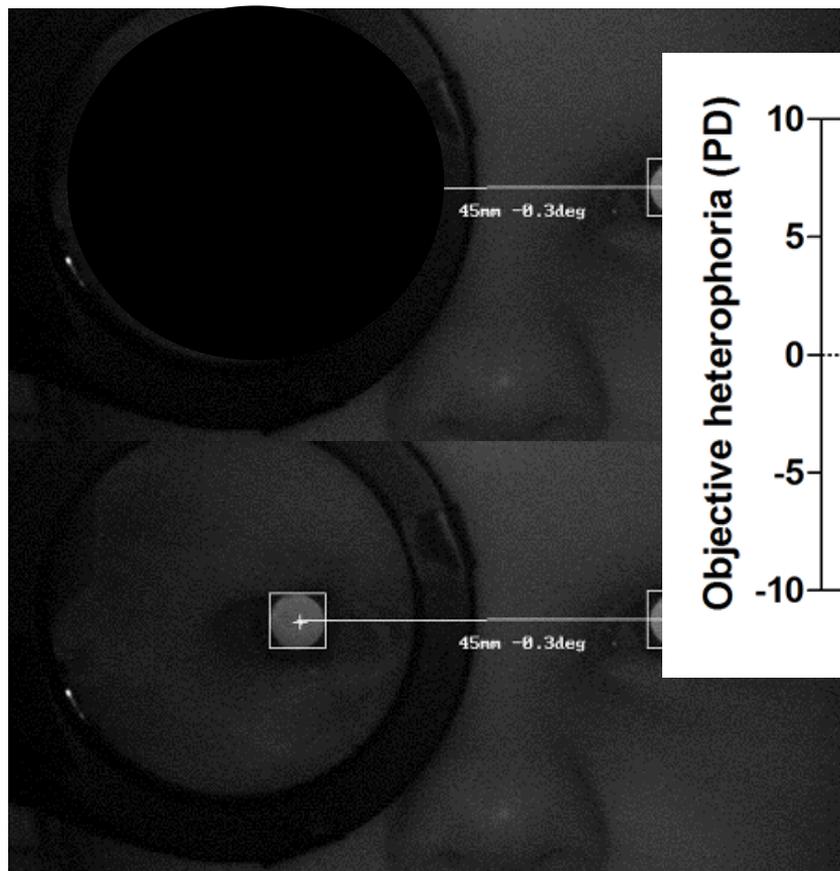


How large is the phoria of young infants?

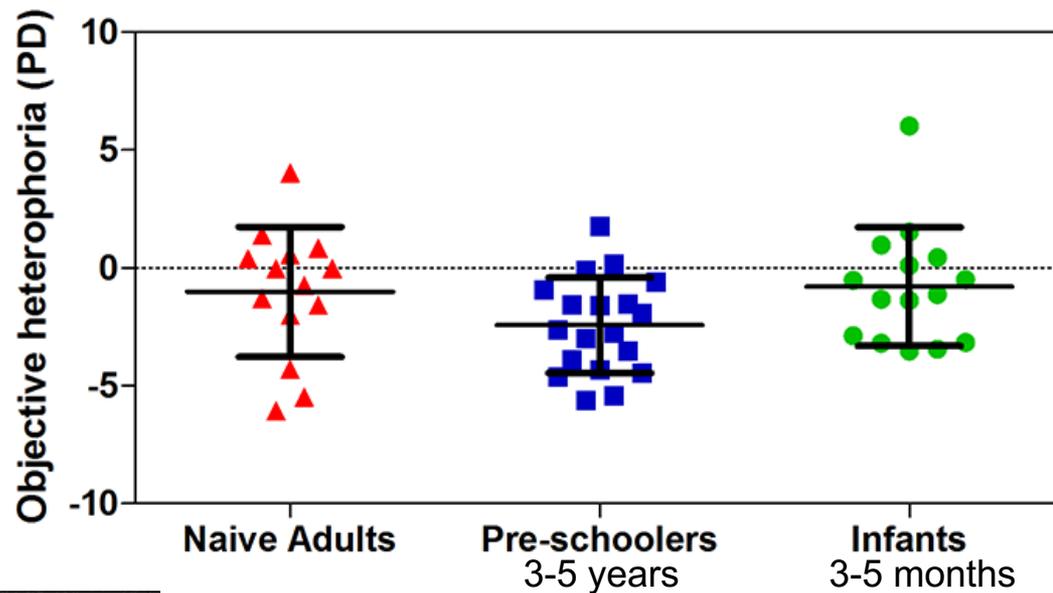
Is it convergent (esophoric)?

What is their fusional range?



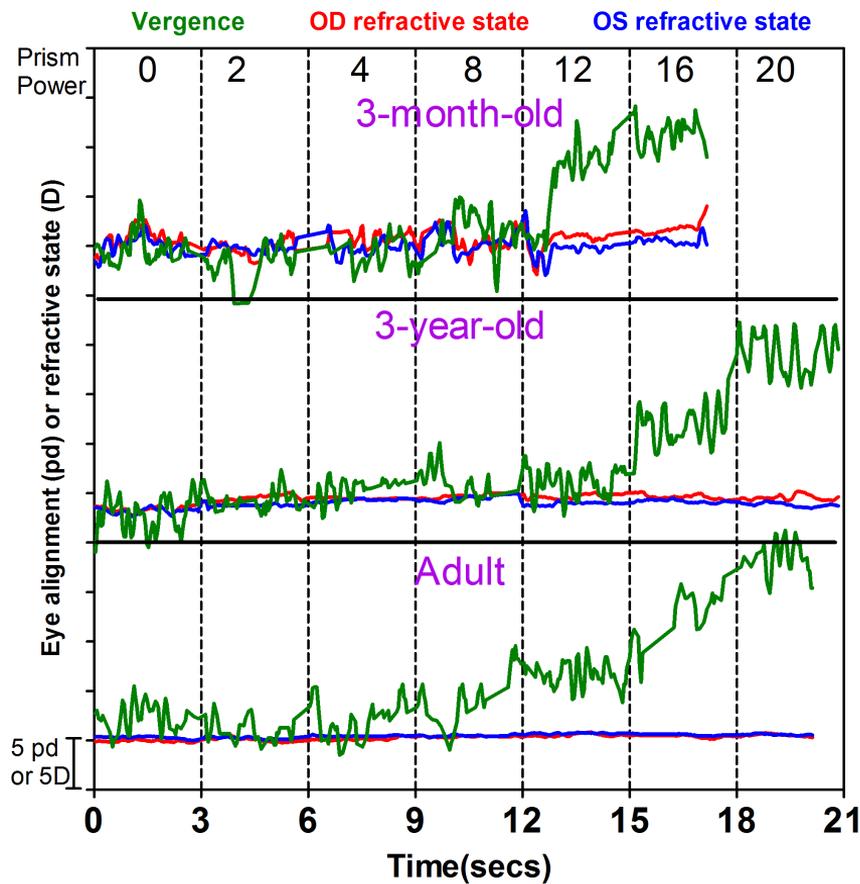
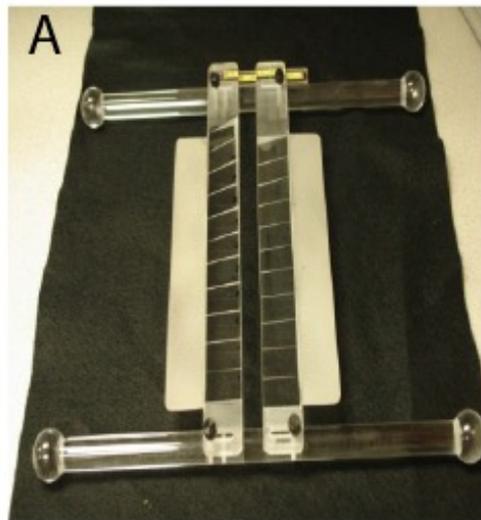
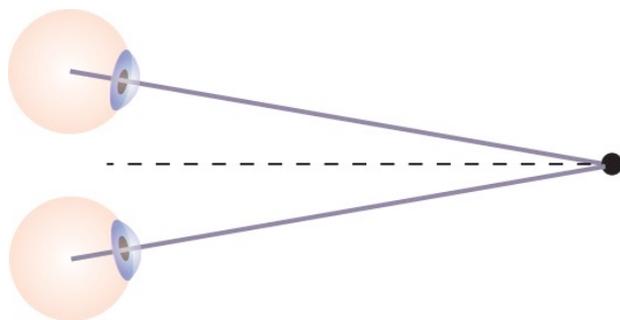


80cm viewing distance

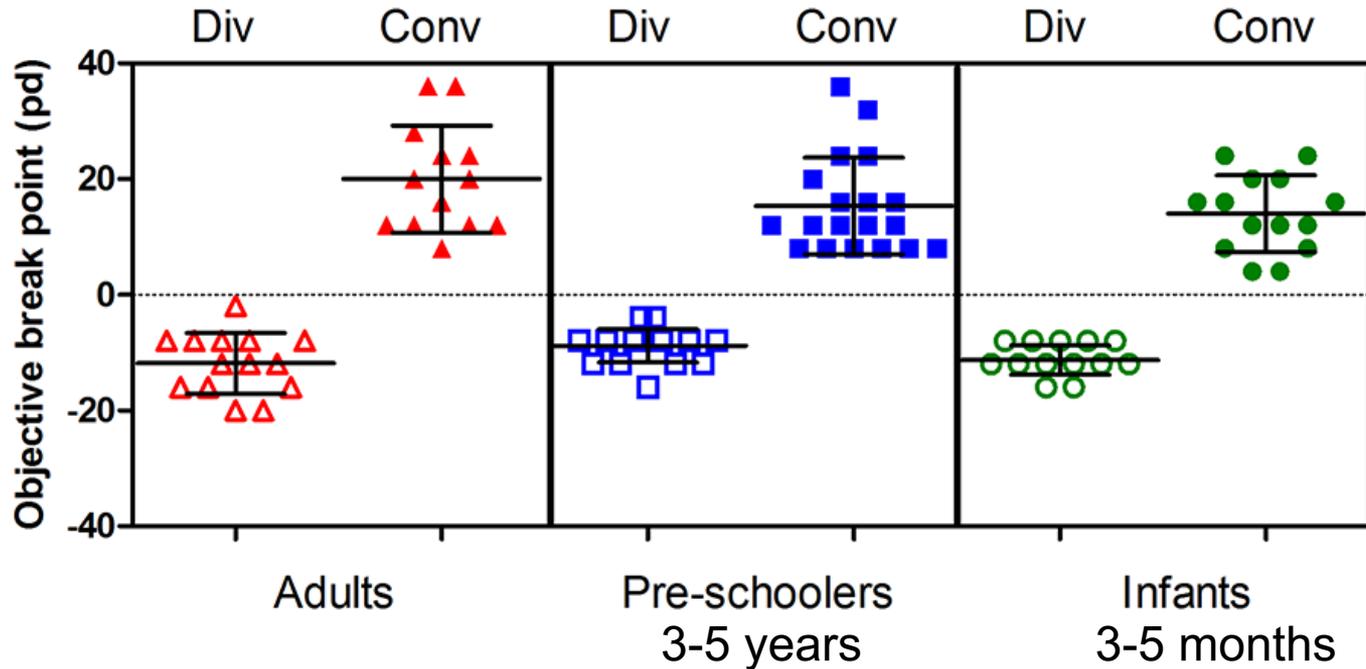


No effect of age, $F(2,46)=2.7$, $p=0.1$

Lam et al (1996); Chen et al (2000)



Studies of adults: Morgan 1944, Wesson 1982, Sheedy & Saladin 1978, Daum 1989



80cm viewing distance

No main effect of age ($F = 1.9, p=0.15$)

Main effect of direction on absolute magnitude ($F = 2413.5, p < 0.001$)

Summary:

While infants have significant immaturities in their spatial vision and their accommodation and vergence demands:

- Vergence and accommodation are sensitive to less than a couple of degrees and 0.5D, respectively, within weeks after birth.
- Disparity alone can be used to drive vergence responses despite other stable conflicting cues at least by the second month after birth.
- Under occlusion 3-5 month-olds have adult-like alignment at 80cm, with adult-like fusional vergence ranges.

What does it take for this system to derail and how does the brain then adapt? (Bharadwaj & Candy 2009 & 2011)

