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

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Refractive error

Interpupillary Distance

Pryor 1969

MacLachlan & Howland, 2002

Banks & Salapatek, 1978

Norcia, Tyler & Hamer, 1990

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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

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

Wang, Candy, Teel & Jacobs 2008
Gaze stability?

Seemiller, Port & Candy (2018) JOV
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

Vergence

Accommodation

4.5 deg 2.28 deg 1.14 deg

2D 1D 0.5D

Response (MA or D)

Time (s)

Age (days)

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?

Amplitude (deg) vs. Time (sec) for various ages and stimuli.

- 0.1 Hz

Amplitude (deg) vs. Age (days) for adults and infants.

Filled - 0.1 Hz
Open - 0.067 + 0.133 Hz

Seemiller, Cumming & Candy (2018) JOV
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

Adult

2.0D/MA

8wks

stimulus and response

OS Acc
OD Acc
Verg
Stimulus

CCG in velocity

Correlation

Latency(s)

Correlation

Latency(s)
22/23 full-term, typical birthweight infants gave usable data (48/269 trials excluded)
How robust is their eye alignment?

How large is the phoria of young infants?
Is it convergent (esophoric)?
What is their fusional range?
No effect of age, $F(2,46)=2.7$, $p=0.1$


Sreenivasan, Babinsky, Wu & Candy (2016) IOVS
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)