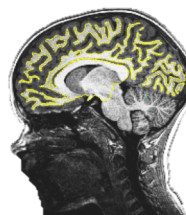


Developing an optimized visuomotor system



Tessa Dekker

CBCD 21st anniversary workshop, November 2019

Centre for Brain and Cognitive Development



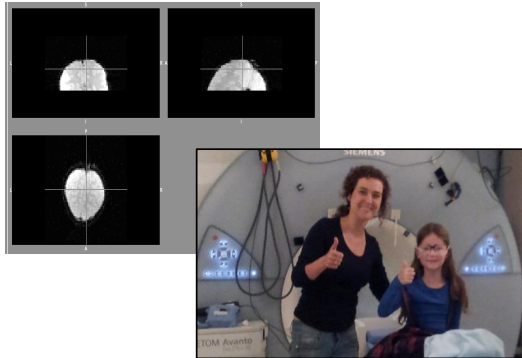
MSc



Centre for Brain and Cognitive Development

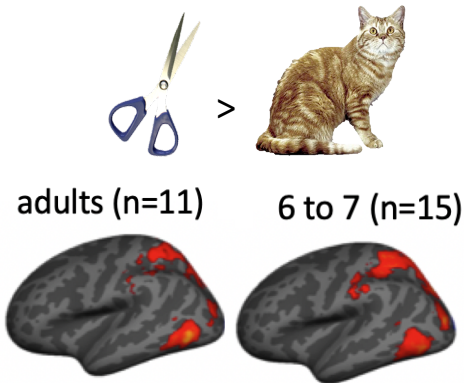


PhD



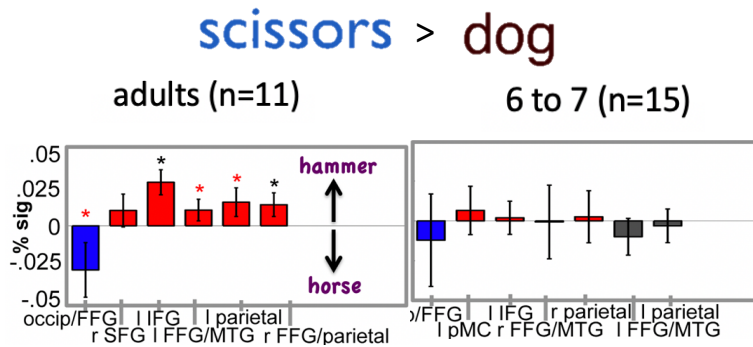
Dorsal and ventral stream activation and object recognition performance in school-age children

Tessa Dekker ^a, Denis Mareschal ^a, Martin I. Sereno ^{a,b}, Mark H. Johnson ^{a,*}

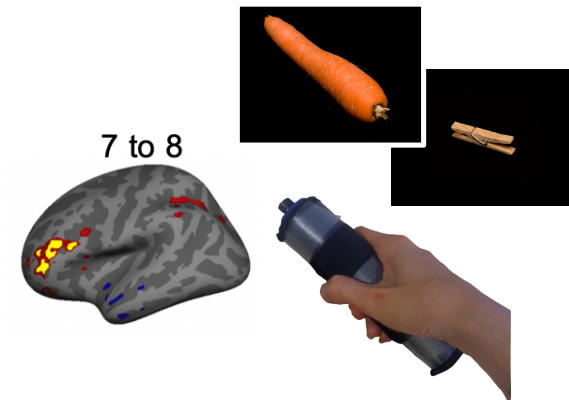


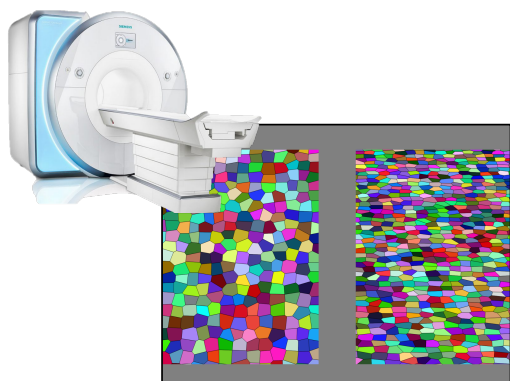
Picturing words? Sensorimotor cortex activation for printed words in child and adult readers

Tessa M. Dekker ^{a,b,*}, Denis Mareschal ^b, Mark H. Johnson ^b, Martin I. Sereno ^{b,c}



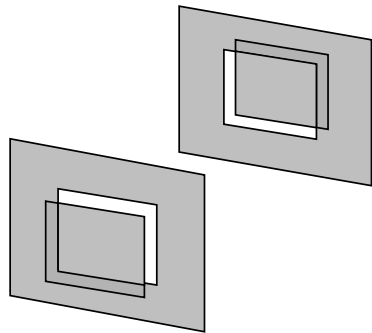
Suppression of the impulse to grasp develops late
Hopefully submitted one day soon...



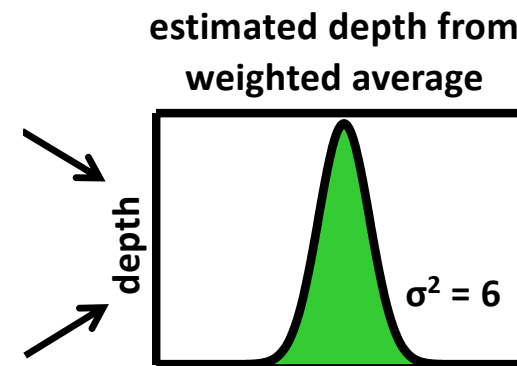
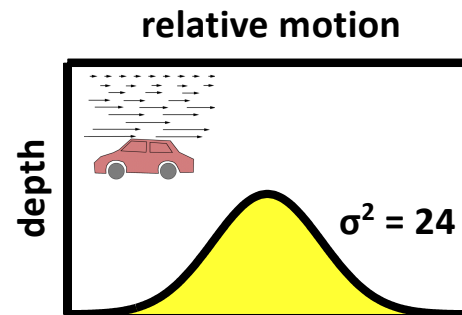
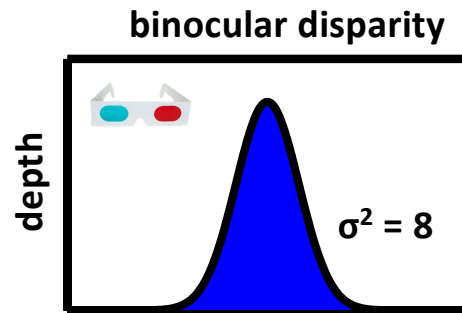


UCL Institute of ophthalmology

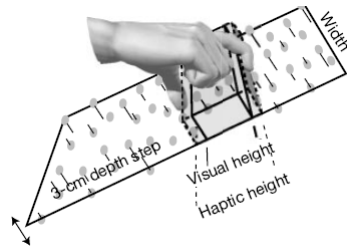
Ban, Preston, Meesan & Welchman, *Nat Neurosci*, 2012



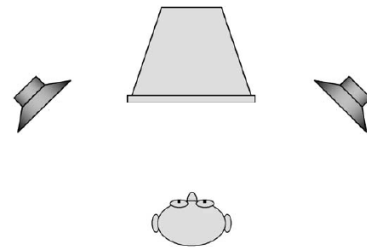
visual cues to the depth of a plane



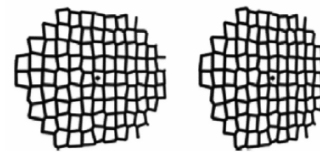
$$1/\sigma_d^2 + 1/\sigma_m^2 = 1/\sigma_{d+m}^2$$



Vision + touch cues to size
(Ernst & Banks, *Nature* 2002)



Vision + audition cues to location
(Alais & Burr, *Curr Biol* 2004)



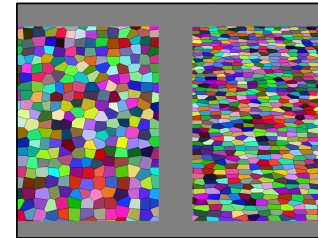
Visual depth cues to slant
(Hillis et al., *J of Vision* 2004)



Visual-haptic task
Gori et al, *Curr Biol* 2008



Navigation
Nardini et al, *Curr Biol* 2008



Visual slant estimation
Nardini et al, *PNAS* 2010



Vis-aud localisation
Gori et al, *Fr Int N'sci* 2012



Pointing
Nardini et al, *JEP:HPP* 2013

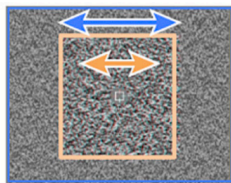
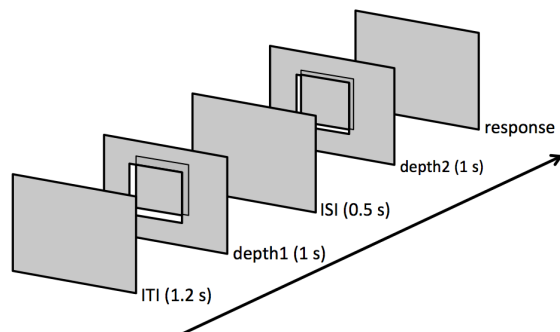


Haptic-auditory size
Petrini et al, *Dev Sci* 2014

- Cue integration in sensory cortex still developing?
- Or are fusion mechanisms present earlier, but information not accessed?

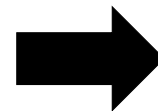
Ban, Preston, Meesan & Welchman, *Nat Neurosci* (2012)

Psychophysics

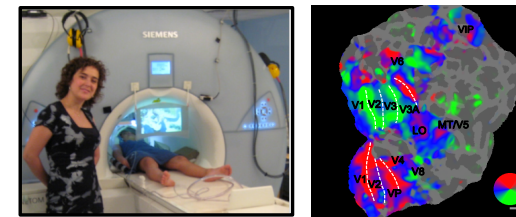


fusion criterion = Congruent > Conflicting depth Cues

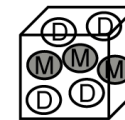
measure integration of disparity and relative motion cues to depth during depth discrimination



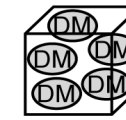
pattern analysis fMRI



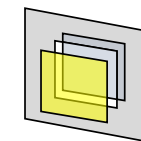
separate



fuse



~1mm³

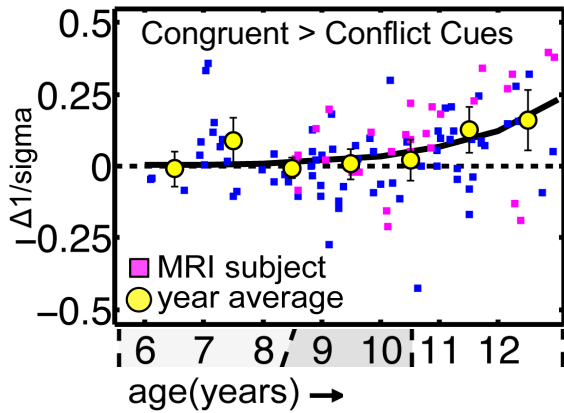


conflict

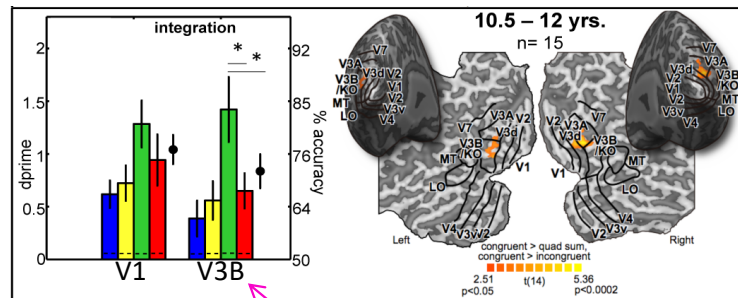
measure fusion of depth cues in cortex during fixation task

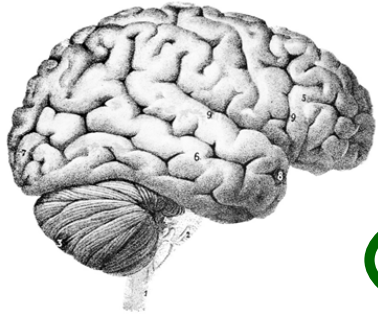
Dekker, Ban, van de Velde, Welchman, Sereno & Nardini, Curr Bio (2015)

Psychophysics



fMRI





Why do younger participants not optimally combine visual depth cues?

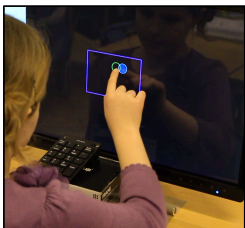
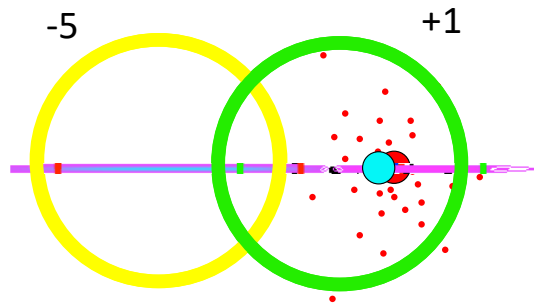
- Fusion mechanisms in the brain are still developing

Why does development take such a long time?

- Senses are still be calibrating, so more biased
- Weaker coupling prior
- Poor read-out of the reliability of sensory estimates

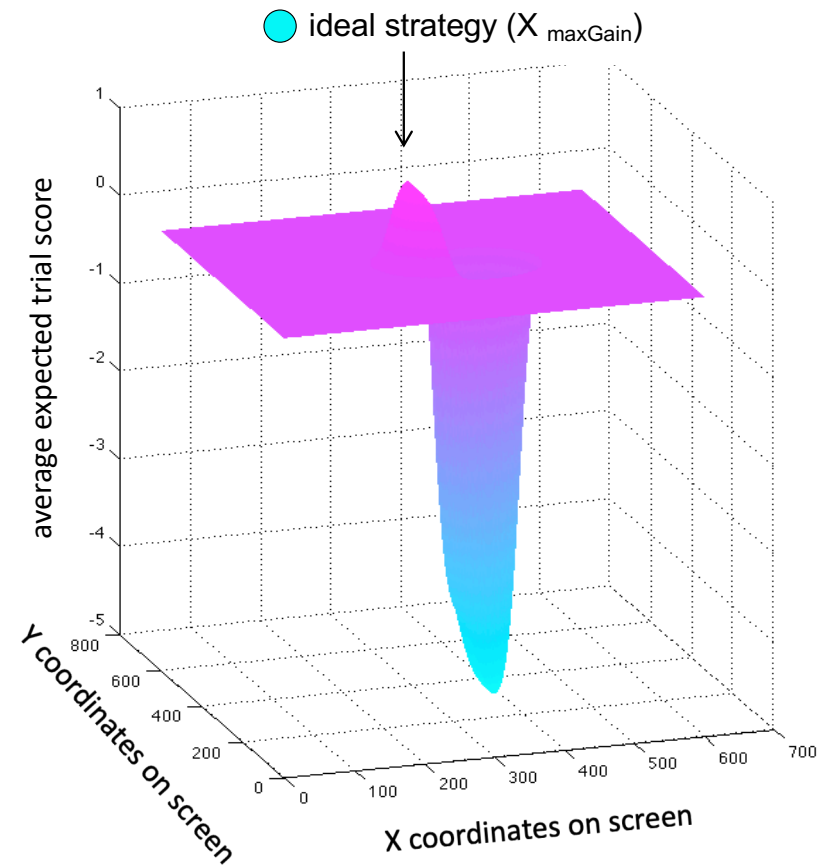
Trommershauer, Landy & Maloney *Psychol Sci*, 2006

time-limited reaching task

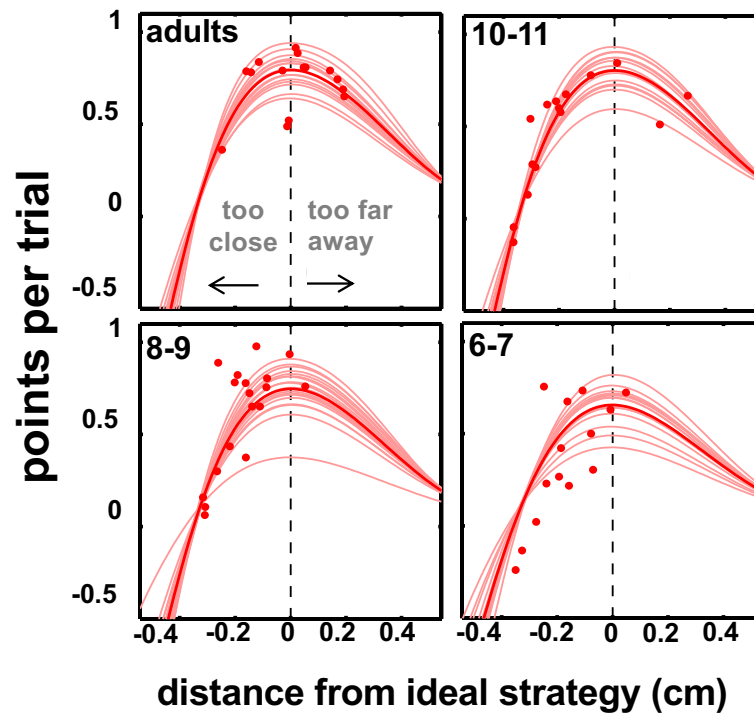


- reach end-points per trial
- mean of end-points
- ideal mean location

Dekker & Nardini (2016), *Developmental Science*

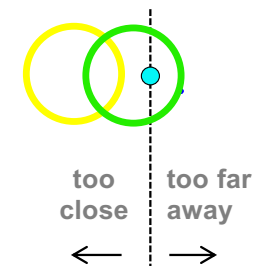


scores across aiming strategies



Dekker & Nardini, Dev. Sci (2016)

----- ideal strategy ($X_{\max \text{ gain}}$)
— predicted score
● measured strategy & score



- Participants of all ages stuck with their strategy from the start of the task – suggesting relatively minor role for reinforcement learning

Which developmental mechanism may explain this?

- Poor representation of own visuomotor precision?

Or:

- Assigning lower cost to losing points or higher cost to missing
- Preference for central pointing



Experimental
psychology



UCL Institute of
ophthalmology

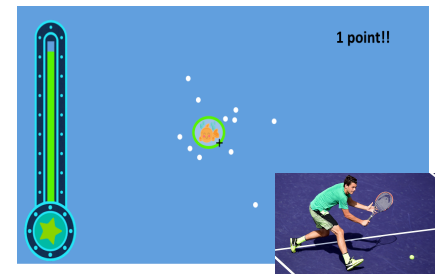


buy location cues to find the fish



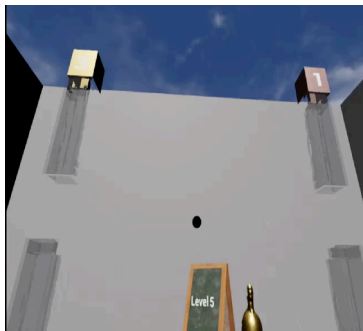
Jones, Juni, Landin, et al., (JEP:General, 2019)

find and catch the fish before the time runs out



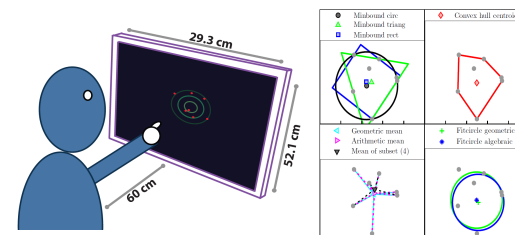
Large, Jones & Dekker, in prep

stand where you pop the most balloons



Large, Smeets, Brenner & Dekker, in prep

find the middle of the dot cues

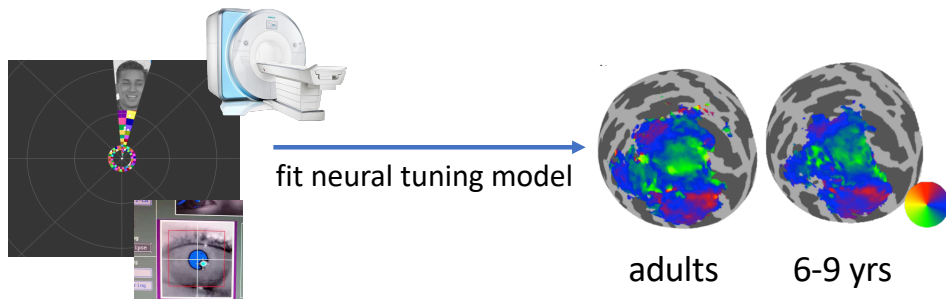


Juni, Geruckis & Maloney (2017)

Children do not just average location cues inefficiently, they use a qualitatively different averaging rule

Fitting visual neural tuning models to brain responses in visual cortex

Population receptive field mapping fMRI



Retinotopic tuning of population receptive fields in visual cortex adult-like by age 6 years

Dekker, T. M., Schwarzkopf, D. S., de Haas, B., Nardini, M., & Sereno, M. I., *Dev Cog Neuro* (2019).

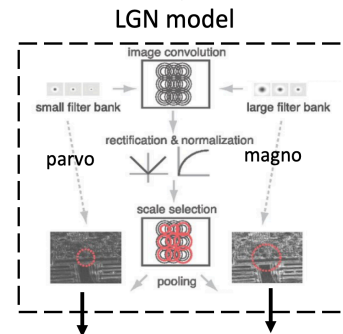
Fitting a developing LGN model to single-trial EEG



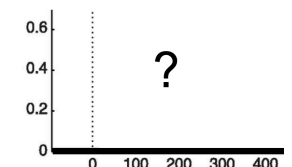
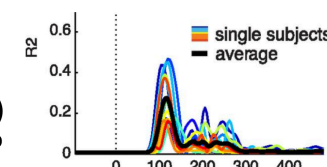
Neurally plausible model of image filtering in mature brain

Do summary stats from model correlate with adult visual EEG signal?

How well does adult LGN model explain child EEG?

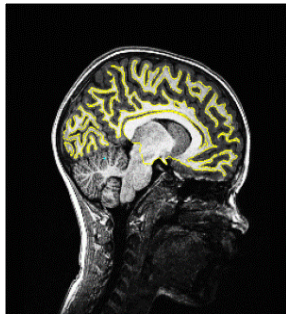


contrast energy (CE) mean local edge info
spatial coherence (SC) variability of edge info



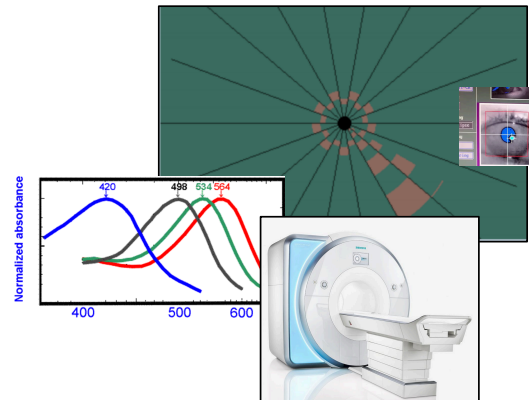
Measuring cortical plasticity in developmental disorders of vision

8-year-old achromatopsia patient without retinal cone function



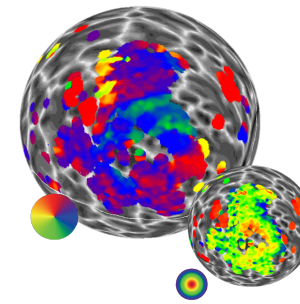
In progress

cone- & rod-selective fMRI with eye tracking

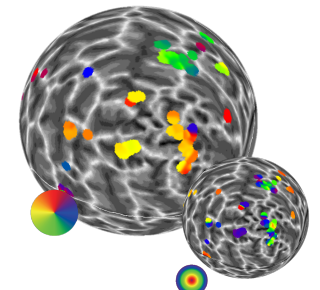


Atypical retinotopic maps on visual cortex surface

Rod map



Cone map





Happy birthday CBCD!!!!
thank you so much for

the multi-method, multidisciplinary, mechanism-
oriented approach to studying development, inspiring
so much exciting research in so many
&
many long-time collaborators and friends from all over
the world