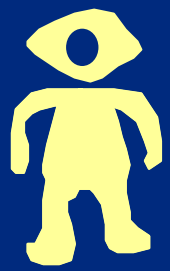
VSS 2007

High-density VERPs show distinct mechanisms for global form and motion processing in adults and infants

Oliver Braddick[1], J Wattam-Bell[2], Dee Birtles[1,2], J Atkinson[2], Claes von Hofsten[3], Pär Nyström[3]



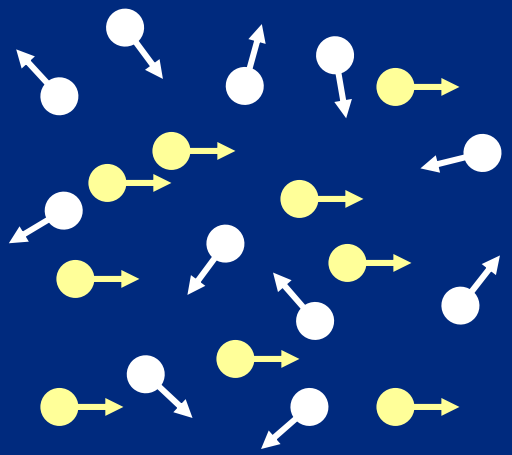
[1]*Experimental Psychology, University of Oxford*
[2]*Visual Development Unit, University College London*
[3]*Department of Psychology, Uppsala University, Sweden*

http://www.psychol.ucl.ac.uk/vdu/publications.html

Local and global cortical visual processing

- V1 : small receptive fields, respond to *local* features (e.g. oriented line segments)

- extra-striate visual areas : larger receptive fields, respond to ‘global’ properties . . .



macaque V5/MT *(dorsal)*

response to coherence level of random dot motion

(Britten et al, *J Neurosci*, 1992; *Vis Neurosci*, 1993)

macaque V4 *(ventral)*

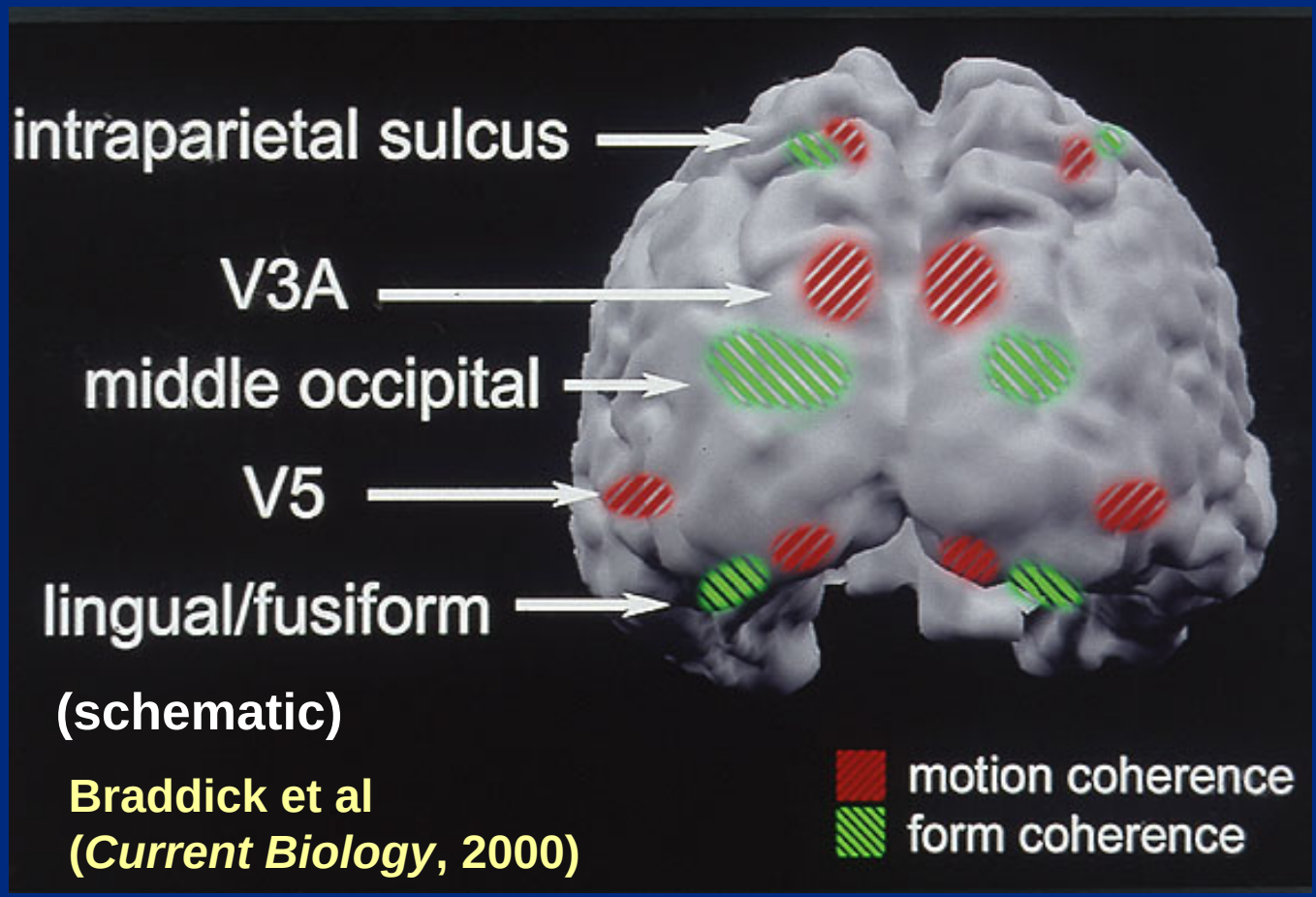
response to concentric or radial configurations

(Gallant Braun & Van Essen, *Science*, 1993):

fMRI: coherent - incoherent

form

motion



form & motion coherence activate:

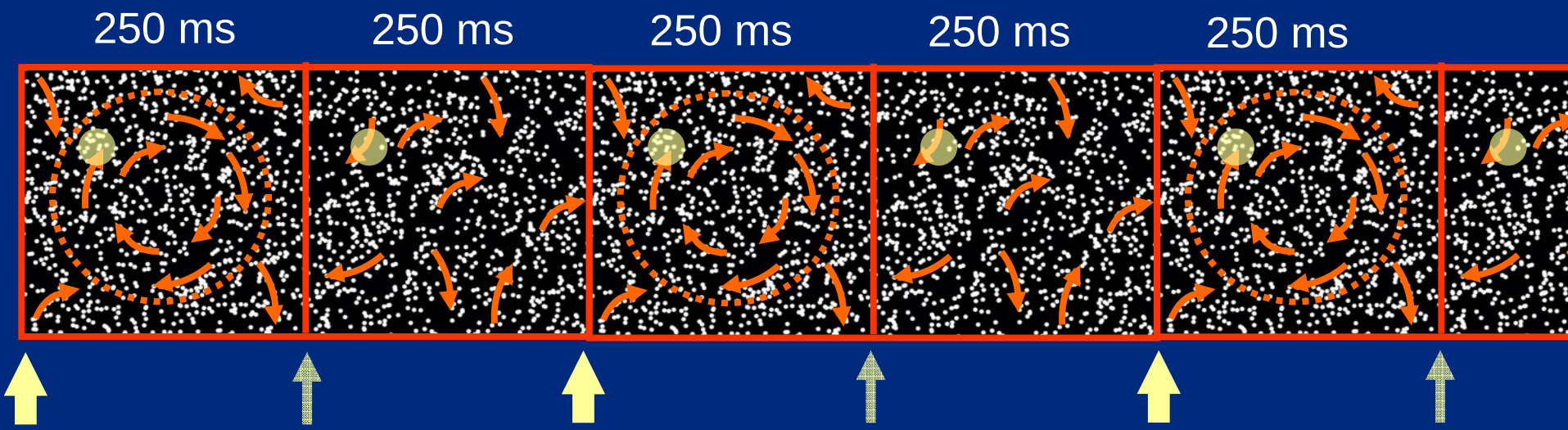
- **extra-striate, not striate cortex**
- **independent, non-overlapping networks**

- Can we use measures of global motion and form performance to tap human extrastriate visual function?
- We would like to track **normal human development** of global processing…
- .. and **‘dorsal stream vulnerability’** in developmental disorders *(Atkinson et al, 1999; Braddick et al, 2003)*

Can we use a VERP method to identify separate global and local components of the response?

VERP global motion stimulus

- **Every 500 ms (2 Hz, first harmonic = F1) there is onset of global structure.**
- **The local motion events at onset and offset of global structure are similar**

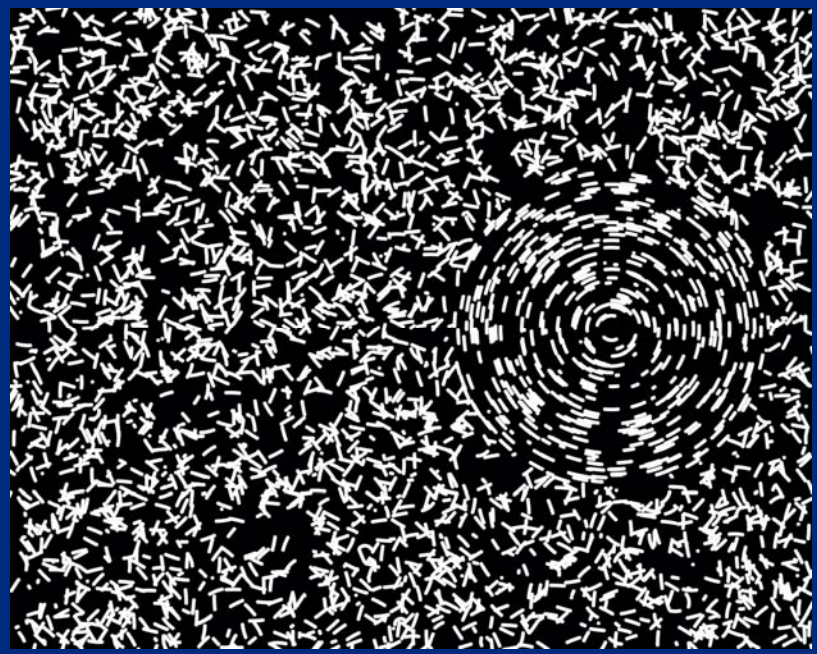


- **So a VERP response at F1 reflects differential responses to onset and offset of global structure**
- **…and must arise from a global motion mechanism**

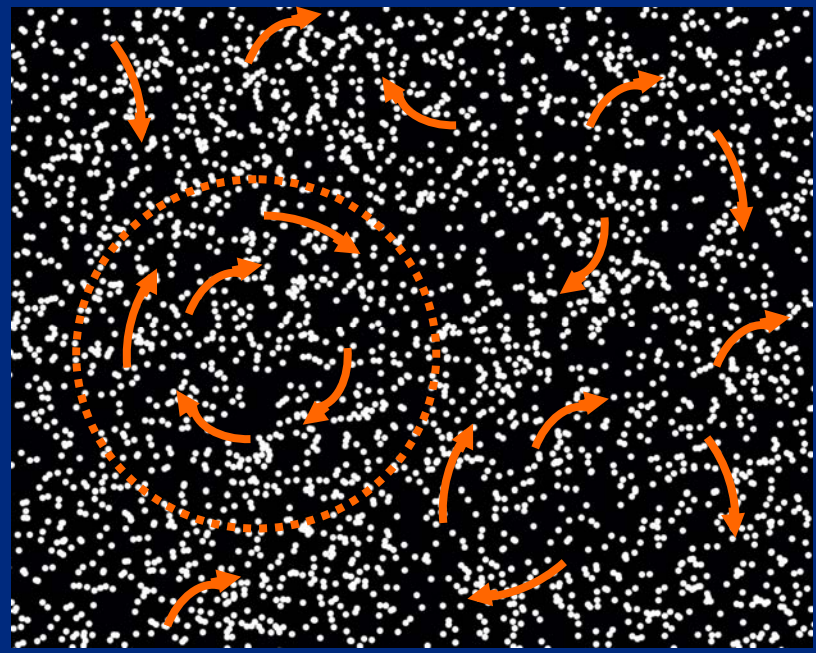
Motion coherence VEP stimulus

Direct comparison of form & motion coherence

Form coherence



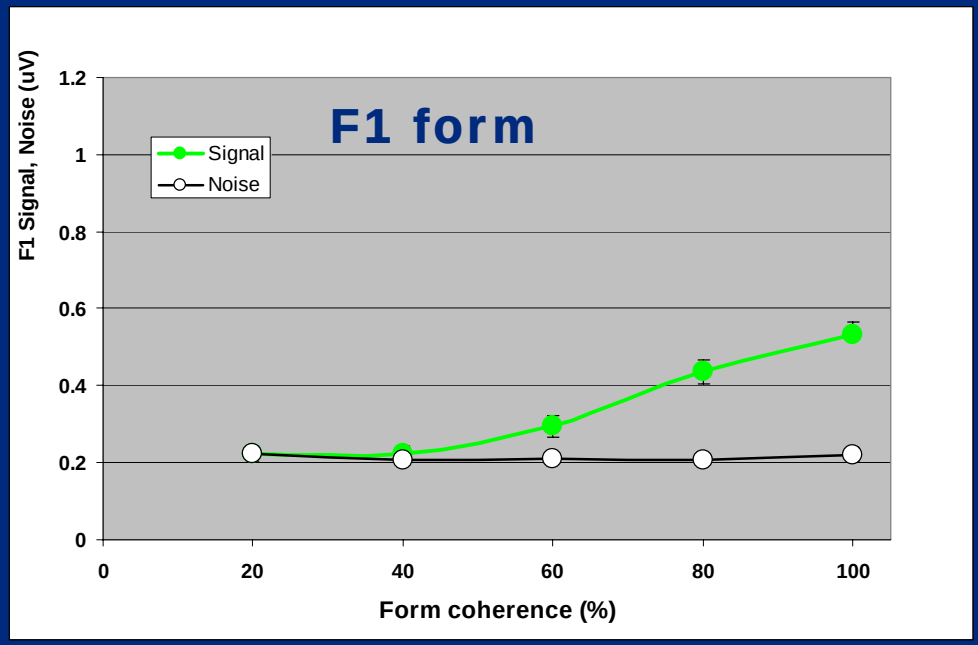
Motion coherence

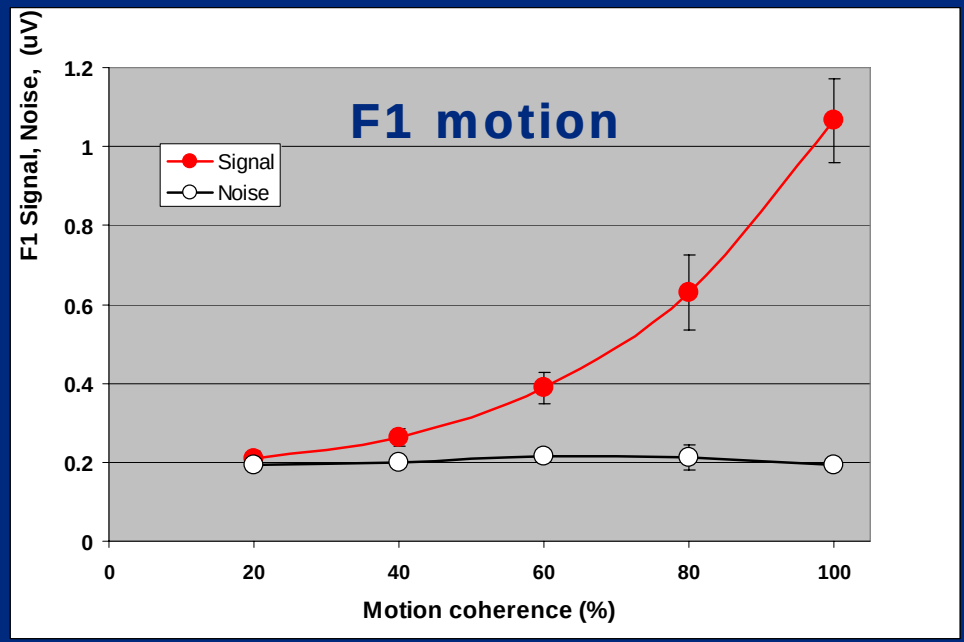


- Pattern sequences for global form and motion have the same structure
- Dots plotted successively generate rotational ***motion***
- The same dots plotted simultaneously generate static arcs for concentric global ***form***

VEP amplitude varies with coherence

- data presented at VSS 2006 showed that F1 amplitudes varied with % coherence for both form and motion
- signature of a global process



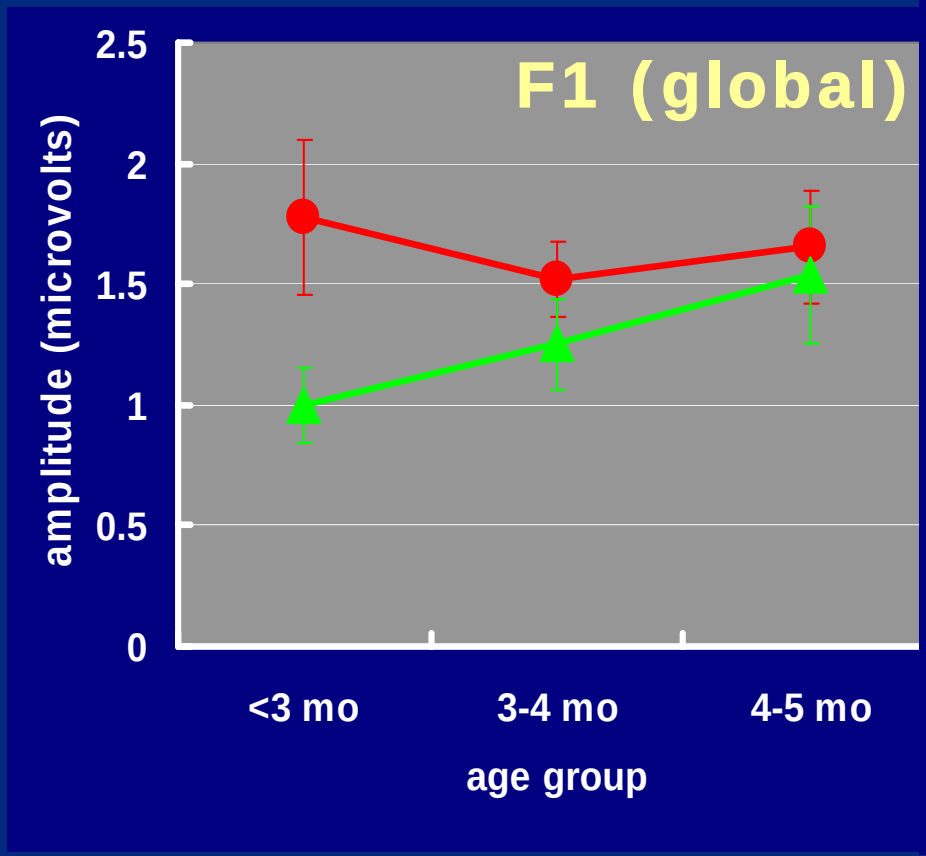


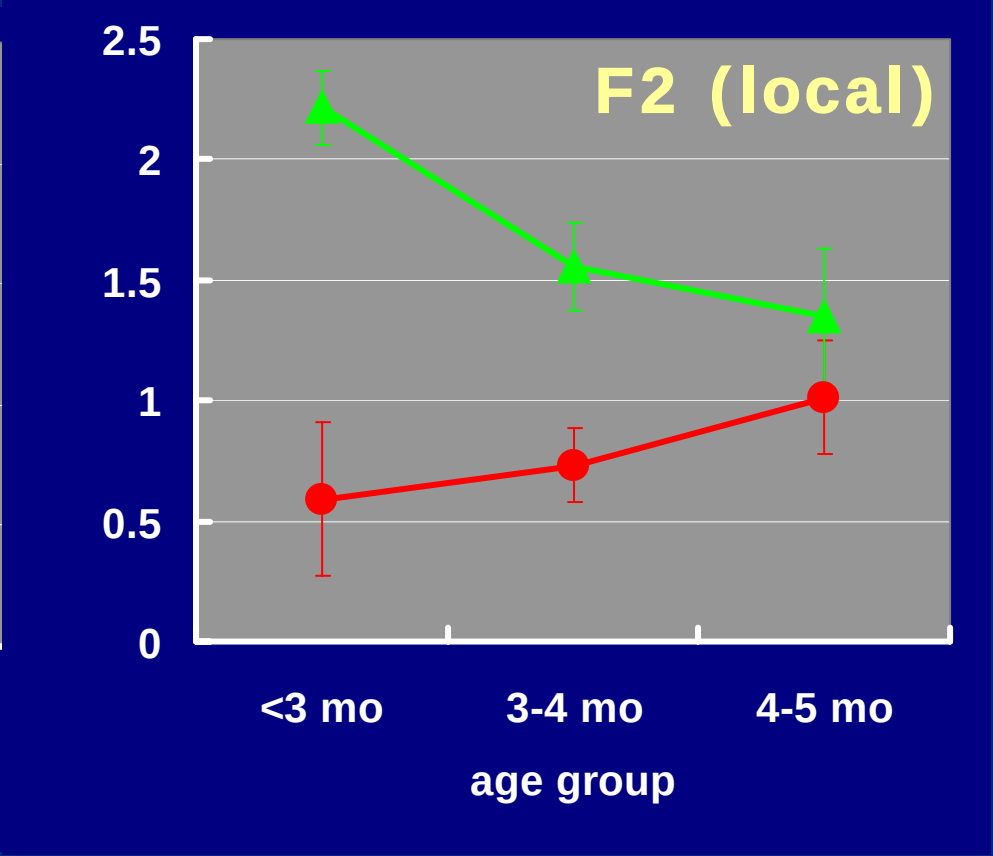
Form and motion coherence VERPs in infants

- Record signal from occipital and vertex leads
- Steady state VERPs at 1 Hz
- Each infant tested on both form and motion stimuli (random order)
- 200 sweeps averaged for each stimulus
- Amplitudes measured for F1 and F2 frequencies, and significance assessed by circular variance test

development of global VEP: amplitudes

results on 47 infants aged 9-23 weeks

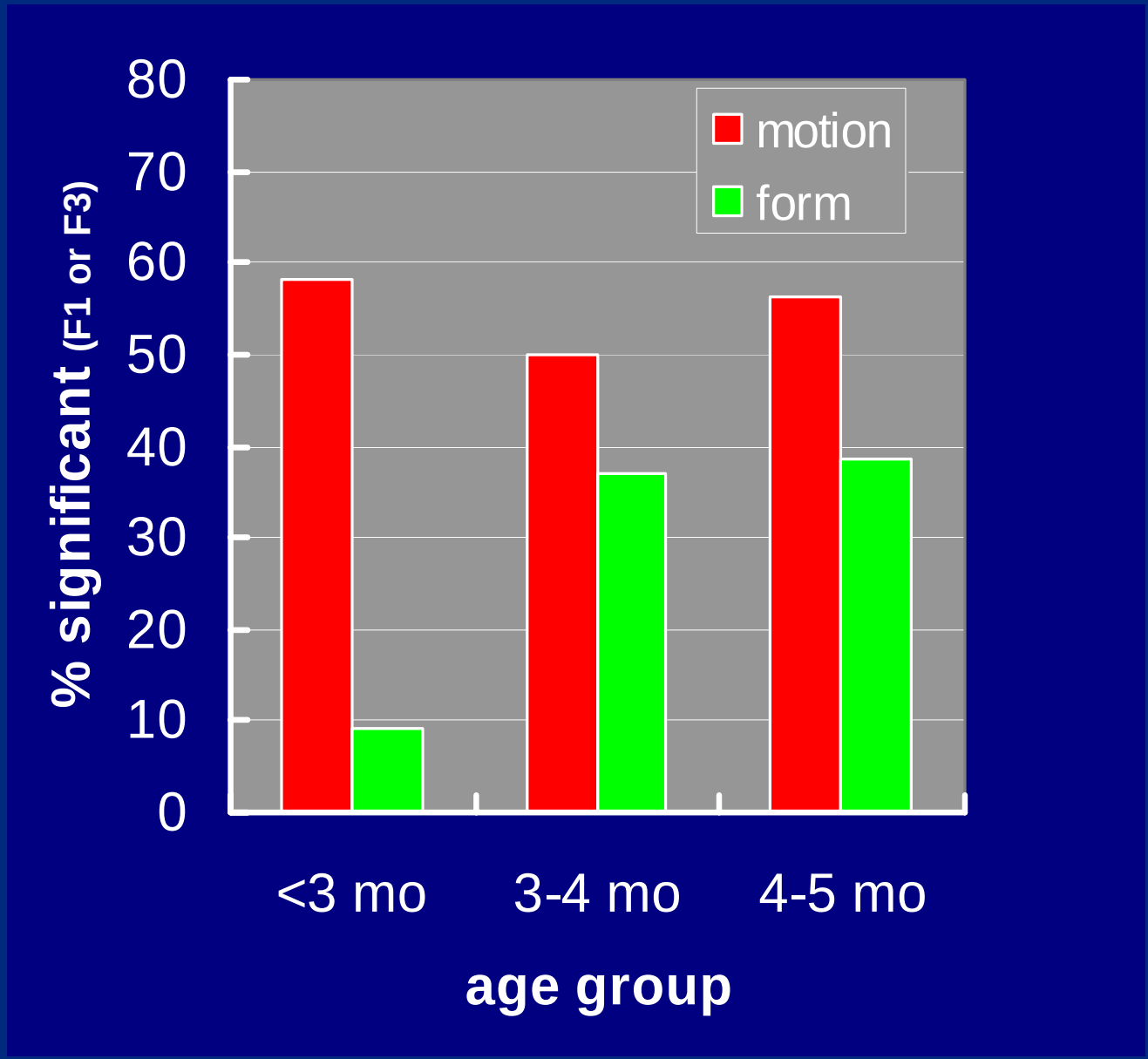




motion

form

development of global VEP: % infants significant



can we provide evidence that the global form and motion responses arise from distinct cortical mechanisms?

High density steady-state VERP recording

EGI Geodesic sensor net

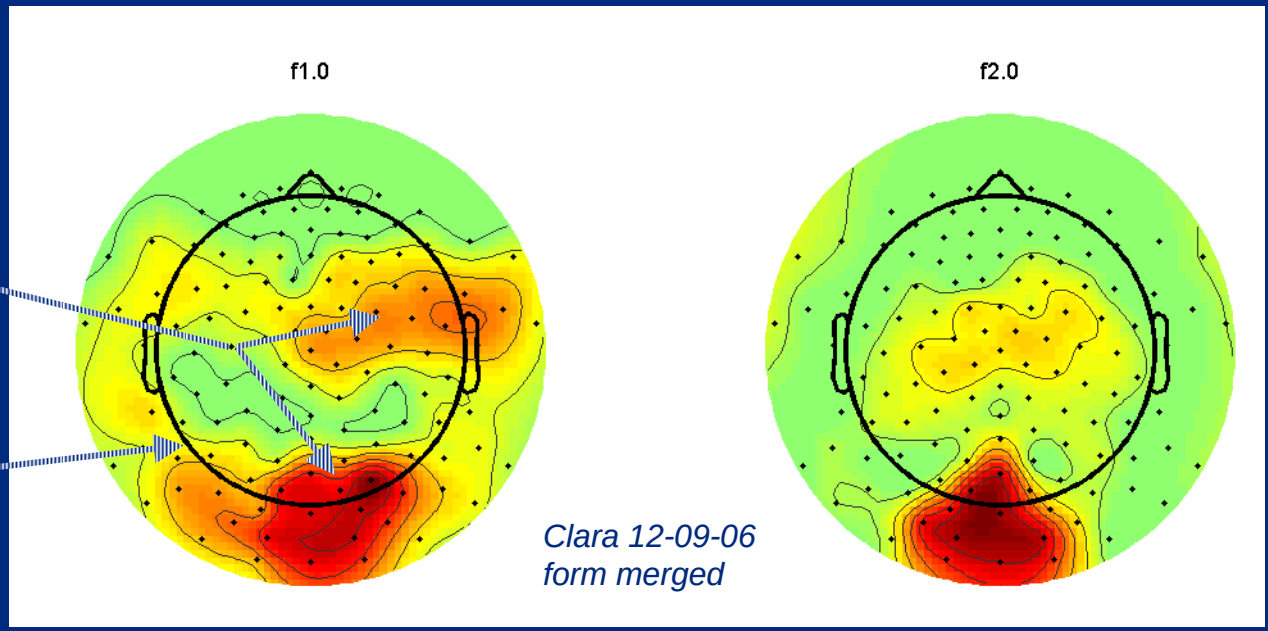
128 channels

phase & amplitude of frequency components at F1 (2 Hz) and F2 (4 Hz) extracted from averaged signal in each channel

Example: adult global form response

posterior and anterior maxima have opposite phase – ie arising from a single dipole

circle is circumference of head through nasion & inion – points outside are electrodes below this



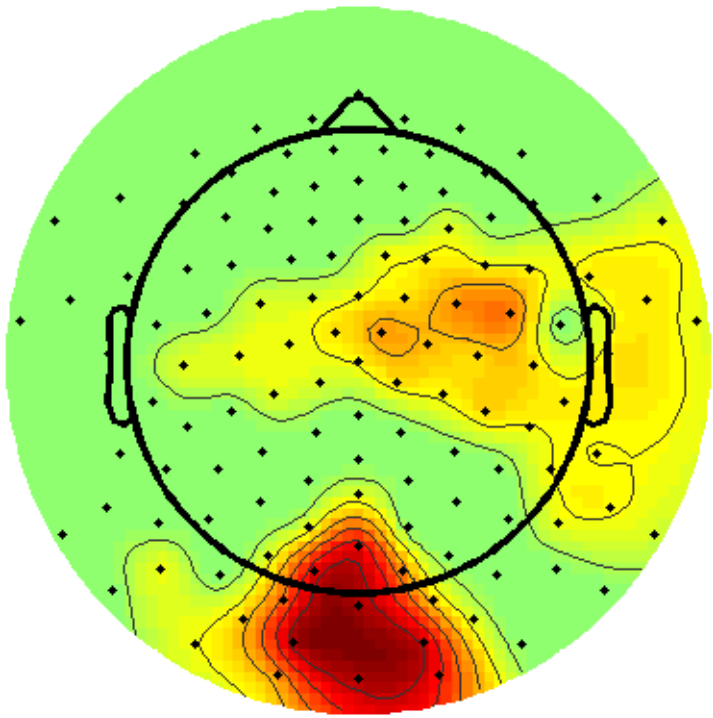
F1 – response to onset of global organization

F2 – response to local pattern changes

maps show value of T^2circ, thresholded at P<0.05 corrected

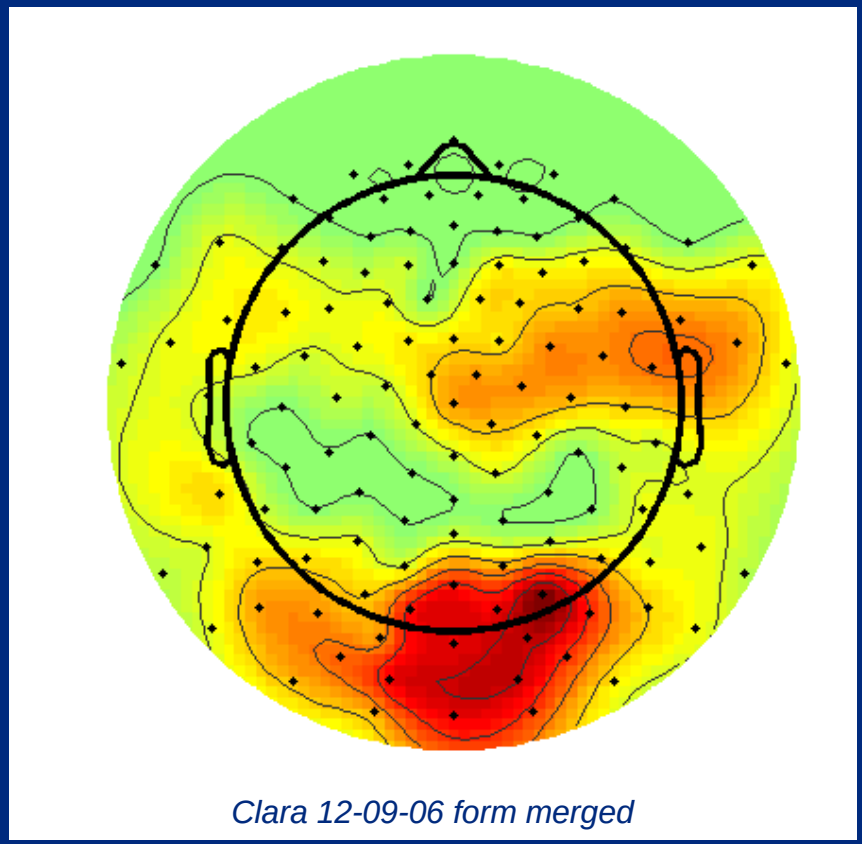
Comparison: adult F1 responses to:

global motion



Clara 12-09-06 motion merged

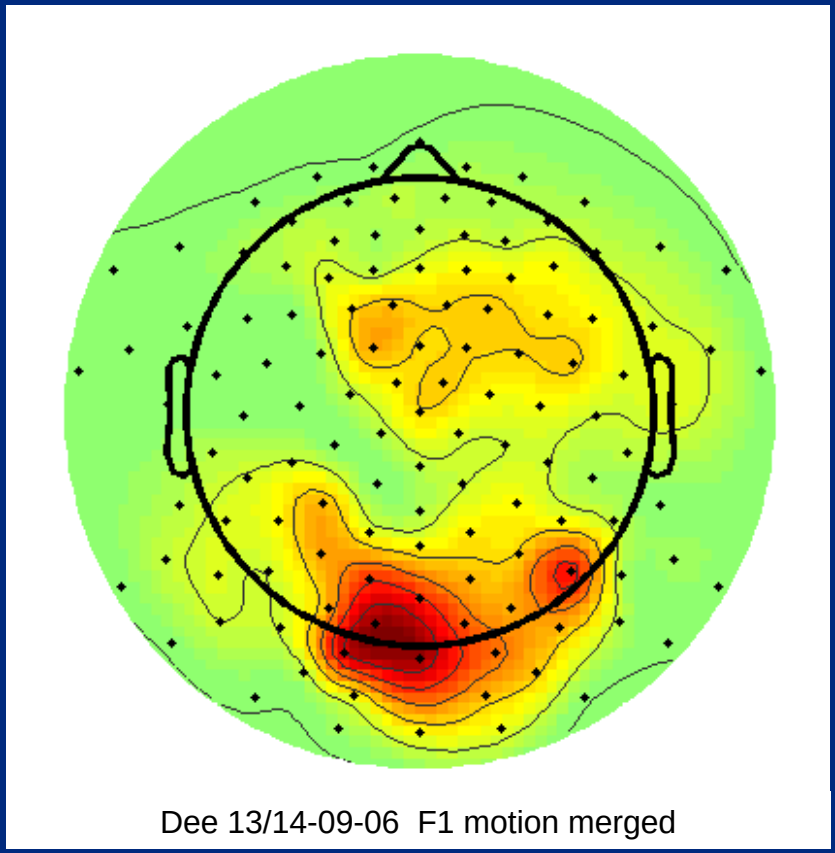
global form



Clara 12-09-06 form merged

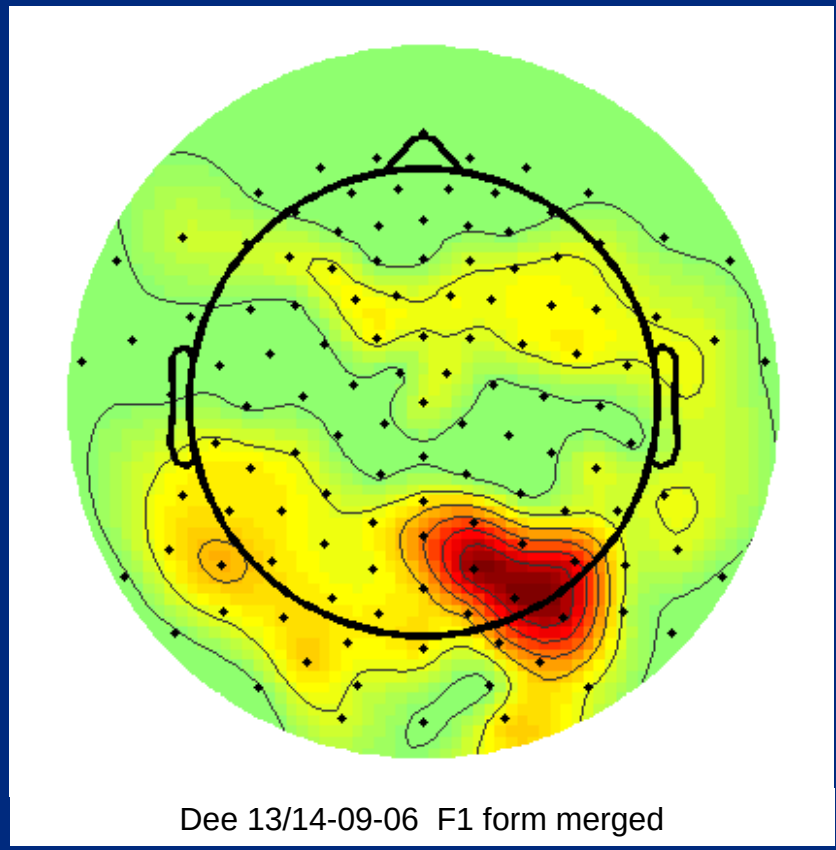
Comparison: adult F1 responses to:

global motion



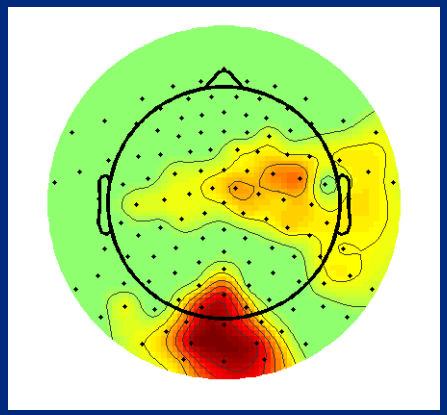
Dee 13/14-09-06 F1 motion merged

global form

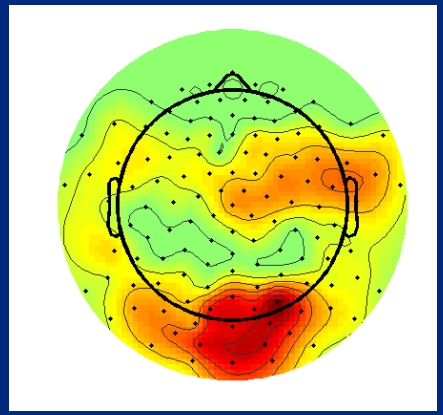


Dee 13/14-09-06 F1 form merged

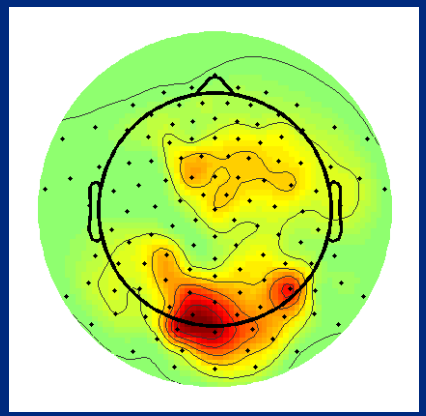
adult summary

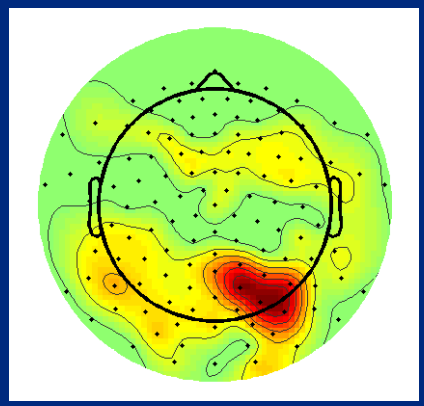


F1 motion



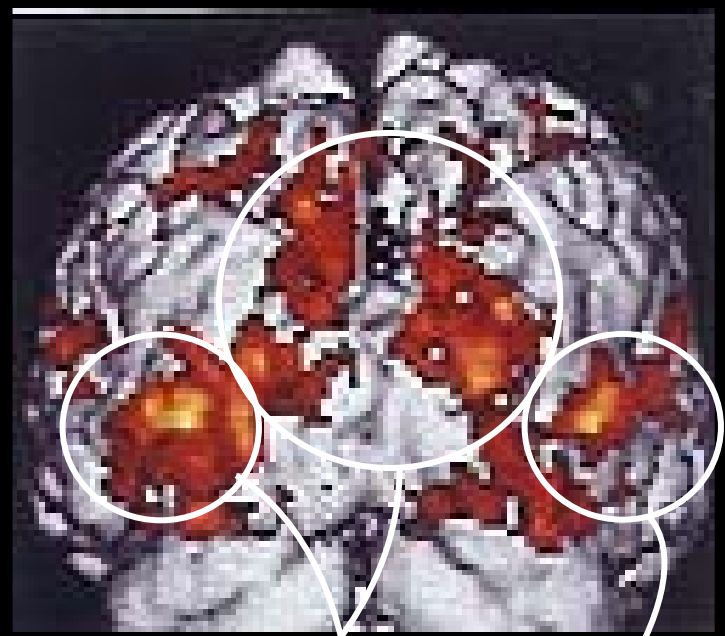
F1 form





- global motion and form both yield clear occipital signals
- form and motion signal distributions are significantly different (vector normalized signals – McCarthy & Wood 1985)
- global motion close to the midline
- global form more lateral (one or both sides)

JA – activation by motion coherent - incoherent



midline sources ???

lateral sources ???

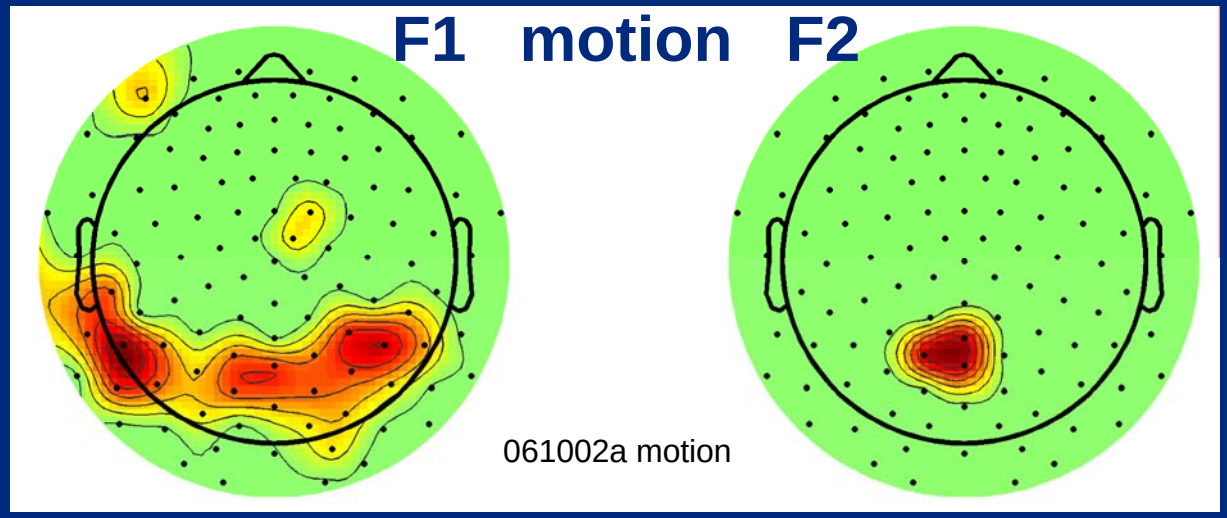
what about infants?

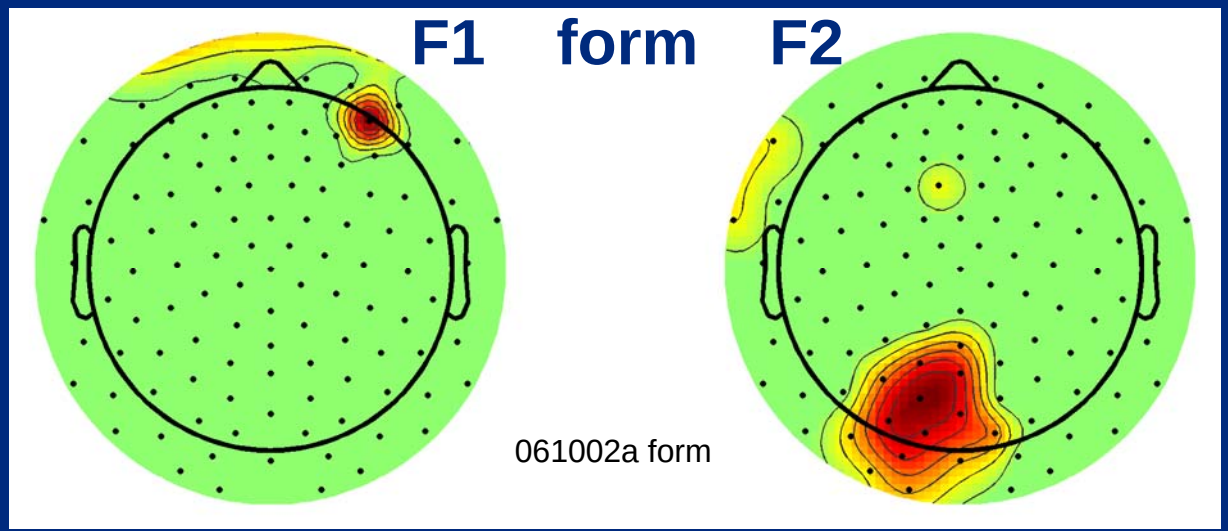
26 infants tested around age months ….

example infant 1

motion – broadly distributed F1

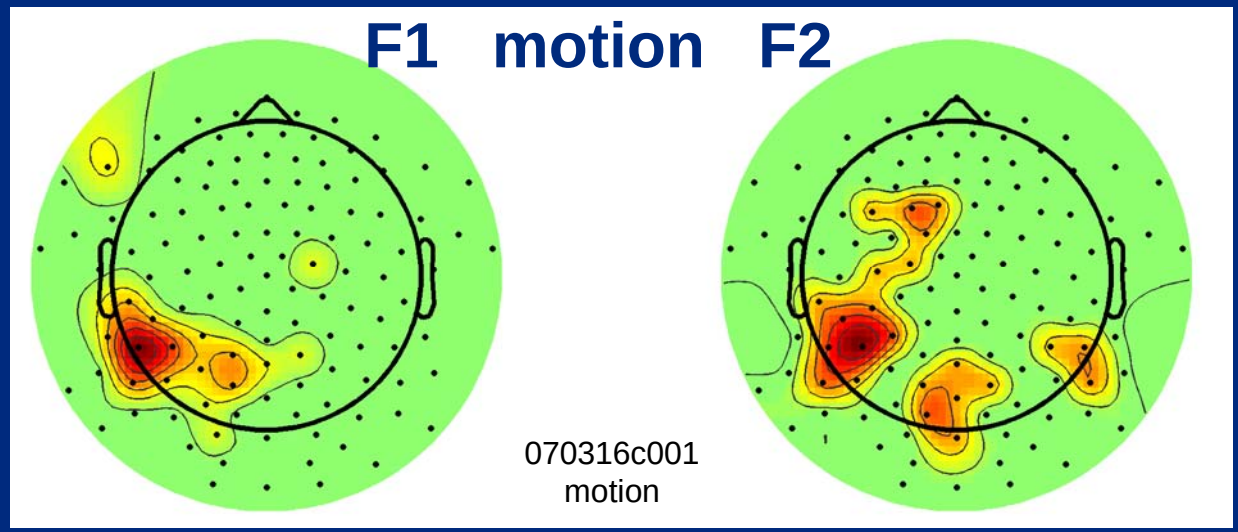
form – F2 (local) response only



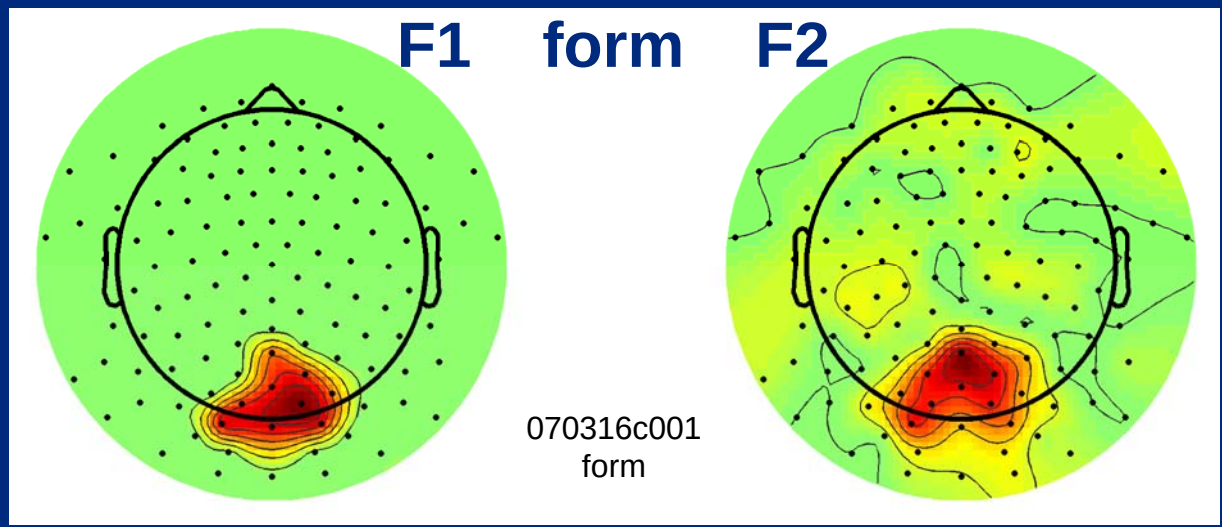


example infant 2

motion – F1 lateral left



form – F1 on midline

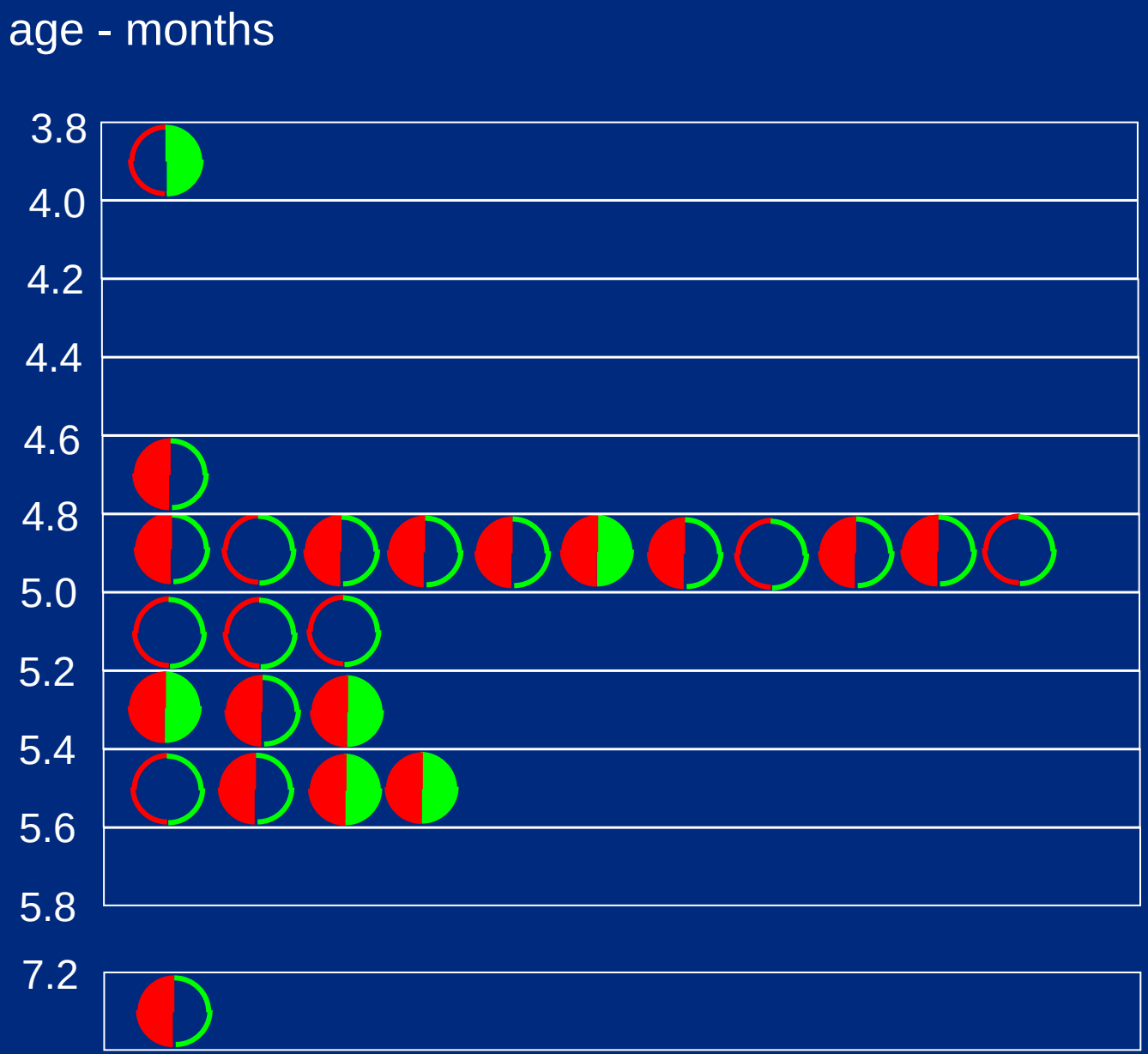


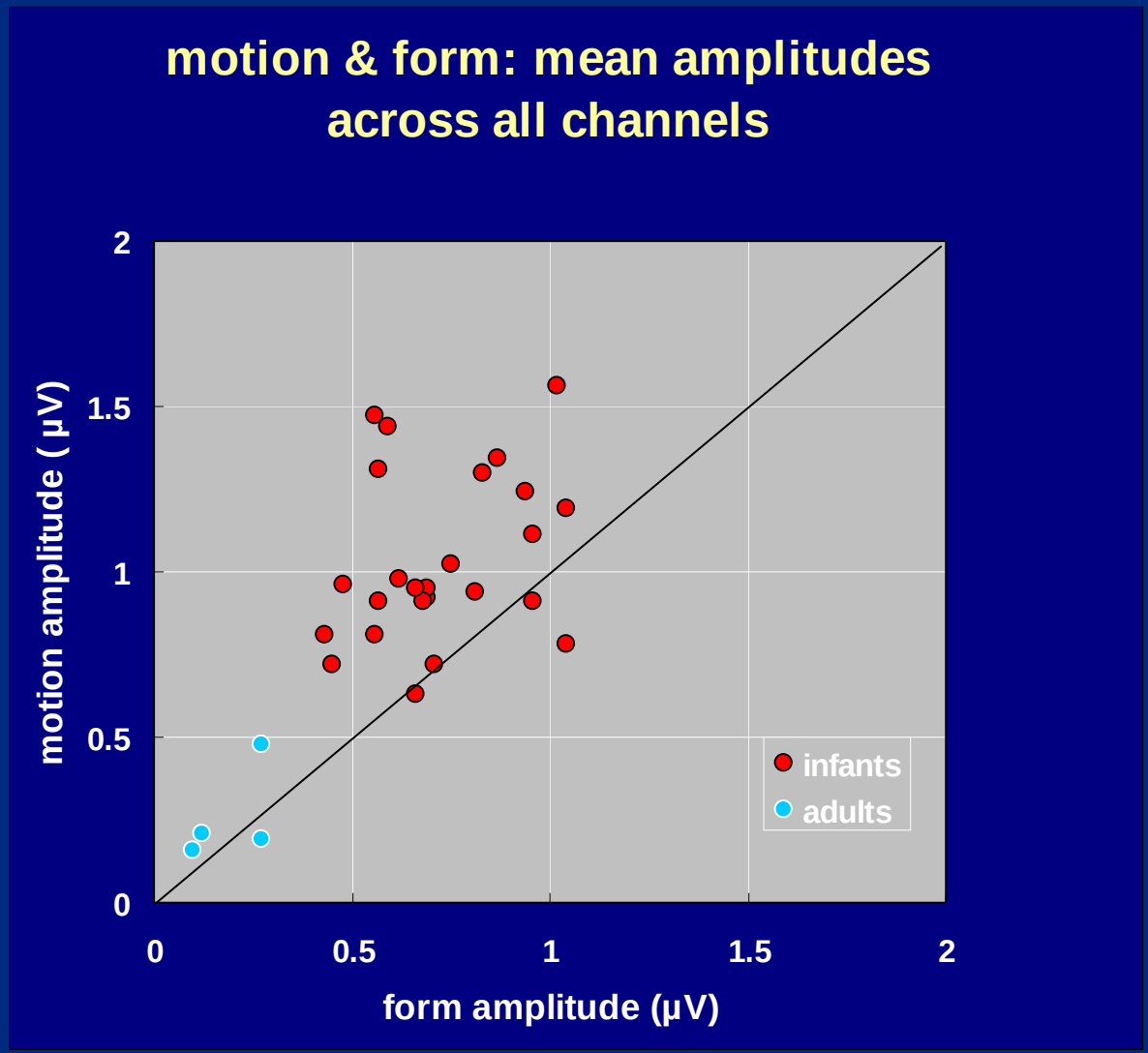
motion & form responses from individual infants

significant response on posterior cluster of channels

- global motion
n = 18/26

- global form
n = 6/26

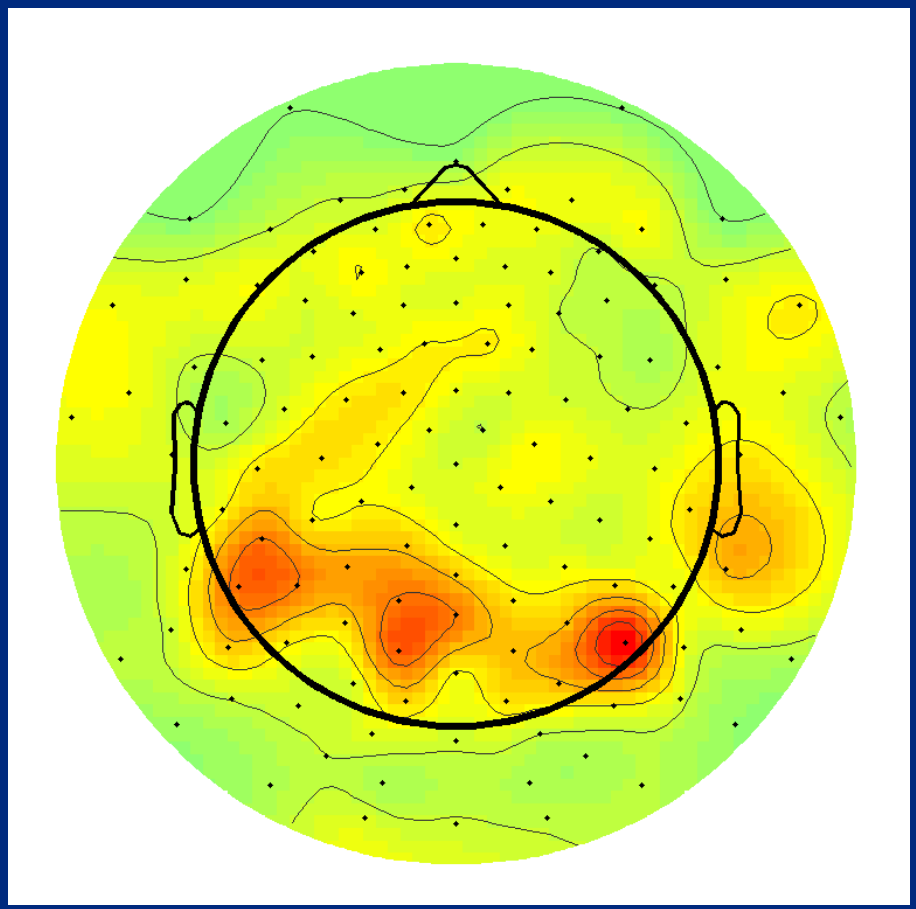




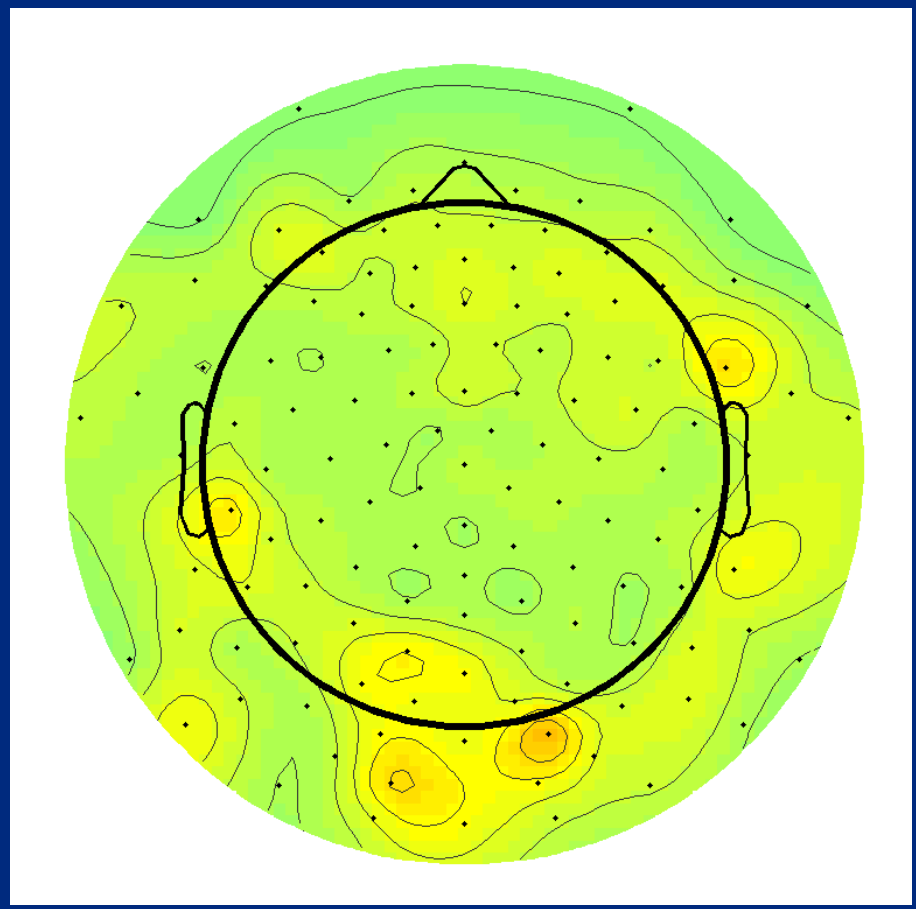
Amplitude data confirm that, in 5 mo infants, global motion gives stronger signals than global form

Comparison: merged F1 from 6 infants who showed significant responses to both form & motion:

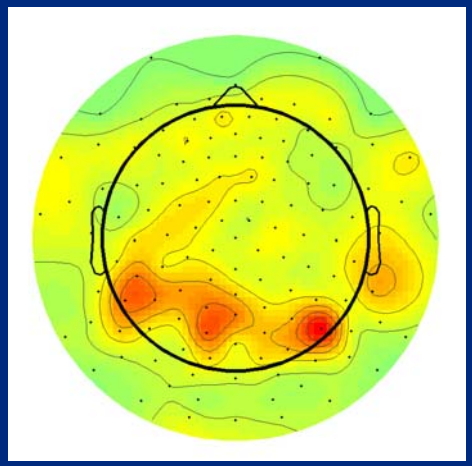
global motion



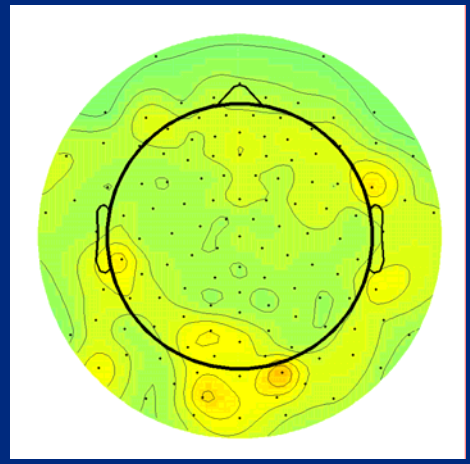
global form



infants: summary



global motion



global form

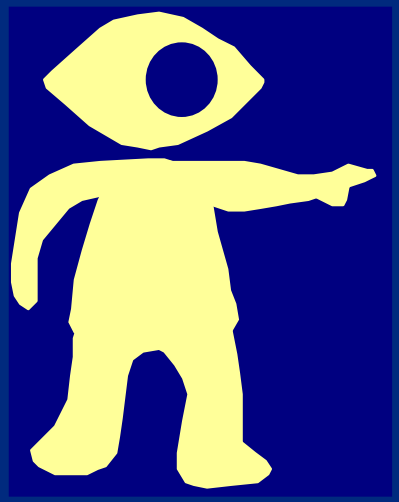
- spatial distribution from global form and motion are significantly different on each individual infant who shows both responses.

- form signal, while relatively weak, is concentrated on the midline
- motion signal shows strong activity on lateral channels

- **different source distribution from the corresponding signals in adult**
- **basis of global processing may change from infancy to adulthood**

whatever next?

- source analysis (but ideally needs MRI’s)
- compare distributions of global motion signals and those from local direction reversal
- compare distributions from different forms of global motion (translation, expansion, rotation)
- apply method to infants at risk of perinatal brain damage



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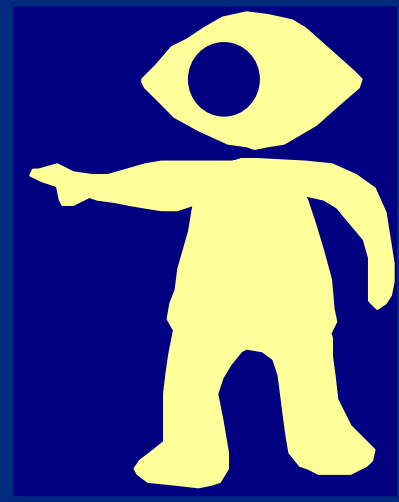
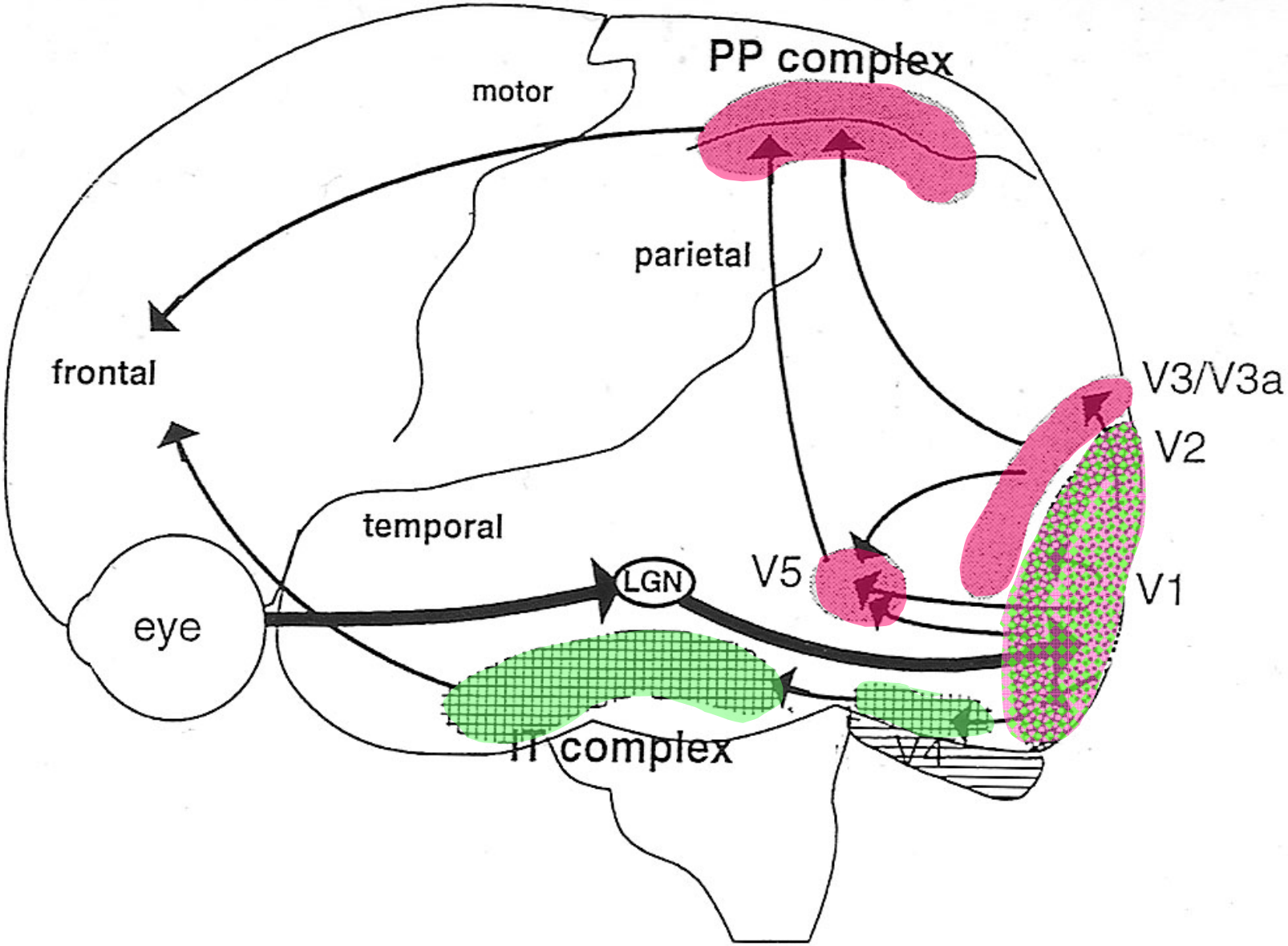


Thank you!

Medical Research Council & Swedish Research Council for support

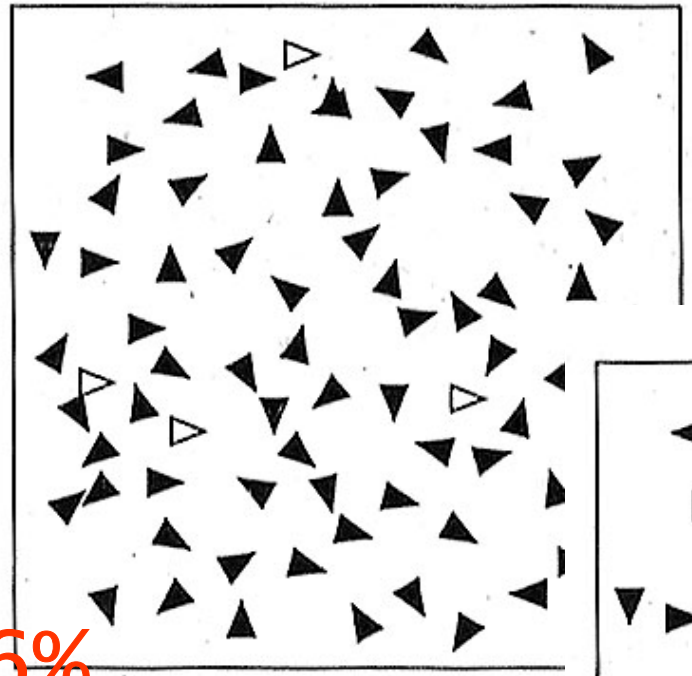
Colleagues in Visual Development Unit UCL, & Uppsala Baby Lab

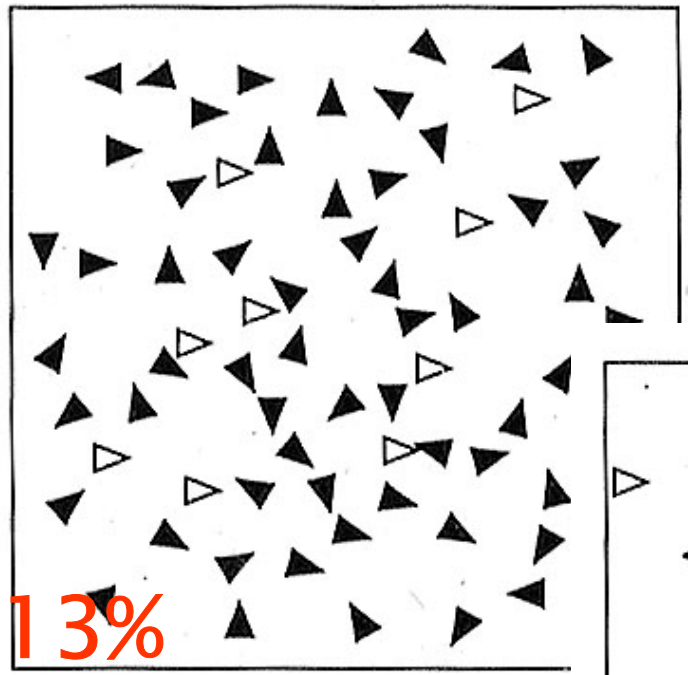
Patient babies and parents!

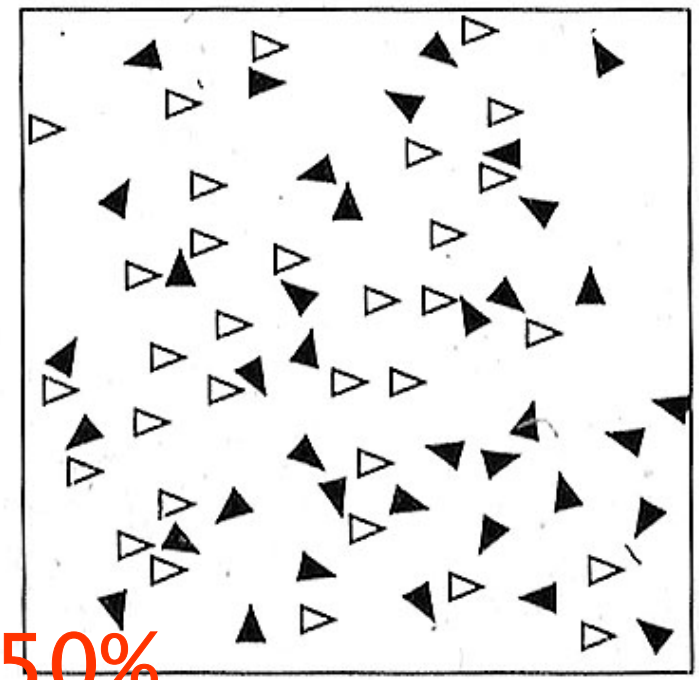


Ventral and dorsal cortical streams

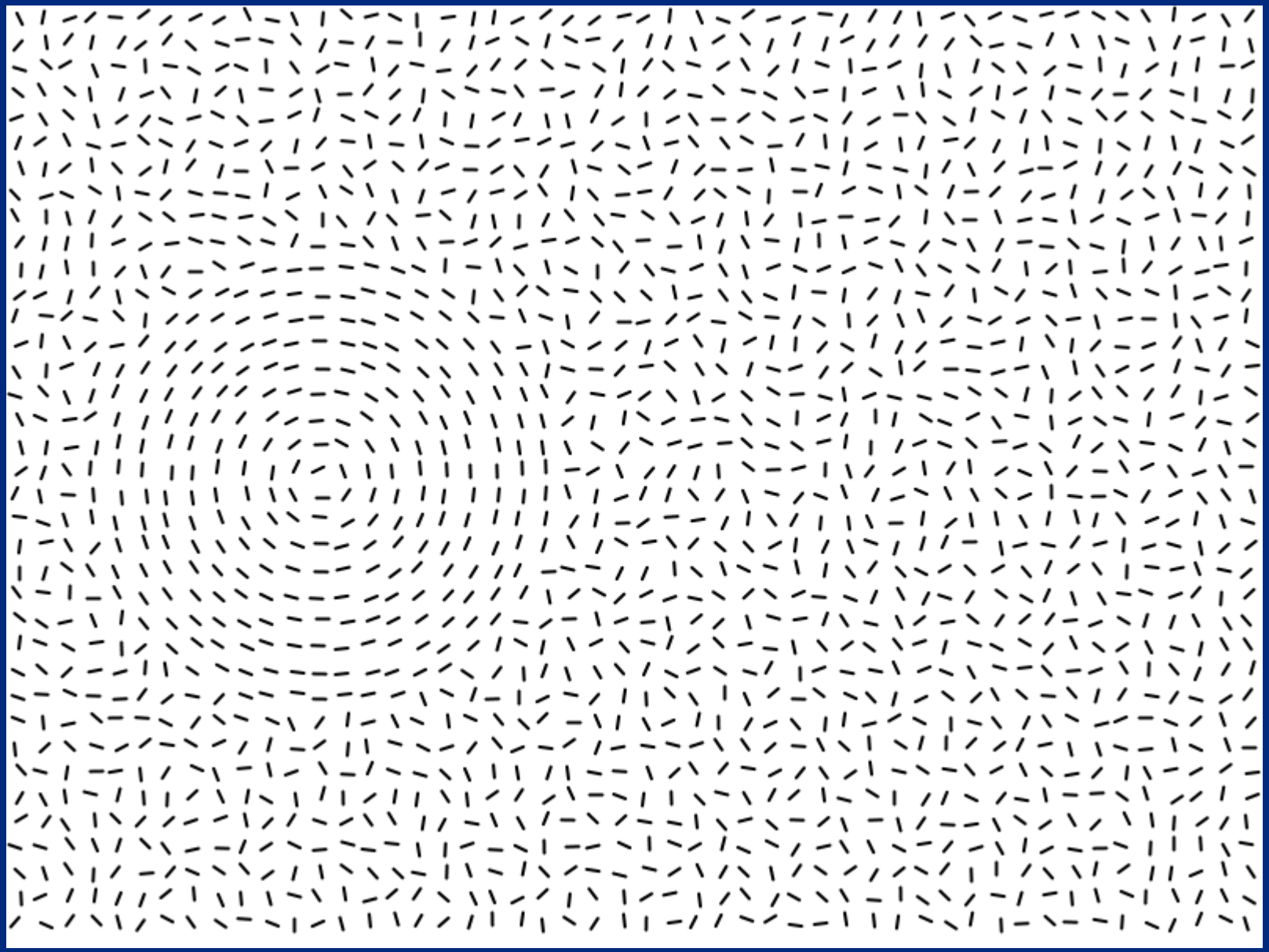
motion coherence thresholds





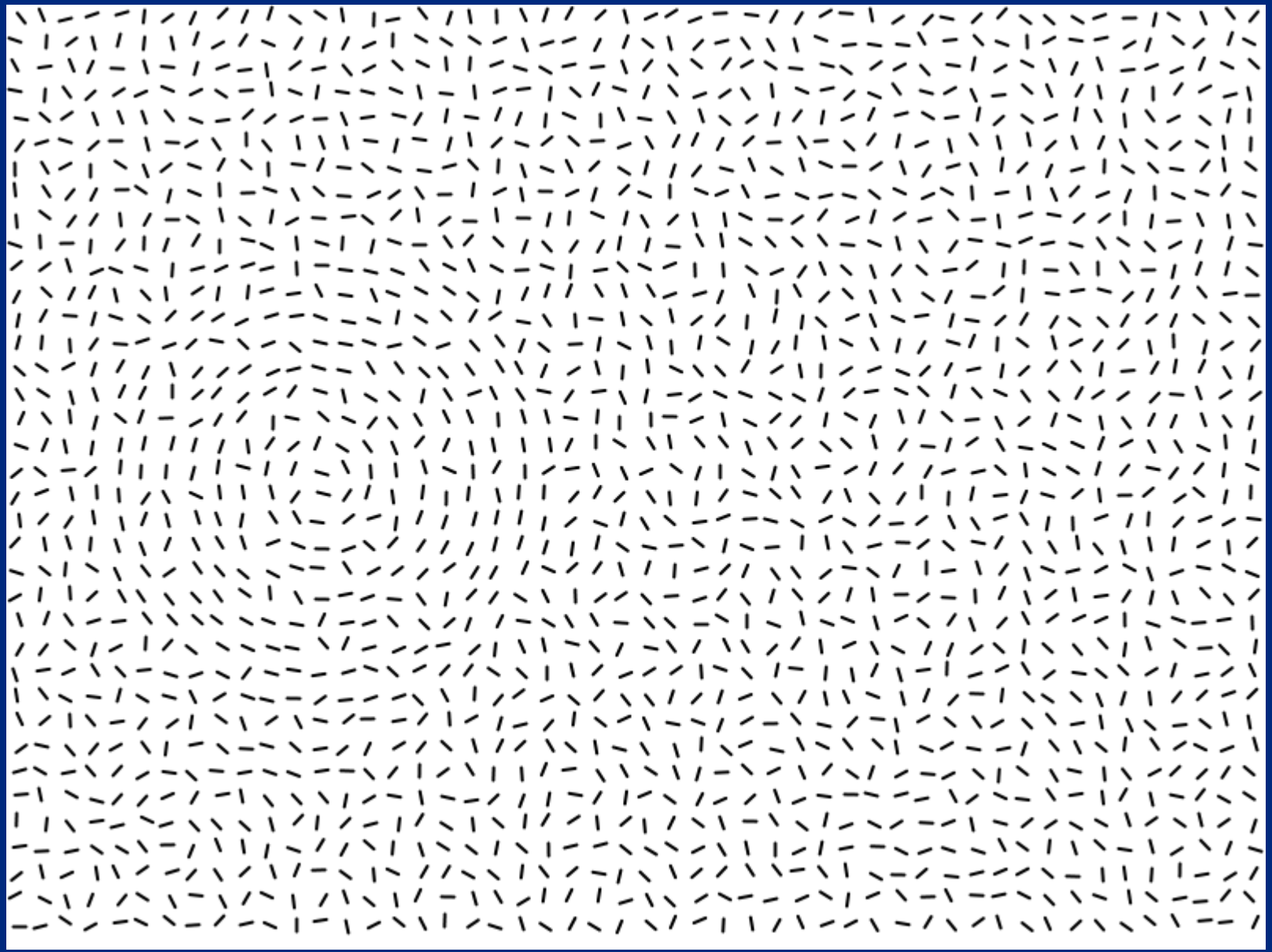


Form coherence



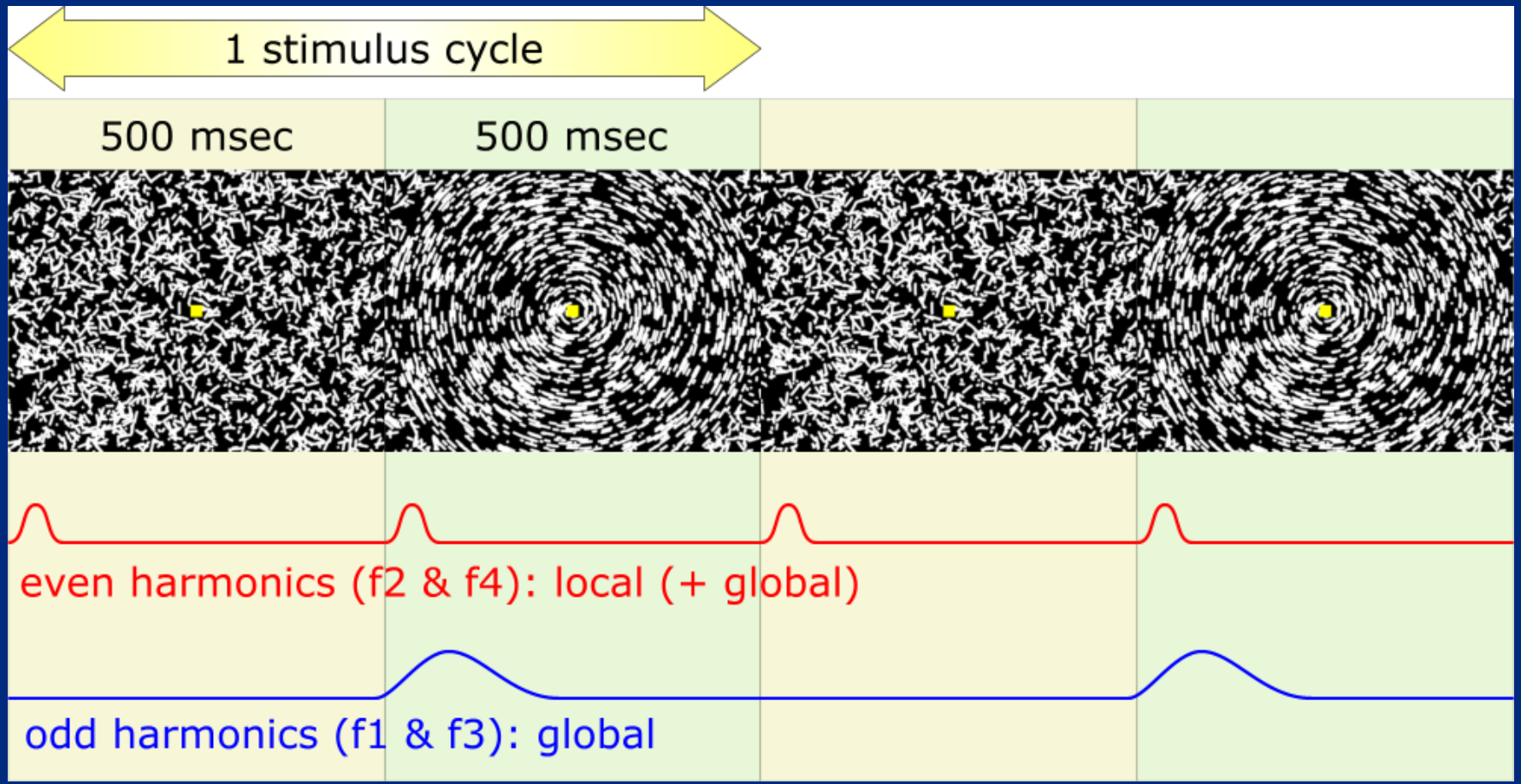
Coherence = 100%

Form coherence



coherence = 60%

Global VEP stimuli



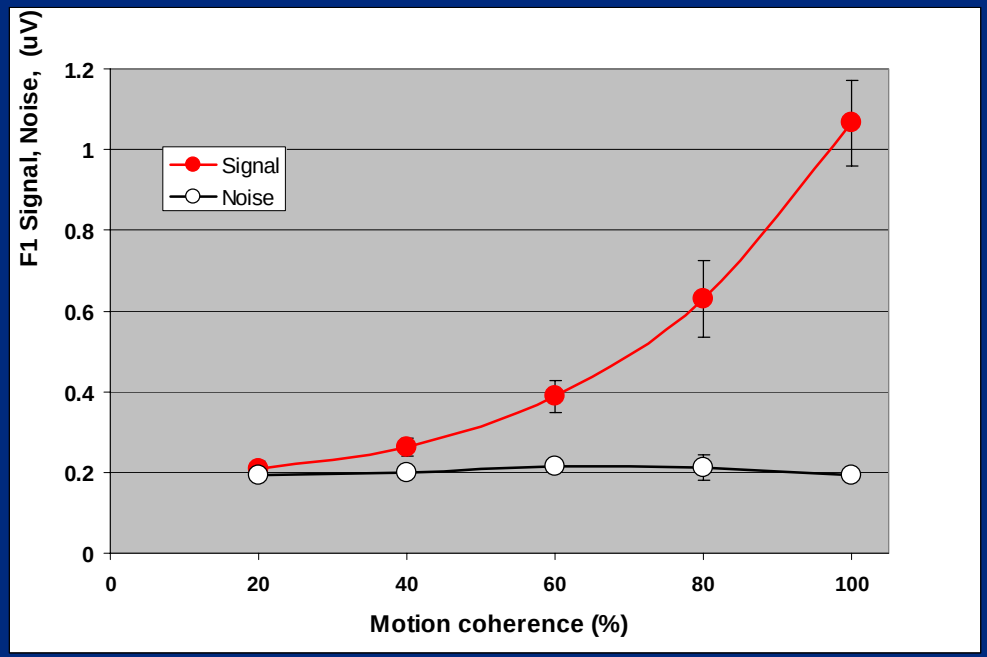
even harmonics = similar responses at onset & offset – may arise from *local* changes

odd harmonics = different at onset & offset – so indicate *global* processing

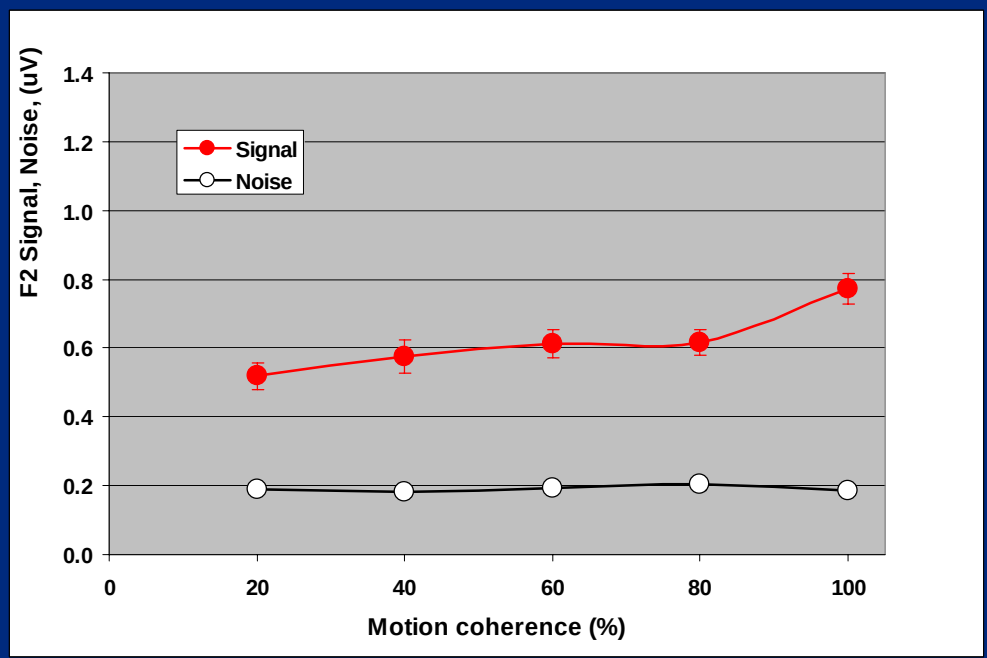
Motion coherence VEP amplitude

As for form, F1 motion responses increase with coherence – a global response

F1 motion responses show small increase with coherence – maybe a global as well as local contribution?



F1



F2