



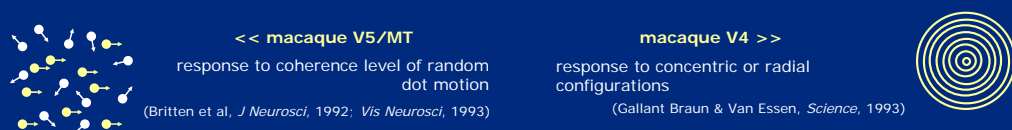
Brain responses to global perceptual coherence



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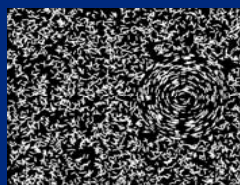
Local and global cortical visual processing

- V1 : small receptive fields, respond to *local* features (e.g. oriented line segments)
- extra-striate visual areas : larger receptive fields, respond to 'global' properties . . .

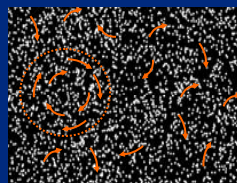


- Can we use measures of global motion and form performance to tap human extrastriate visual function?
- We would like to track **normal human development** of global processing...
- .. and '**dorsal stream vulnerability**' in developmental disorders (Atkinson et al, 1999; Braddick et al, 2003)

Matched stimuli for form and motion coherence

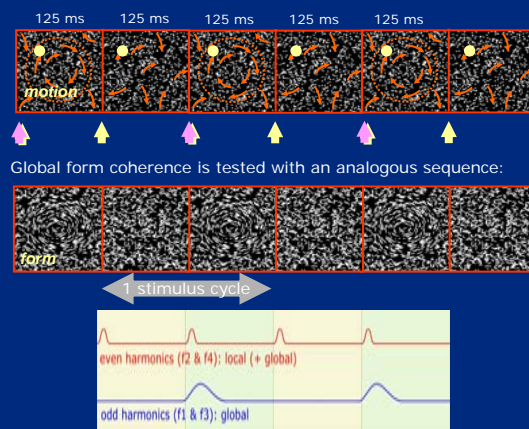


- Pattern sequences for global form and motion have the same structure
- Dots plotted successively generate rotational **motion**
- The same dots plotted simultaneously generate static arcs for concentric global **form**



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

- Coherent rotation and random motion alternate
- In both patterns, individual dots move along the same arc trajectories (limited lifetime)
- The global structure of the motion changes every 125 ms
- Every 125 ms (8 Hz, second harmonic = F2) there is a change of local motion direction at any given location (e.g. ●)
- So both local and global changes occur at frequency **F2**
- VERP response at this frequency does not prove that global processing is occurring
- Every 250 ms (4 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 mechanism



Local and global contributions to F1 and F2 responses

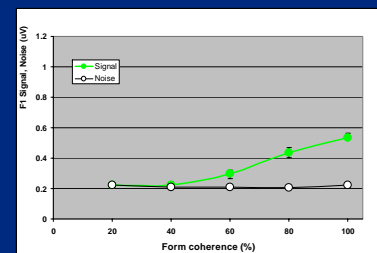
- For both form and motion, coherence can be varied by randomising the orientation of a percentage of the arc trajectories
- Reducing coherence will reduce any signal which depends on the onset or offset of global structure
- Local changes between independent random elements will be, on average, as large as those between random and coherent structure
- So, global responses will be a function of coherence, and local responses will be independent of coherence

VERP amplitudes for form and motion coherence sequences measured at frequencies F1 and F2 (4 Hz & 8 Hz) measured on 15 subjects

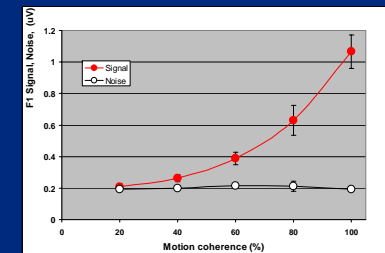
Noise amplitude measured over band +/- 10% of the signal frequency

FORM

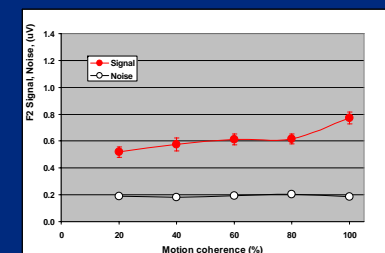
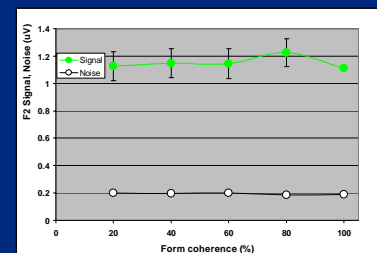
F1



MOTION



F2

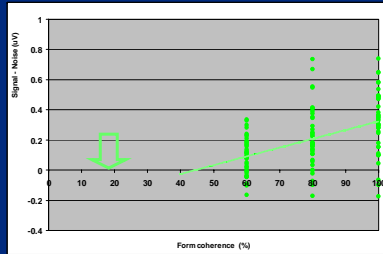


- F1 responses for both form and motion show an orderly increase of amplitude with coherence. We conclude these signals arise from global processing mechanisms
- F2 responses are independent of the level of form coherence. They show a modest increase of amplitude with motion coherence. We conclude these signals arise primarily from local processing.
- At our occipital midline recording site, global motion signals are approximately twice the amplitude of global form signals. Does this reflect the sensitivity of the underlying processes? Probably not...

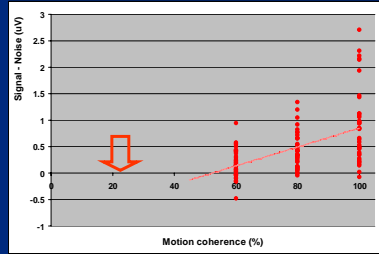
Braddick et al Brain responses to global perceptual coherence (2)

How does VERP amplitude relate to global coherence sensitivity?

- For domains such as contrast (Campbell & Maffei 1970) and visual acuity (Norcia & Tyler 1985), extrapolation of the VEP amplitude to zero has been used to estimate psychophysical thresholds.
- We measured coherence thresholds on the same subjects, using 2IFC for half-cycle of the VERP stimulus (125 msec)
- Amplitude was taken as F1 signal-noise, and extrapolated from the values at 60% coherence and above, where it was approximately linear with coherence. Mean psychophysical threshold is shown by an arrow on the same graph.



VEP extrapolation: psychophysical threshold = 2.4:1



VEP extrapolation: psychophysical threshold = 2.3:1

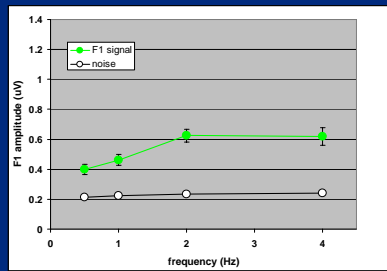
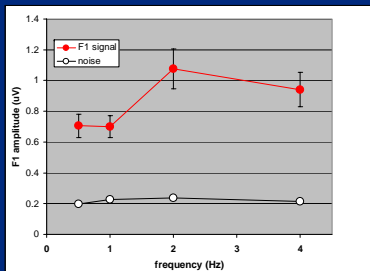
- F1 extrapolated to zero at values well above psychophysical coherence threshold.
- Nonetheless, the relation between this intercept and the threshold was consistent.
- Intercepts for form and motion are similar, even though signal amplitudes are very different
- The intercept is a much more meaningful measure of relative sensitivity than is raw signal amplitude.

What is the frequency dependence of the global form and motion VERP?

- For steady state VEP recording, high stimulus frequencies mean shorter recording runs, and often reduced noise.
- But global processing presumably requires temporal integration which implies low-pass response. What is the optimal frequency for recording global form and motion VERPs?

VERP amplitudes for form and motion coherence sequences, at stimulus frequencies 0.5 – 4 Hz measured on 27 subjects

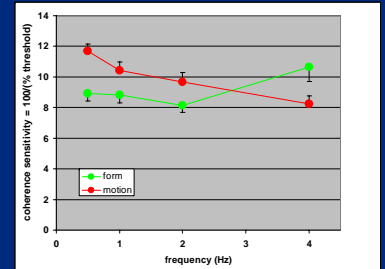
Noise amplitude measured over band +/- 10% of the signal frequency



- VERP amplitude and signal:noise ratio improve with frequency for both global motion and global form. There may be a small reduction in motion VEP amplitude at the highest frequency tested (4 Hz), but the shape of the two functions is similar.

How does global VERP frequency response relate to psychophysical measures of coherence sensitivity?

- We measured coherence thresholds on 8 of the same subjects, using 2IFC for one half-cycle of the VERP stimulus, at each of the frequencies tested (125 -1000 msec)
- Sensitivity ($= 1/\text{threshold}$) varied little with frequency (stimulus duration) for form coherence
- Motion coherence sensitivity showed a monotonic decline with increasing frequency (decreasing duration).
- Neither form nor motion psychophysics showed any evidence of response increasing with frequency (as seen in the VERP)
- The different temporal functions seen for form and motion is also quite different from the VERP results



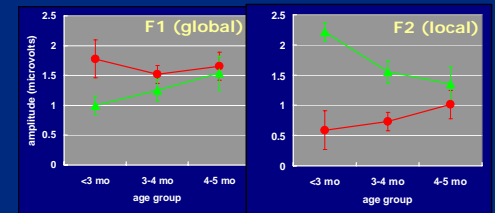
- again, VERP amplitude is not necessarily a good guide to psychophysical sensitivity

- the temporal integration reflected in psychophysical sensitivity to global motion must occur at a different neural site from that tapped by the coherence VERP

Application to the development of global processing in infancy



- We have used the same VERP method to test 47 infants aged 9-23 weeks (some of this data was presented by Atkinson at VSS 2005)
- Each infant tested on both form and motion (randomized order)
- Stimulus frequency = 1 Hz



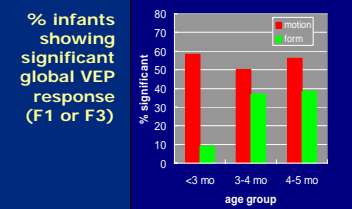
- global processing can be measured in infants

- infants age 2-3 mo show global motion processing, close to the age at which cortical directionality first emerges (Wattam-Bell 1991, 1992; Braddick et al 2005)

- little change in global motion processing between 2-5 mo

- global form processing emerges more slowly over this age range

- what is the relationship to 'dorsal vulnerability' shown in global motion thresholds at 4+ years? (Atkinson et al, 1999; Braddick et al, 2003)



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