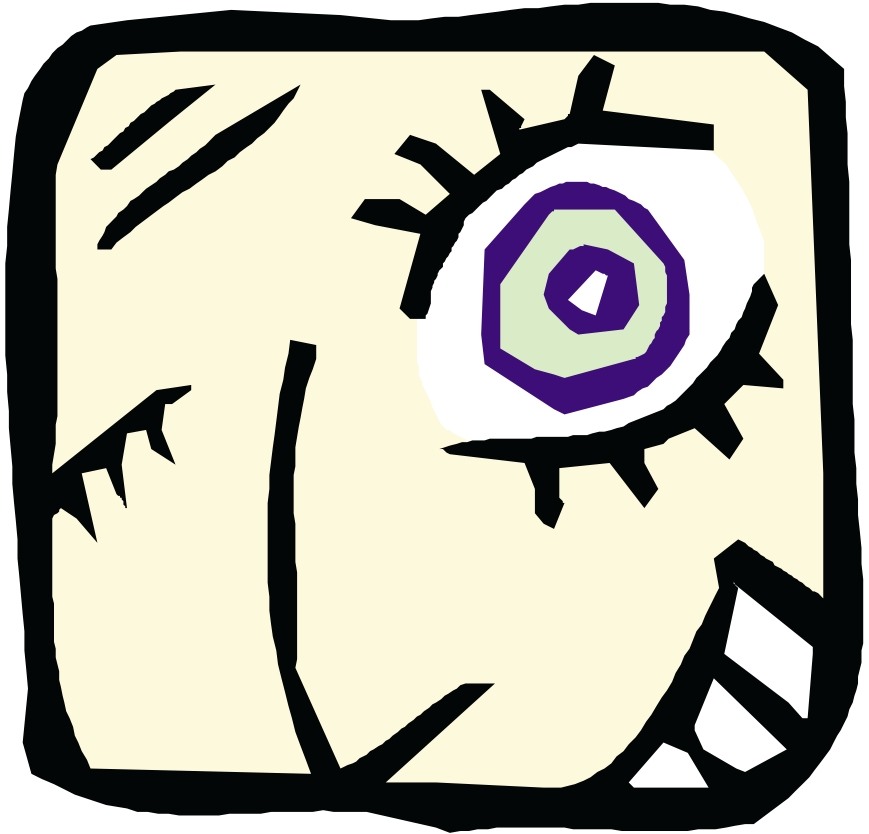


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*Bulletin of the  
Applied Vision  
Association*



AVA 2000 - Motion and imaging  
Programme and abstracts  
AVA Christmas meeting at Aston - abstracts  
References on Vision

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*AIM OF THE AVA: TO PROMOTE AND ADVANCE THE APPLICATION  
OF RESEARCH WORK IN ALL AREAS RELATED TO VISION*



# ***Noticeboard***



## **AVA on the Internet**

The Applied Vision Association now has its own world wide web pages at:  
*<http://www.dmu.ac.uk/ava/>*

The pages contain details of who is on the committee, contact emails, latest details on forthcoming AVA meetings and links to other vision related pages. There are also archives of abstracts from previous AVA meetings.

There is also an AVA anonymous ftp site at: *<ftp://hc.les.dmu.ac.uk>*

This site contains:

- a hyperspectral data set of natural scenes produced by Gavin Brelstaff (see <http://www.crs4.it/~gjb/ftpJOSA.html>).
- David Foster's bootstrap program for estimating the accuracy of a statistical estimate derived from a set of experimental data (see <http://www.op.umist.ac.uk/bootstrap.html>).

If there is anything else you think this archive should contain then let us know.

## **AVA and OPO Subscriptions**

Membership for 1999/2000 will be as follows: ordinary members £18, student members £9. Those members who pay by standing order for the AVA and Ophthalmic and Physiological Optics please check that the correct amount is being paid to the AVA.

## ***Editorial***

This issue of the Bulletin contains abstracts from the AVA Christmas meeting at Aston University. We also include programme details and abstracts for the AVA Annual meeting to be held at the College of Optometrists on 15<sup>th</sup> March 2000. If you have any comments on the Bulletin of the AVA then do contact me: [mscase@dmu.ac.uk](mailto:mscase@dmu.ac.uk)

**Deadline for copy for the next Bulletin - 14<sup>th</sup> April 2000**

## **Geoffrey J. Burton Memorial Fund**

The fund was established in 1986 with the aim of providing financial assistance to students (postgraduates studying for a higher degree or first-year postdoctoral junior scientists) based in the UK travelling to any conferences or meetings at which they will be presenting a paper or poster. Donations to the fund can be directed to the AVA secretariat and cheques etc. should be made payable to "The Geoffrey J. Burton Memorial Fund".

The maximum award to any one individual is £400.

The AVA Committee has decided that from now on there will be a single award made once a year. The closing date for awards will be the last day in February each year and will be for conferences held from 1<sup>st</sup> March to the end of the following February (i.e. there will not be retrospective awards). Applicants do not have to be presenting at an AVA conference.

The next closing date for applications is:

28<sup>th</sup> February 2001

for conferences held between 1<sup>st</sup> March 2001 and 28<sup>th</sup> February 2002.

To apply for an award you need to complete an application form which is available from:

The AVA Secretariat,  
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42 Craven Street,  
London,  
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A PDF format version of the application form is available on the AVA web site at:

<http://www.dmu.ac.uk/ava/>

# **AVA Annual Meeting and AGM Motion Perception and Imaging**

Wednesday 15<sup>th</sup> March 2000  
College of Optometrists, London

GEOFFREY J. BURTON MEMORIAL LECTURE

**Professor A.T. Smith**  
**Department of Psychology, Royal Holloway, London**  
**“fMRI studies of the human visual cortex”**

## **Programme**

10.00 Registration and Coffee

10.30 Search for Contrast-Defined Motion.

H.A. Allen and A.M. Derrington, University of Nottingham.

10.50 How do we process biological motion?

Ian M. Thornton, Max-Planck-Institute for Biological Cybernetics,  
Tuebingen, Germany.

11.10 Motion Opponency in Motion Detection.

Edward Powell and Mark Georgeson, University of Birmingham.

11.30 A model of motion adaptation and motion after-effects based upon  
principal component regression.

Keith Langley, University College London.

11.50 Complex Motion Detection in Human Vision.

T.S. Meese, Aston University.

12.10 Buffet lunch and posters

13.30 AVA Annual General Meeting

14.00 Geoffrey Burton Memorial Lecture

fMRI studies of the human visual cortex

Professor Andrew T. Smith, Royal Holloway, London.

15.00 Object-based selection operating on a spatial representation made salient by dimensional segmentation mechanisms.

R.B. O'Grady and H.J. Muller, Birkbeck College, University of London and Universitat Leipzig, Germany.

15.20 Effects of dynamic chromatic and luminance contrast noise on the perception of coherent motion.

J. L. Barbur, J. A. Harlow and M. Fahle, City University, London.

15.40 Tea and Posters

16.10 Contrast sensitivity functions for temporal phase discrimination.

M.J. Wright, Brunel University.

16.30 Inter-ocular distance, enhanced disparity information and the control of prehension.

Mark F. Bradshaw, Paul B. Hibbard, Simon J. Watt, Rob van der Willigen, Neil Stringer, Ian R.L. Davies, Nick Beagley and Andrew Willis University of Surrey and Defence Evaluation Research Agency, Farnborough.

16.50 Novel visual phenomena associated with zero persistence scanned displays.

R.J.M. Jones, Defence Evaluation Research Agency, Farnborough.

17.10 Wine and Posters

## **Posters**

Temporal delay affects the reach but not the grasp in natural prehension movements.

S.J. Watt and M.F. Bradshaw, University of Surrey.

Visual acuity with CRT and LCD displays.

P.A. Ward, S.K. King and J.P. Viveash, Defence Evaluation Research Agency, Farnborough.

Speed discrimination for transparent motion.

J.M. Wallace and P. Mamassian, University of Glasgow.

Towards Real-time Implementation of a Biologically Motivated Model of Human Motion Detection.

J. Dale, A. Johnston, C. Benton, P. McOwan and M. Hodgetts, University College London and Queen Mary and Westfield College, London.

Pointing to stereoscopically defined planar surfaces.

R.F. van der Willigen, M.F. Bradshaw and Paul B. Hibbard, University of Surrey.

Colour discrimination performance at extreme gaze angles through visors coated with band-pass filters.

Eric Liggins and Claire Roberts, Defence Evaluation Research Agency, Farnborough.

Enhanced Disparity Information and Telepresence.

Neil S. Stringer, Mark F. Bradshaw, Ian R.L. Davies, Nick Beagley and Andrew Willis, University of Surrey and Defence Evaluation Research Agency, Farnborough.

### **Exhibitors:**

Cambridge Research Systems Ltd  
Tracksys Ltd

Registration is £25 for non AVA members and £16 for members (£15 and £10 for students) which includes refreshments and lunch.

### **Abstracts.**

#### **Search for Contrast-Defined Motion**

H.A. Allen\*, A.M. Derrington\*\* (School of Psychology, University of Nottingham, University Park, Nottingham NG7 2RD; e-mail:

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\*\*andrew.derrington@nottingham.ac.uk)

We investigated whether observers could process multiple patches of contrast-defined motion simultaneously. We measured the duration required by observers to discriminate between two different four patch patterns of either luminance - or contrast-defined motion. In the first experiment, motion within the patches was consistent with global rotation.

In one interval of temporal 2AFC task, all four patches contained motion consistent with anticlockwise rotation and in the other interval, 1,2 or 4 patches contained inconsistent motion (opposite direction). In the second experiment, all four patches contained leftwards motion in one interval and 1,2 or 4 contained inconsistent motion in the other interval. In both experiments, observers indicated which interval contained inconsistent motion.

The two experiments produced similar results. For luminance-defined patterns, we found that the number of patches of inconsistent motion had little effect on the presentation duration required by observers to discriminate between the patterns. For contrast-defined motion, as the number of patches of inconsistent motion increased there was a rapid decrease in the duration required. We estimated the minimum duration that would be required for observers to check each patch in turn for both experiments. For luminance-defined patterns, observers performed the tasks much quicker than this estimate. For contrast-defined patterns, they required presentation durations far longer than our estimate. We conclude that multiple patches of contrast-defined motion cannot be processed simultaneously.

## **How do we process biological motion?**

Ian M. Thornton

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e-mail [ian.thornton@tuebingen.mpg.de](mailto:ian.thornton@tuebingen.mpg.de)

Johansson's point-light walker figures remain one of the most powerful and convincing examples of the role that motion can play in the perception of form. How exactly does our visual system take a few isolated points of light and provide us with such compelling impressions of human action?

Here I present data from a series of studies demonstrating that biological motion processing can come to rely almost exclusively on EITHER bottom-up or top-down processing mechanisms. Using a dual-task paradigm I will show that when attention is allocated to a demanding secondary task (change detection), direction discrimination performance drops from near ceiling levels (85% plus), when walkers are masked by randomly moving elements, to complete chance (50%), when more complex, scrambled walker

masks are used. This dissociation under dual-task conditions adds further weight to the suggestion that the high, single-task performance commonly reported with both random and scrambled masks is achieved via very different, yet equally effective, processing mechanisms. A second series of studies will further explore the role of attention during biological motion processing using standard visual search techniques. In conclusion, I will argue that the effective use of both high and low-level integration strategies is highly adaptive, given the ecological significance of human and animal action, and may well be at the core of what appears to make biological motion “special”.

### **Motion Opponency in Motion Detection.**

Edward Powell & Mark Georgeson

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Several theoretical models of motion detection (e.g. Adelson & Bergen, 1985; Simoncelli & Heeger, 1998) incorporate an opponent stage of analysis, in which motion direction is coded by the difference in output between opposite (e.g. leftward and rightward) detectors. Psychophysical evidence for motion opponency, however, has been weak or disputed. We used a two-alternative forced-choice staircase procedure to measure contrast thresholds for moving sinewave gratings (0.5 c/deg, 8 or 20 Hz drift rate) superimposed on a counterphase flickering mask of the same spatial and temporal frequency. Low contrast maskers made movement detection easier (facilitation) while higher contrast masks made it more difficult (masking), resulting in a characteristic dipper-shaped threshold function. The slope of the masking function was close to 1 (Weber's Law). Importantly, sensitivity to motion depended on the difference between opposite motion signals. Sensitivity doubled when the test signal (an increase in rightward energy) also had a decrease in leftward energy (or vice-versa). A motion energy model that incorporates subtractive motion opponency and a divisive gain control - with only 2 free parameters - successfully accounts for both unmasked detection and masked discrimination performance.

## **A model of motion adaptation and motion after-effects based upon principal component regression**

Keith Langley

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A gradient-based model to help explain effects of adaptation to moving signals is compared with established energy models of motion detection. The novel feature of the proposed model is that measurements of the image signals are assumed to be subject to error in both dimensions of space and time. This assumption, when combined with a maximising rather than nulling strategy for adaptive effects (see Langley, AVA Meeting Aston, 1999) necessarily constrains models of motion perception to be based upon principal component regression rather than linear regression. It is shown, that response suppression of (model) complex cell neurons that input into the model may account for (i) significant increases in perceived speed after adaptation to static patterns and testing with slowly moving patterns, (ii) increases in perceived speed after adaptation to patterns moving at a medium speed and testing at high speed, and (iii) decreases in perceived speed in the opponent direction to a quickly moving adapting signal. Neither of predictions (ii) or (iii) are supported by an energy-based account of motion detection. It is concluded through comparisons of the proposed model's speed transfer function with existing psychophysical data that the visual system processes motion signals with the tacit assumption that image measurements are subject to error in both space and time.

## **Complex Motion Detection in Human Vision**

T. S. Meese

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Four 2IFC summation experiments were performed to explore properties of complex motion detectors in human vision. Coherence thresholds (% of signal dots) were measured for detecting one or two signals (from:

expansion, rotation, deformation & translation) in noise for random-dot kinematograms (eg. Harris & Meese, *Perception*, 25 supp, 129). Stimuli contained up to 440 randomly positioned dots and were viewed through a luminance damped annular window (5 deg and 0.5 deg diameters). Noise dots (random directions) were always contained within the entire display. In Experiment 1, signal dots were contained in either (a) the upper quadrant alone or (b) the entire display. For (b), thresholds fell within the range of perfect linear summation and quadratic summation amongst the four quadrants, depending upon stimulus condition and observer. These results are generally consistent with motion detectors that sum linearly across multiple motion directions; less than perfect linear summation is shown to be consistent with nonlinear summation (eg. probability summation) between detectors that are suboptimal for the stimuli (eg. one-dimensional 'shear' and 'compression' mechanisms; see Meese & Harris, 1997, *Vision Research*, 37, 2369-2379). In Experiment 2, summation was typically less than quadratic for pairs of orthogonal stimuli (eg. expansion and rotation), suggesting probability summation between independent detectors. In Experiment 3, direction ( $d$ ) bandwidths for summation were found to be broad, [approximating  $\cosine(d)$ ], for all stimulus types, suggesting detectors with broad stimulus selectivity. In Experiment 4, substantial summation was found for pairs of stimuli with opposite directions of motion (eg. expansion and contraction) for all stimulus types, except deformation, where performance degraded. This last result suggests an inhibitory input for deformation 'detectors', but not for expansion, rotation and translation 'detectors'.

### **Object-based selection operating on a spatial representation made salient by dimensional segmentation mechanisms**

R.B. O'Grady<sup>1</sup>, H.J. Muller<sup>1,2</sup>

<sup>1</sup>School of Psychology, Birkebeck College, University of London, Malet Street, London WC1E 7HX, <sup>2</sup>Institut für Allgemeine Psychologie, Universität Leipzig, Seeburgstrasse 14-20, D-04103 Leipzig, Germany. e-mail r.ogrady@bbk.ac.uk

Three experiments re-investigated selective attention in the 'ring-cueing' paradigm of Egly and Homa [1984; *Journal of Experimental Psychology: Human Perception and Performance*, **10**, 778-793]. Observers were cued to attend to one of three concentric rings of radius 1°, 2° or 3°, and their

target-detection accuracy on cued and uncued rings was measured (using sensitivity parameter  $A'$  as dependent variable). Experiment 1, which used a central colour cue to indicate a like-coloured ring, replicated the ring-cueing effects reported by Egly and Homa. Experiments 2 and 3 examined whether these effects were produced by observers exploiting secondary-depth cues in the display (i.e., although drawn on a flat plane, the display might have suggested a tunnel receding in depth). With colour cues, the availability of secondary-depth information relative to the deliberate disruption of secondary-depth information, had no significant influence on the ring-cueing effects. However, making the rings monochrome and using a central size cue (central symbol whose radius: large, intermediate or small, indicated which ring: outer, middle or inner, was most likely to contain the target) significantly reduced the ring-cueing effects when the depth information was disrupted. The results suggest that selection was object-based, operating on a spatial 'grouped-array' representation of the cued ring made salient by colour or depth-based segmentation mechanisms.

## **Effects of dynamic chromatic and luminance contrast noise on the perception of coherent motion**

J. L. Barbur, J. A. Harlow and M. Fahle

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The purpose of this study was to investigate the independence of mechanisms involved in the detection of colour and luminance contrast defined motion in human vision. In addition, we also studied the effects of static or dynamic luminance contrast (LC) or chromatic contrast (CC) noise on thresholds for detection of either static or moving patterns defined by either colour or luminance contrast.

Random dynamic noise was used to generate a texture of checks (check size  $0.2^\circ \times 0.2^\circ$ ) by changing either the chromaticity or luminance of each texture element according to uniform luminance or chromaticity distributions. The textured pattern was generated in the centre of a uniform background field subtending  $29^\circ \times 23^\circ$  ( $L = 16 \text{ cd m}^{-2}$ ,  $(x, y) = (0.305, 0.323)$ ). Dynamic noise was generated by varying randomly either the luminance or the chromaticity of each texture element, every 80 ms. The

luminance range was specified as a % of background luminance. 1D chromatic contrast noise was specified by random sampling along a line of constant hue and 2D chromatic noise required random sampling over a specified region that varied in both hue and saturation. In addition to the ongoing, noise-generated, random motion of the texture elements, a subset of checks, defined either by a fixed luminance or chromatic contrast shifted systematically in the same direction so as to generate coherent movement. We measured the effect of LC and CC noise on thresholds for detection of either stationary or moving test patterns defined by either colour or luminance contrast.

The results show that chromatic detection thresholds are largely unaffected by LC noise. On the other hand, the perception of coherent motion of colour defined, spatially random checks was completely disrupted by LC noise. Thresholds for detection of either stationary or moving luminance contrast defined patterns were affected equally by either the presence of 1D or 2D chromatic contrast noise. Once above detection threshold, the perception of luminance contrast defined coherent motion was found to be independent of chromatic contrast noise.

The results suggest that unique mechanisms exist for the processing of luminance contrast defined motion, independently of any colour defined motion. The results also suggest that colour defined motion does not have its own first order motion detection mechanism and that the perception of colour defined motion is based largely on feature tracking.

## **Contrast sensitivity functions for temporal phase discrimination**

M.J. Wright

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It was previously found that the perception of depth in simple shape-from-shading stimuli showed low-pass tuning to temporal frequency modulation, with a cutoff around 7Hz (Wright, M.J., ECVP 1998). It was proposed that the perception of luminance gradients depends on a low temporal frequency mechanism.

This was tested using counterphase gratings (whose spatial gradient averaged over time is, of course, zero). The task was to discriminate between pairs of gratings that were temporally modulated either in phase (0 deg), or 90 deg apart in phase. That is, pairs of counterphase gratings, each in a circular window, were presented to the subject, and the task was to say whether they were modulating in phase or out of phase.

At very low temporal frequencies this is trivially easy because one grating is at full contrast when the other is at zero contrast. However with increasing temporal frequency the discrimination becomes impossible long before the grating loses visibility.

Contrast thresholds for “in-phase versus out-of-phase” discrimination of two counterphasing gratings were determined using a forced-choice method. The gratings were presented at a range of fixed contrasts spanning the threshold and 75% correct points were determined from fitted psychometric functions.

Contrast sensitivity functions (CSF) for temporal phase discrimination were low-pass with a high frequency cutoff in the range 3Hz-7Hz depending on spatial frequency. The CSF for temporal phase discrimination was found to differ in shape from the temporal CSF for detection of a counterphase grating, as measured with the same displays.

Analysis of these tuning functions supports evidence from a number of sources that temporal integration is required for the perception of the lightness or darkness of surfaces, and for the perception of luminance gradients.

### **Inter-ocular distance, enhanced disparity information and the control of prehension.**

Mark F. Bradshaw<sup>1</sup>, Paul B. Hibbard<sup>1</sup>, Simon J. Watt<sup>1</sup>, Rob van der Willigen<sup>1</sup>, Neil Stringer<sup>1</sup>, Ian R.L. Davies<sup>1</sup>, Nick Beagley<sup>2</sup> and Andrew Willis<sup>2</sup>

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Binocular disparity is considered pre-eminent in the control of reaching behaviour. One reason for this is that once suitably scaled (with an estimate of viewing distance and inter-ocular distance) it can specify metrical depth relationships within a scene. Such information is necessary in order to plan the transport and grasp phase of a reaching movement (i.e. absolute distance and size are required). If prehension is controlled via a binocular telepresence system, an opportunity arises to augment disparity information by increasing the inter-camera distance (ICD) beyond normal interocular distance, thereby increasing the magnitude (and range) of binocular disparity information. Whether an observer can take advantage of enhanced disparities to control reaching movements is unknown. Here we examine the effects of manipulating ICD on reaching movements with ICDs ranging from 6.5cm to 26cm. Typically sized, real world objects (both familiar and unfamiliar) were placed in a scene and reaching performance was assessed. An experimental sequence consisted of three blocks. The first and last block used a normal ICD/IOD of 6.5 cm whereas the middle block used an increased ICD. Larger than normal ICDs were found to disrupt reaching performance, with slower peak velocities and smaller grip apertures being observed. This was more pronounced for unfamiliar objects. Little evidence for learning was found.

### **Novel visual phenomena associated with zero persistence scanned displays.**

RJM Jones

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Although scanned displays are relatively common, all conventional display technologies have display persistence. Zero persistence scanned displays have recently become available, and early experiments using these displays have indicated several unexpected visual phenomena, for example, Kelly *et al* (Inv. Ophth. Vis. Sci. (Suppl) **39**, S399, 1998) found that flicker sensitivity was reduced when using a zero persistence display, compared with a CRT display. We have performed experiments to investigate several aspects of vision using zero persistence displays, using a generic zero persistence display. **Methods:** Brightness matching was performed by presenting a scanned, uniform field on the display, except

for a small central portion of the display, which was illuminated continuously. The brightness of this central portion was adjusted until the brightness matched that of the remaining part of the display. The luminance of the display ranged from 10 to 30 cd.m<sup>2</sup>. Refresh rates were continuously variable up to 250Hz. Flicker sensitivity was measured using a similar approach to that of Corbett and White (Nature, **261**, 689, 1976), except that the refresh frequency was also altered, and the display brightness remained constant (15 cd.m<sup>2</sup>). Subjects were also asked to report any other unusual aspects of the display. **Results:** All subjects matched the display to a less bright continuous source. This effect was most noticeable at lower refresh rates (a factor of 1.2 at 60-70Hz), but was still present at over 100 Hz. The perception of flicker was found to be 'slightly annoying' at 37 Hz. **Conclusions:** Zero persistence displays seem to give a lower perceived sensitivity to brightness and flicker. Several mechanisms for these differences will be suggested.

## **Temporal delay affects the reach but not the grasp in natural prehension movements**

S.J. Watt and M.F. Bradshaw

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Neuropsychological evidence suggests a dissociation between the systems involved in perceptual processes and those involved in the control of action (Milner and Goodale, 1995). We have reported previously that temporal delays between stimulus presentation and response produced inaccurate reaches to remembered distances whereas performance in a perceptual task was unaffected (Bradshaw et al., 1998). This is consistent with Milner and Goodale's account as extrinsic object properties such as egocentric distance need to be updated rapidly as observers move around the world in order to accurately control the transport component of their reach. Here, we investigate the prediction that temporal delay similarly affects the grasp component even though intrinsic object properties, such as size and shape, do not change when observers move. 16 participants made open-loop reaches to three different sized objects placed at 25 and 40 cm along the midline, with a delay between target presentation (2 seconds) and response of 0, 1, 2 and 4 seconds. A MacReflex motion analysis system was used to record kinematic and spatial parameters of the movements.

The results indicated that the reach component was increasingly affected as temporal delay was increased. Movements showed significantly slower peak wrist velocities, and detailed analysis of individual velocity profiles revealed that participants increasingly under-reached for the objects as delay increased. In contrast the grasp component was not affected by temporal delay. Maximum grip apertures remained consistent across all delay conditions and scaled only with object size. We conclude that extrinsic object information starts to deteriorate within 1 second, whereas intrinsic object information remains invariant over the range of delays tested. These results are inconsistent with the complete dissociation between the systems involved in perception and action, as proposed by Milner and Goodale.

## **Visual acuity with CRT and LCD displays**

PA Ward, SK King and JP Viveash

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Due to their reduced weight, power requirements and size, liquid crystal displays (LCD) are becoming the technology of choice over cathode ray tube (CRT) displays in both the commercial and military markets. Several studies have compared visual performance on LCD and CRT systems, but always in a static environment. One key application of LCDs is in vehicles; an environment where vibration can be an important human factor. Previous work has shown that visual performance deteriorates when the observer is subject to vibration Viveash, J.P. et al (1994 Displays 15:74-75). This study examined visual performance using a simple acuity task performed on LCD and CRT displays whilst the head was vibrated. Six subjects carried out the experiment. During the acuity task the head was vibrated at 0, 14, 28 and 56Hz. The vibration was applied directly to the head through a chin rest fixed to a small electromagnetic vibrator. The subject viewed the displays from 6m. Both displays were matched for visual angle, contrast and luminance, and refresh rate (60Hz). The display consisted of a series of black illiterate E's on a white background ( $90\text{cd.m}^{-2}$ ). The illiterate E's ranged in visual acuities from 6/4 to 6/12 following normal Snellen rules. The results indicate a significant reduction in visual acuity using LCD displays for vibration frequencies approaching the

refresh rate of the display system. Acuity was maintained on the CRT system even though image distortion was perceived. Thus under some conditions where the head is subject to vibration selection of display technology could affect visual performance.

### *Acknowledgement*

This work was carried out as part of Technology Group 5 (Human Sciences and Synthetic Environments) of the MoD Corporate Research Programme

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## **Speed discrimination for transparent motion**

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Motion transparency occurs when two motions in the same spatial location are perceived as distinct surfaces in motion, one sliding over the other. A number of studies have established the necessary conditions for the perception of motion transparency. In terms of Adelson & Movshon's [1982. *Nature*, **300**, 523-525] velocity space combination rule transparency occurs when combination fails. This can be due to a difference in spatial frequency, contrast, orientation and speed between the two components. Stoner, Albright & Ramachandran [1990. *Nature*, **344**, 153-155] found that perception of motion transparency is dependent on the physics of transparency and by this account the motion system "knows" transparency. More recently Qian, Andersen & Adelson [1994. *The Journal of Neuroscience*, **14**(12), 7357-7366] found that the phenomenon depends on 'unbalanced' motion signals that generate residual activation in MT/V5. To further explore the nature of transparent motion perception we measured speed discrimination thresholds in two tasks utilising standard signal-detection paradigms. In the *motion coherency* task, we presented two random dot kinematograms of translatory motions (left and right) in

successive temporal intervals. Subjects were required to indicate which motion they perceived as being faster in a forced 'left' or 'right' response. In the *motion transparency* task, two translatory motions (left and right) were superimposed in a single temporal interval to simulate two transparent surfaces moving in opposite directions. Again, subjects were forced to respond 'left' or 'right' according to the motion they perceived as being faster. In both tasks different levels of noise, consisting of random dots moving at random speeds drawn from a fixed uniform distribution, were added to the stimuli while the speed ratio between standard and target stimuli was held constant. This was repeated for a range of speed ratios. We found that the relation between thresholds in the two tasks does not remain constant over the range of speed ratios. At large speed ratios, speed discrimination thresholds were higher in the transparency task than in the coherency task, while for low speed ratios thresholds were lower for transparent stimuli than the coherent stimuli. We discuss the implications of these results for models of motion transparency.

## **Towards a Real-time Implementation of a Biologically Motivated Model of Human Motion Detection**

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A complete model of visual motion processing requires a mathematical description which provides both a coherent computational strategy for motion extraction, and a computational role for components of the motion algorithm which can be identified with properties of neurones in visual cortex. The system as a whole should also reflect the performance of the human visual system in a variety of psychophysical motion tasks. We have been developing a model of visual motion processing which draws on known properties of neurones in the visual pathway, and which can be tested by deriving predictions for human performance for critical motion sequences and comparing the predictions against experimental data. The

model represents the image luminance in a local region by means of a Taylor expansion. In order to compute velocity this representation is differentiated with respect to space and time. Speed and inverse speed estimates are calculated for a range of directions at the point of interest, allowing us to recover speed in terms of the amplitude of these radial functions and direction as a phase angle relative to some chosen reference frame. The mathematical model can also be applied to real video image sequences. Increases in the computational power available to computer vision systems is allowing us to develop a real-time implementation of the model, capable of extracting optical flow estimation from live video. Transferring this mathematical model of the biology into applicable technology provides further tests of the effectiveness of the approach, as well as a potentially useful computer vision system.

### **Pointing to stereoscopically defined planar surfaces.**

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Disparity-defined planar surfaces, oriented about a horizontal axis, are often perceived faster, and with more apparent slant, than those oriented about a vertical axis — the slant anisotropy (Rogers & Graham, 1983 *Sci* 1409-11; Gillam et al, 1984 *Per & Psych* 559-64). Does a similar anisotropy exist when we reach to stereoscopically defined surfaces? In two experiments we compared perceptual and visuo-motor indices of (*i*) slant magnitude estimation (*ii*) time-course for slant recovery. The stimuli were 10% random-dot surfaces with irregular boundaries that subtended 10 deg. They were presented on a single monitor viewed through a semi-silvered mirror set at 45 degrees to the median plane. The simulated viewing distance was 30 cm and the slants depicted ranged from 0 to  $\pm 60$  degrees. Perceptual judgements were recorded by setting the orientation of a line to match the slant of the surface. Visuo-motor performance (pointing along the edge of the stimuli) was recorded by a MacReflex system. Pointing was 'disparity open-loop' in that only a monocular view of the hand was available during pointing. There were marked individual

differences in terms of slant magnitude. No anisotropy was evident in either of the conditions for two of the eight subjects; four subjects showed a similar anisotropy in both conditions; and two observers showed a profound anisotropy in the perceptual condition which disappeared in the visuo-motor condition. In terms of time-course all subjects behaved similarly, perceptual settings built up over time reaching asymptote by six to eight secs. In the visuo-motor condition, however, slant was fully realised immediately and did not build-up with longer presentation durations. Slant reversals were more evident in the perceptual condition. For most subjects a similar response to surface slant is evident for both tasks. However, small but reliable differences between the tasks, were found for all subjects, in their temporal nature.

### **Colour discrimination performance at extreme gaze angles through visors coated with band-pass filters.**

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Predicting colour discrimination performance at extreme gaze angles when viewing a scene through a protective band-pass filter coating on a large visor is non-trivial. Left and right eyes are provided with different spectral information about the scene, but judgements and ordering of hues can still be performed. The current experiment used the Farnsworth-Munsell 100 Hue test (FM-100) to assess binocular colour discrimination under a well-matched daylight illuminant (Macbeth Spectralight II) for both straight-ahead ( $0^\circ$ ) and extreme ( $30^\circ$ ) gaze angles. 10 subjects with normal colour discrimination participated in trials using a novel filtered laser protection visor consisting of dielectric interference coatings on a dyed polycarbonate substrate. Error scores were computed according to the method described by Farnsworth, and the  $30^\circ$  scores compared with the baseline (no filter) and the  $0^\circ$  conditions. Trials were also conducted using comparable neutral density filters to eliminate luminance-dependent effects. Results analysed in the usual manner showed that there was a highly significant ( $p < 0.001$ ) difference between the  $0^\circ$  and  $30^\circ$  angle viewing conditions through the filter, the colour discrimination at  $30^\circ$  being poorer.

However, the error scores were typically skewed in each case (confirmed by calculation of skewness,  $g$ ) and the data were subsequently subjected to appropriate transformation<sup>1</sup> (after KINNEAR, *Vision Res.* 10 423-433 (1970)) and re-analysis. The loss in colour discrimination does not appear to mimic any of the classical congenital or acquired colour vision defects, as shown by polar plots of FM-100 error scores. The implication for protective visors is that spectral transmission that changes with gaze angle must be taken into account if the visor is to be used when the wearer is performing visual tasks with colour-critical content.

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## **Enhanced Disparity Information Under Telepresence**

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Stereopsis can provide a powerful cue to depth, however, binocular disparities vary with the inverse square of viewing distance (approximately) and fall below threshold within a few metres. Telepresence systems present the opportunity to augment disparities by increasing the inter-camera distance, effectively increasing the interocular distance of the user.

Recovering a full metric representation of the field of view is computationally expensive, and it is likely that we have evolved to recover the lowest order geometrical representation sufficient to perform the task at hand. For many telepresence applications, the answer to the design question of what visual information to provide is influenced by the minimum bandwidth principle; provide just sufficient information for sufficient performance.

With this in mind, performance on three tasks, differing in the minimum geometry required to perform them, were compared under normal and

hyperstereopsis conditions. All tasks involved subjects positioning a “mobile” (with one degree of freedom) within a scene viewed, via remote cameras, on a monitor using a field sequential display and temporal shuttering glasses.

Overall, it was concluded that subjects use different strategies for different perceptual tasks and that they can learn to use enhanced disparity information to increase the range over which these tasks are possible.

# **From Sensation to Perception The 4<sup>th</sup> AVA Christmas Meeting**

**Vision Sciences, Aston University  
21<sup>st</sup> December 1999  
Abstracts**

## **Blur discrimination and its relation to blur-mediated depth perception**

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Retinal images of three-dimensional scenes are likely to contain regions that are spatially blurred by differing amounts, due to depth-of-focus limitations in the eye. A difference in blur between one region in the image and another therefore offers a cue that objects in the two regions lie at different depths. However, 'region blur' cannot specify depth ordering, since the more blurred region could lie nearer or further away than the less blurred region. This ambiguity can be resolved using 'border blur' (the degree of blur in the border between the regions) eg. a blurred border would indicate the presence of an occluding edge attached to the more blurred region. Results of experiments to investigate perceived depth ordering in textured images containing only blur depth cues indicate that border blur does influence depth ordering, but only at relatively large blur values. Data from experiments to measure blur discrimination in the same stimuli indicate that thresholds for detecting border blur are significantly higher than thresholds for detecting region blur. The sensory limitations of detecting blur can be related to its perceptual salience in depth judgements.

## **Perceived contrast of filtered natural images**

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In previous work which has involved altering the amplitude-spectral slope of natural images and measuring object discrimination in images with different values of the spectral slope, we found optimal object discrimination when the slope values are natural (typically around 1.2). Performance is worse when the slopes are markedly steeper or shallower. Object discrimination was measured within sequences of morphed images.

However, we noticed that the “natural” images (slopes around 1.2) appeared to have a higher perceived contrast than the blurred or whitened images (with steeper and shallower slopes respectively). Neither the Fourier amplitude content of these “natural” images, nor that Fourier amplitude content weighted by the observer’s contrast sensitivity function, suggest any kind of maximum for the “natural” images. Thus, it seems that there is a nontrivial dependence of perceived contrast on the degree to which the spectral characteristics of an image are “natural”.

A possible model which might account for such a result is the suggestion (D. J. Field and N. Brady, 1997, *Vision Research*, **37**, 3367-3383) that natural images stimulate the bank of cortical filters to a roughly equal extent. We tested this model by selecting images whose unmodified amplitude slopes increasingly departed from the value of 1.2. A simple “filter bank” model would predict that contrast would peak for slopes around 1.2 even if these were produced by modifying the image. Instead, we found that the unmodified, “natural” image has the highest contrast even if its slope is markedly different from 1.2. Thus, perceived contrast cannot be simply predicted by second-order image statistics and associated cortical filter models.

Supported by BBSRC.

### **Psychophysics of change detection in multiple Gabor target arrays**

Michael Wright, Alison Green, Stephen Baker. (Department of Human Sciences, Brunel University, Uxbridge, UB8 3PH, U.K; e-mail: Michael.Wright@brunel.ac.uk)

The purpose of the study was to investigate how a psychophysical threshold for a spatial frequency change depends on the number of targets simultaneously present. The stimuli used were two 150msec frames each containing 1-4 Gabor targets. A “change/no change” discrimination was employed, comparing the stimuli in the two frames. Using a partial report technique (to equalise response variables), it was found that the log of the Weber fraction for spatial frequency change discrimination was

proportional to the log of the number of targets. The slope of this function (the set-size effect) was greater than has been reported for visual search tasks. The limitation was not a perceptual one affecting the visibility of the stimuli, because pre-cueing one out of four targets restored performance to the level found with a single target. With post-cueing (partial report) there was no difference in performance at 250 msec and 2000 msec inter-stimulus interval (ISI). However, where there was no cueing and only one target could change on a given trial, there was a larger set-size effect at 2000 than 250 msec ISI. Parallel division of attentional resources in the encoding of stimuli could account for the set size effects, but the last finding suggests a memory component as well. It is argued that such low-level effects could account for the phenomenon of “change blindness”.

### **Fourth-root summation for stimulus patches that are remote in position and orientation**

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Consider a log-log plot of contrast detection threshold versus total area of a single or multiple patches of a sine-wave grating stimulus. On such a plot, the term ‘fourth-root summation’ is sometimes used when performance improves with a slope of  $-1/4$ . One possible interpretation of fourth-root summation is probability summation between independent stimulus detectors with finite receptive field sizes. In a recent paper, Bonnef & Sagi (1998; *Vision Research*, **38**, 3541-3553) reported a series of experimental results on spatial summation using many 12.5 c/deg stimulus patches having full-width at half-heights of 1.4 cycles. They concluded that fourth-root summation occurs only when (i) stimulus patches are placed closer than about 4 stimulus widths apart and (ii) when the arrangement of the stimulus patches forms smooth contours. For other conditions, summation was found to be less than fourth-root summation. The authors suggest that one interpretation of their results is that fourth-root summation is due to facilitation between contour extracting mechanisms that interact over short distances and along smooth curves. I present results of further summation experiments that are consistent with the probability summation interpretation of fourth-root summation and challenge the contour facilitation interpretation. For example, using stimulus patches similar to those used by Bonnef and Sagi, but with a spatial frequency of 4 c/deg, fourth-root summation is found for four patches placed 24 stimulus widths apart, indicating that

proximity is not crucial for fourth-root summation. In a second experiment, fourth-root summation was found for a pair of orthogonally oriented step-edges, indicating that contour colinearity is not crucial for fourth-root summation.

### **What and where is adaptation? A contrast gain control model of the tilt aftereffect**

Mark Georgeson (School of Psychology University of Birmingham Birmingham B15 2TT UK; e-mail: M.A.Georgeson@bham.ac.uk).

There seems little doubt that the classical distribution-shift model (in which visual aftereffects arise from an adaptation-induced shift in the activity distribution across an ordered set of neurons) is qualitatively correct, but what can we learn from aftereffects about the selectivity, contrast response and adaptive properties of visual coding mechanisms? Drawing on several recent models of cortical cell responses (the contrast gain control models of Heeger; Foley; Wilson & Humanski) I modelled the tilt aftereffect (TAE) by assuming that the response of the  $i$ th neuron can be described by:

$$R_i = \frac{(S_i C_t)^n}{k^n + (A_i S_i C_a)^n + C_t^n},$$

where  $C$  is grating contrast,  $S$  is orientation-tuned sensitivity,  $A$  controls strength of adaptation and subscripts  $a$  and  $t$  refer to the adapting and test gratings respectively. Note that the divisive gain term contains a non-selective effect of test contrast and a selective effect of the adapting stimulus. Visually coded orientation was taken as the vector sum of responses across orientation-labelled cells spaced at  $5^\circ$  intervals. The TAE was measured using a staircase nulling method for gratings of 2 c/deg at 5 adapting orientations, with adapting contrasts of 4, 16, 64% and test contrasts of 4 - 64%. Results showed that the TAE grew almost linearly with the log of the adapt/test contrast ratio. This effect puts strong constraints on the form of the model's contrast response. The TAE peaked around  $\pm 20^\circ$  adapting orientation. A good fit to the data was obtained with Gaussian orientation tuning of each unit ( $s = 7.2$  deg for both adaptation and test sensitivities), but only when both  $k$  and  $n$  were low ( $k=1\%$ ,  $n=0.37$ ). This indicates a contrast response quite different from those shown by V1 cells (monkey median values  $k=32\%$ ,  $n=2.0$ ) and may reflect a later stage whose role is orientation coding, not contrast coding.

### **Human motion perception: Currents in the stream**

David Badcock (University of Western Australia, Stirling Highway, Nedlands, 6907, Western Australia; E-mail: david@psy.uwa.edu.au)

It has become popular to refer to two streams of processing within the hierarchy of cortical areas in the human visual system: a motion- and a form-processing stream. Given this conception it is important to ask whether the two streams are further sub divided and also to what extent they interact in vision.

One concerted research effort has focused on whether there are sub-streams within the motion-processing system selectively sensitive to first- and second-order stimulus properties. I will present a series of experiments, designed to tap different levels of the motion-processing hierarchy, which show that for at least one specific pair of first- and second-order properties motion-processing receives separate inputs at all levels tested (Badcock, D.R. & Khuu, S.K. *Psych. Res.*, in press). In this case it is useful to think of functional sub-streams.

Following this a series of experiments will be presented which question the functional independence of form and motion processing by showing that form-processing mechanisms can provide a significant input to the motion-system. Sequences of Glass patterns will be displayed which have a common global form but are uncorrelated with each other. These sequences contain motion signals of random velocity but the common global form shapes the perceived motion direction (Ross & Badcock, 1999, *Perception*, **28 supp**, 27). Thus the independence of the form and motion streams seems to have been overstated.

### **Speed gain control via nulling of opponent and non-opponent processes in a model of motion perception**

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A computational model of motion perception and adaptive effects is proposed. The model, which is gradient-based, adheres to the neural constraint that transmitted signals are positive-valued functions by posing the problem of motion detection as a linear programming problem. Three possible neural sites for motion after-effects are identified. The first (V1 simple cells) stems from adjustments of the temporal bandwidth of

bandpass filters. Adaptation is motivated by automatic gain control (AGC) processes that increase filter temporal bandwidth as a function of increasing image contrast. The second (V1 complex cells) stems from AGC and adjustments of temporal bandwidth from the squared and pooled response of the raw bandpass filter responses. Coding for image speed at this stage includes both opponent and non-opponent signal combinations. For non-opponent signal combinations, a nulling strategy is proposed. The nulling strategy codes for the space-time product of spatial and temporal gradient signals by scaling the squared sum of these elements and by subtracting the square of each individual element. The nulling scheme posits that adaptive effects stem from suppression of ancillary neurons rather than signal bearing neurons; a reversal of traditional explanations for adaptive effects as posited by energy-based speed coding. In the final stage (MT cells), motion is detected by iteration and represented by the responses of a small number of speed tuned neurons. AGC processes again affect motion computations at this final level, which in line with the previous stages is modelled by adjustments of feedback gain. The model may, by virtue of its cascaded stages of processing, explain a variety of empirically observed motion after-effects notably; speed increases, speed decreases, direction repulsion and the manner by which some of these effects can vary as a function of image contrast, frequency and speed.

### **Evidence for object-based selection operating on a grouped array of locations**

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Two experiments investigated space- and object-based selection effects using variants of the 'ring-cueing' paradigm of Egly and Homa (1984, *Journal of Experimental Psychology: Human Perception and Performance* **10** 778-793). The results revealed significant cueing modulation for non-ring configurations of target locations spanning a range of retinal eccentricities, with the cueing effects independent of eccentricity and confined to the configuration of locations (rather than extending to locations within the space enclosed by the cued configuration). These results are consistent with object-based selection operating on a 'grouped

spatial array' (Vecera and Farah, 1994, *Journal of Experimental Psychology: General* **123** 146-160). Object selection may be based on a supra-dimensional saliency map representation of the field, modulated by feature-specific segmentation mechanisms (e.g., an object may be made salient on the basis of its color). Complex objects may be represented by grouped saliency signals. In this way, a two-dimensional (2D) spatial (saliency) representation may provide the common format for object-based selection, prior to full object definition.

### **Spatial resolution and metamerism in coloured natural scenes**

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Measurements of the spectral reflectance functions of natural surfaces imply that metamerism is rare under natural illumination; that is, there are probably very few pairs of naturally occurring surfaces which, despite being spectrally distinct, give rise to color signals that would be confused by the human eye. This leaves the possibility, however, that a similar sort of metamerism could arise by combination: a human observer may confuse members of the set of all colour signals which could be produced by illuminating linear combinations of naturally occurring spectral reflectance functions. Such a phenomenon would be of ecological relevance, since the linear combinations required to produce these combined spectra could arise naturally as a result of an observer being unable to resolve two or more spectrally distinct surfaces in an image. To gauge the prevalence of this type of metamerism in natural scenes, CIE DE measurements were made on spatially averaged data derived from hyperspectral images. The results, which are discussed in terms of the relationship between the colour-coding properties of the human visual system and the statistics of the natural environment, imply that metamerism-by-combination is possible but unlikely.

### **Psychological colour space is physical colour space**

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Colour Space is a set of related perceptual qualities. Its structure can be described from viewpoints either external and physical, or internal and psychological. Descriptions from the external viewpoint are given as the output of a model of the physical processes of colour vision. Description from the internal viewpoint can be made through assertions such as “Yellow is more akin to Red than Blue”.

Data on the psychological structure of colour space was gathered using linguistic tasks phrased in terms of the Basic Colour Terms [Berlin B, Kay P, 1969 *Basic Color Terms: their universality and evolution* (Berkeley: University of California Press)]. Similarity and lightness data were collected using questionnaires consisting of questions such as “which is the more similar pair, Blue & Pink or Orange & Green?” and “which is lighter Brown or Grey?”. A total of 47,557 similarity judgements were collected from 195 subjects and 2,560 lightness judgements were collected from 47 subjects. Topological data were derived from a colour naming system [*The ISCC-NBS Method of Designating Colors and a Dictionary of Color Names*, 1955 (NBS Circular 553)].

A contemporary model of the processes of colour vision was used to determine the physical structure of colour space. This model makes use of the Body Colour Solid [Schrödinger, E, 1920 *Ann. Physik* **62**, 603], which represents the gamut of possible cone responses to objects viewed under a fixed illuminant.

Agreement between the psychological and physical structures of colour space is demonstrated by showing the similarity between a pair of approximate symmetries—one of the psychological structure and the other of the physical structure. This supports the hypothesis that the subject of the two descriptions is the same.

### **Heading in the right direction?**

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Analyses of the optic flow field from J.J. Gibson onwards have shown that there is information to specify the point of impact in the visual scene if locomotion were to continue along the same path. Locomotion direction can be modified if there is a discrepancy between the actual and desired points of impact. Use of these optic flow characteristics would be highly desirable if there are forces, such as side winds or cross currents, which result in there being a difference between the observer’s direction of heading (with respect to a body or vehicle axis) and their actual locomotor

path. If there are no such forces, observers could use the visual direction of the intended target (with respect to a body or vehicle axis) to alter their locomotor direction either directly, by changing their walking or swimming direction, or more indirectly by turning a steering wheel. Studies by Rushton et al (1998; *Current Biology* **8**, 1191-94) and Rogers and Dalton (1999; *Investigative Ophthalmology and Visual Science*, **40** S764) suggest that observers rely more on visual direction than optic flow. Providing richer optic flow information through motion parallax or the addition of road markings produces locomotor paths which are more consistent with the use of optic flow information but these results are also consistent with the greater salience of static (rather than dynamic) alignment cues in these situations. Thus it remains to be shown if optic flow per se plays any role in the control of locomotor direction.

### **Is heading information necessary for timing behaviour?**

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The optic flow generated by forward ego-movement contains information about both heading and time-to-contact (TTC) with an object ahead. Estimating TTC with a frontoparallel plane requires information about either the distance of an image element from the focus of expansion (FOE) and its instantaneous rate of motion or the instantaneous rate of change of the distance between two image elements. Both methods work well with pure expansion. However, when rotation is introduced the former requires a prior decomposition of the flow while the latter remains unaffected. Here, human sensitivity to heading and TTC were tested with random-dot-kinematograms (2, 4, 9, 16, or 25 dots) depicting a rotating surface moving towards the observer. The size and the duration of the display were 17x17deg and 1 sec, respectively. It was found that increasing the distance of the focus of rotation (FOR) from the FOE decreased heading sensitivity but left TTC sensitivity intact. A small effect of rate of rotation on both heading and TTC performance was observed but this effect depended on FOR angle and display density, respectively. Moreover, heading performance did not improve even when motion parallax was introduced. In addition, observers could estimate heading accurately even with 2 dot displays but their TTC performance deteriorated. Finally, disturbing the spatiotemporal structure of the displays did not substantially affect either heading or TTC. It was

concluded that heading and TTC are solved independently and that TTC is based on the instantaneous rate of change of the distance between image elements.

### **Fixation could simplify, not complicate, the interpretation of retinal flow**

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It has long been assumed that the visual system analyses retinal flow by decomposing it into rotational and translational flow (Longuet-Higgins and Prazdny, 1980, *Proceedings of the Royal Society, B*, **208**, 385-397). However, for a fixating observer, these two components are tightly linked to one another. In this case, an alternative method, originally used to describe the binocular disparity field (Gårding et al, 1995, *Vision Research*, **35**, 703-722), is particularly appropriate. Retinal flow is divided into changes in eccentricity ( $D_r$ ) and changes in meridional angle ( $D_q$ ). The latter, called 'polar angle disparities' for binocular viewing, can be used to recover the relief structure of the scene. We show how information about the direction of heading can be recovered using a similar hierarchy of heuristics. The maintenance of fixation while the observer moves, far from complicating the interpretation of retinal flow, simplifies these computations.

We show how a reference frame for storing the visual direction and depth of points can be built up using the polar angles ( $r$  and  $q$ ) and changes in polar angles ( $D_r$  and  $D_q$ ) between pairs and triples of points. The representation is similar to recent computer vision models that record the parallax of points against a frame of distant points (Irani and Anandan, 1998, *Proceedings of the IEEE*, **86**, 905-921). We show how data in the representation could be built up over a series of fixations and for different directions of translation of the observer.

### **The onset repulsion effect**

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There have been many previous reports of mislocalization associated with moving objects (e.g. Flashlag Effect, Fröhlich Effect, Representational Momentum). Across five experiments, we explore a new effect which is unusual in that the mislocalization error is always back along the observed path of motion. That is, when observers are asked to localize both the initial *and* the final position of a moving object, by far the largest and most systematic error they make is in placing the starting point too early along the correct path of motion. Errors orthogonal to the path of motion and errors in localizing the stopping point are small by comparison. Errors are also very small when motion is implied rather than continuous. The effect can be observed with and without fixation, and as with other mislocalization effects, shows some dependence on direction and velocity. As the most obvious prediction in these studies, based on previous reports of mislocalization and the known properties of the visual system, would be for forward rather than backward errors, discussion will focus on specific aspects of the current paradigm that might give rise to the observed pattern of results. In particular, the influence of compensation strategies, illusory acceleration effects and distance versus length errors will be discussed.

### **What information do we use during interception of an approaching projectile?**

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The ability to intercept or deflect an approaching projectile is critical to survival. What information do we use during projectile interception? In the related actions of reaching for static or laterally moving objects, and walking towards a target, it has been shown that we utilise information about the instantaneous direction of the target relative to the body (egocentric direction), specified by gaze direction and retinal location. However, the models of projectile interception that have been proposed instead rely on projectile trajectory information which is specified in the binocular retinal flow fields (Regan 1997 *Journal of Sports Sciences*, **15**, 533-558), or by the focus of expansion on the textured surface of the projectile (Lee & Young 1985 in *Brain Mechanisms and Spatial Vision*. Eds Ingle et al), or avoid the issue by specifying quantities in the theoretical optic array (Peper, et al 1994 *Journal of Experimental Psychology: Human*

*Perception and Performance*, **20**, 591-612.). We investigated projectile interception by having observers attempt to deflect approaching balls whilst viewing through horizontally oriented variable prisms. Prisms selectively perturb the perceived direction of an object, relative to the observer, but leave retinal flow relations such as object speed and relative object position unchanged. We found systematic errors that are compatible with the use of instantaneous direction, relative to the body (egocentric direction), during interception of a projectile. This finding puts projectile interception into the larger class of actions that rely on egocentric direction information.

### **The Aston MEG system**

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I will present a brief overview of the principles of MEG and outline the vision related MEG research conducted as Aston in recent years. This includes studies of evoked response to chromatic and motion stimuli, and studies with amblyopic and hemianopic subjects. The full head coverage and greater sensitivity of the new Wellcome Trust funded MEG system makes possible visual studies extending beyond primary sensory/perceptual processing, and some initial work on new lines of investigation will be presented.

### **Effect on visual function of laser flash from devices containing optical limiters**

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The effect of introducing a safe (sub-MPE) laser flash into a subject's visual field was assessed on performance in an aiming task. The aiming task was displayed on a computer monitor and consisted of a fixation cross with an aiming cross controlled by the subject using a joystick. The computer measured how close the subject managed to keep the aiming cross to the fixation cross whilst introducing randomized variations in the aiming cross position to make the task more demanding.

The irradiance distribution of the retinal laser flash was typical of the measured output from an optical device with an inbuilt optical limiter. The laser flash was subjected to spatial filtering such that the resulting

retinal irradiance distribution was representative of real-life measured data. Subjects were also asked to comment on the brightness of the flash. Comments were recorded and subsequently used to support and interpret the objective performance results. The presence and size of an afterimage was characterised by comparing pre-flash aiming performance with temporally and spatially resolved post-flash measurements of aiming performance using the computer-based task.

The laser flash was found to impede performance in the aiming task. The effect, which was greatest for early trials in the experiment, was interpreted as being caused by an afterimage that persisted for, typically, less than 5 seconds. Analysis of aiming scores showed that aiming performance recovered more rapidly at large angular subtenses, which may be interpreted in terms of the retinal irradiance distribution of the flash.

### **A linear mechanism for Gabor-patch alignment in amblyopia**

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Vernier thresholds and alignment bias were measured for 3-Gabor alignment in the vertical and horizontal meridians. The patches, separated by 6 carrier periods, were either collinear or orthogonal. In the orthogonal conditions, the outer (reference) patches were aligned with the configuration, the central patch at right angles to it. Data were gathered from a large sample of amblyopic and normal observers, over a range of spatial frequencies from 2.25-6 cpd. In all groups, and under all conditions, collinearity resulted in a small acuity advantage (reduced thresholds). This improvement was generally in the order of about 10% for amblyopic eyes to 20% for non-amblyopic eyes and normal controls, and was statistically significant ( $p < 0.05$ ). Bias was often larger for amblyopic eyes in the vertical meridian, but did not otherwise vary consistently according to conditions.

Although surprising in the light of previous results (e.g. Keeble & Hess, 1998, *Vision Research*, 38, 827-840), this intuitive finding (of improved acuity for collinear patches) is backed by a sample of more than 20 observers (making about 100 datapoints in all the different conditions). It suggests that an alignment process based on the linear (Fourier) orientations in the stimulus can influence performance even at relatively large separations, and this process, although impaired, is still measurable

in amblyopia. Possible substrates for such a process are elongated filters or collators. Sensitivity to the alignment of the collinear stimulus could be modelled by pythagorean summation of sensitivity to envelope alignment (orthogonal condition) and sensitivity to pure carrier misalignment.

### **Modelling the detection of blur in natural scenes: whitened kurtosis and the rectified contrast spectrum**

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Two independent psychophysical studies (Thomson, 1996, *Investigative Ophthalmology & Visual Science*, **37(3)**:4207; Field & Brady, 1997, *Vision Research* **37(23)**, 3367-3383) have shown that human observers' ability to detect blur in natural scenes depends strongly on an image's individual phase spectrum, even though the experimental stimulus parameter was a measure of power-spectral structure. A model observer capable of accounting for human performance must therefore be sensitive to information in both power and phase spectra. Field & Brady described the rectified contrast spectrum (RCS), which measures the spatial-frequency dependence of the contrast of 'detectable structure' in an image. The RCS models human blur-detection performance reasonably well, predicting that images appear blurred when the contrast of the detectable high-frequency components falls below that of the detectable low-frequency components. The RCS must (by definition) be sensitive to higher- as well as second-order global image statistics; if it can be placed within a more general higher-order statistical framework, regularities in the phase spectra of natural scenes (Thomson, 1999, *Journal of the Optical Society of America A*, **16(7)**, 1549-1553) could be taken into account. We do this by relating the RCS model to one based on a measure known as the whitened kurtosis, defined here as the kurtosis of an image whose power spectrum has been multiplied by an amount proportional to the square of spatial frequency. The ability of these two blur-detection models to account for human performance is compared, and implications for the arrangement of the neural-coding mechanisms involved in blur detection are discussed.

### **Contrast discrimination and summation**

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At contrast detection threshold, performance improves when either the number of (superimposed) sine-wave stimulus patches (with the same or different spatial frequencies and orientations) is increased, or when the size of a stimulus patch is increased. However, contrast discrimination thresholds do not generally improve in the same way (Legge & Foley, 1980, *JOSA*, **70**, 1458-1471). We present a series of suprathreshold summation experiments to examine this issue in more detail. Using 1 c/deg circular stimuli with duration of 100ms and a pedestal contrast of either 15% or 20%, windowed by a raised cosine function: (i) we find no evidence for summation across orthogonal orientations in a plaid, (ii) we confirm the absence of summation for a circular patch of grating whose diameter was increased from 2.5 deg to 11.1 deg, and (iii) we find summation (whose magnitude varied across observers), when the number of stimulus patches, equidistant from fixation, was increased from 1 to 4. Findings (ii) and (iii) are broadly consistent with the results of Bonnef and Sagi (1999, *Vision Research*, **39**, 2597–2602), who suggested that in (ii), short-range inhibitory interactions null the benefits of a summation process. To investigate the temporal dynamics of these putative processes we repeated the experiment in (ii) with stimulus durations of 8 and 33ms. As stimulus diameter was increased from 2.5 deg to 7.4 deg, performance improved with a log-log slope of about 1/4; a characteristic that is sometimes referred to as fourth-root summation. If an active process is responsible for the absence of summation at longer durations, this last result implies that it acts at least 25ms more slowly than the mechanism responsible for summation.

### **The extent of motion integration depends upon contrast.**

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The conditions under which local motion signals are integrated or differentiated are not fully understood (Braddick, 1993 *Trends in neurosciences*, **16**, 263-268). We examined the effect of contrast, inter-element distance and the number of elements upon motion integration. Using a 2IFC speed discrimination task we measured thresholds as a function of contrast (7% and 20%), number of local motion elements (presented in annuli of 2, 4, 8 and 16 Gabor patches) and inter-element distance (rotational distance of 11.25, 22.5, 45, 90, and 180 degrees). Our stimuli (Gabor patches) were vertical sine wave gratings windowed by a two-dimensional Gaussian. The carrier frequency of the gratings was kept constant at 1.9 cycles/degree. The speed of the standard stimulus was 1.6 degrees/sec and was always moving from left to right. The Gaussian window (0.53 degrees of visual angle) was kept stationary throughout each presentation. Psychometric functions were fitted individually for each observer for each of the 15 conditions. Thresholds were defined as the 81% correct point on the fitted Weibull curve.

Our findings are: (i) When the moving stimuli are clearly above threshold (20% contrast) there is no significant decrease in speed discrimination thresholds with increasing number of elements (slope = -0.11). The speed discrimination thresholds asymptote at around 0.4 degrees/second; there is no improvement for more than 2 elements. (ii) When the moving stimuli are close to detection threshold (7% contrast), speed discrimination thresholds decrease as a function of number of elements (slope = -0.39). Speed discrimination thresholds also asymptote at around 0.4 degrees/second; thresholds decrease up to 8 elements. (iii) Contrast detection thresholds decrease as a function of number of elements, but to a lesser extent (slope = -0.15). (iiii) Speed discrimination thresholds are independent of the inter-element distance.

We conclude that the number of elements used for speed discrimination depends on the contrast: for low contrast stimuli (close to detection threshold) integration of up to 8 elements takes place; for high contrast stimuli there is no evidence of integration for more than 2 elements.

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Dickinson, C., Murray, I. and Carden, D. (1996) **John Dalton's Colour Vision Legacy**. Taylor and Francis (784 pages).



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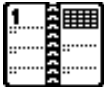
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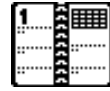
**References supplied (as usual!) by:**

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# *Meetings Calendar*



**2000**

- March 15 AVA 2000 Annual meeting and AGM, London  
Abstract deadline: 31<sup>st</sup> January 2000  
Email: [mscase@dmu.ac.uk](mailto:mscase@dmu.ac.uk)
- April 28-29 Functional Brain Imaging in Vision  
Ft Lauderdale, Florida, USA  
Abstract deadline: 1<sup>st</sup> February 2000  
<http://www.elsevier.com/locate/vision2000>
- April 30-May 5 ARVO Ft Lauderdale, Florida, USA  
Abstract deadline: 3<sup>rd</sup> December 1999  
<http://www.faseb.org/arvo>
- August 27-31 ECVP Groningen, The Netherlands  
Abstract deadline: 1<sup>st</sup> March 2000  
<http://ecvp.med.rug.nl>
- September 15 AVA Natural Images 3, Bristol  
Abstract deadline: 4<sup>th</sup> August 2000  
contact: [I\\_Moorhead@dera.gov.uk](mailto:I_Moorhead@dera.gov.uk)
- November 4-9 Society for Neuroscience  
New Orleans, LA  
<http://www.sfn.org>