APPLIED VISION ASSOCIATION

The Ninth AVA Christmas Meeting

Images, Perception and Psychophysics

Birmingham University
Thursday 16th December 2004

Programme

Room 1.20, Hills Building building,
University of Birmingham

10.55
Welcome

SESSION 1

11.00 Steven Dakin
Assessing local and global factors in motion perception using equivalent

11.30 Tim Meese, Robert Hess & Cristyn Williams
Size matters, but not for everyone: Individual differences for contrast discrimination

11.45 Mark Georgeson & Tim Meese
Fixed or variable noise in contrast discrimination? The jury's still outŠ

12.00 Andrew Schofield, Gillian Hesse & Mark Georgeson
The role of texture amplitude in shape from shading

12.15 Brian Wink, V Salvano-Pardieu & A Taliercio
The effect of illusory brightness and illusory contours on the detection of target lines superimposed on an Ehrenstein figure

12.30 - 1.30
Lunch & Posters

SESSION 2

1.30 Johannes Zanker & Jochen Zeil
Optic flow in natural environments-a downunder perspective

2.00 Hiroshi Ashida, Noriko Yamagishi & Stephen Anderson
Visually-guided actions are dependent on luminance signals

2.15 Nick Scott-Samuel, J. J. Marsh & U. Leonards
Similar processing in visual search and motion perception

2.30 A Tavassoli, I van der Linde, L. K. Cormack & A. C. Bovik
Accelerated classification images for the psychophysical investigation of visual search

2.45 Michael Wright & Louise Lakha
Integration of spatial frequency information in localisation and discrimination tasks

3.00 - 3.30
COFFEE AND POSTERS

SESSION 3

3.30 Lewis Griffin
Geometric texton theory: The 1-D, 2nd order jet

4.00 Alexa Ruppertsberg, Fazila Mayat, Anya Hurlbert & Marina Bloj
Sensitivity to colour gradients and its dependence on complexity of surround

4.15 Sophie Wuerger, Philip Atkinson & Simon Cropper
The unique hues revisited

4.30 P. G. Lovell, T. Troscianko & C. A. Parraga
Distance judgements based on Rayleigh Scattering: The detection of colour changes with distance in blue-yellow opponent channels

4.45 Yazhu Ling & Anya Hurlbert
Memory colours of real, familiar objects under changing illumination

5.00 Pete Thompson
A short chat about Viper

5.05 - ???
WINE AND POSTERS (sponsored by Viper)

Posters will include:

Keith Langley
Leaky predictive coding: A subtractive and divisive fast/slow gain control model for contrast coding

Michael Wright
Attention modulates fMRI activation of motion and form sensitive areas

Ben Vincent, Iain Gilchrist & Tom Troscianko
Progress towards a robotic active visual system

Cyriel Diels & Peter Howarth
Visually-induced motion sickness in the fore-and-aft axis

S. Artemenkov (TBC)
Human visual system functional range and some of its spatial-temporal characteristics

Trade stands:
CRS
Tracksys

Assessing local and global factors in motion perception using equivalent noise

Steven Dakin (Institute of Ophthalmology, Bath Street, London EC1V 9EL, UK. E-mail: s.dakin@ucl.ac.uk)

Our ability to assess which direction a large object is moving depends on two factors: how well we can assess the motion of any one of its parts (local motion) and how efficiently we can combine these estimates together (global motion). Existing techniques for assessing direction sensitivity are typically based on motion coherence thresholds and cannot separate the influence of these local and global factors. This is a cause for concern when the results of applying such techniques within a clinical context (e.g. glaucoma, dyslexia, etc.) are frequently interpreted in terms of global deficits. I will describe a methodology based on equivalent noise that can tease apart global and local limits on motion perception. I will then describe how this paradigm has shed light on (a) the influence of spatial factors (e.g. density) on motion perception, (b) why we are better at judging direction around the cardinal (vertical-horizontal) axes, (c) how eccentricity affects motion perception, and (d) how we see motion transparency.

Size matters, but not for everyone: Individual differences for contrast discrimination

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It is well known that contrast detection thresholds improve with the size of a grating-type stimulus, but it is thought that the benefit of size is abolished well above threshold (Legge & Foley, 1980, Journal of the Optical Society of America, **70**, 1458-1471). Here we challenge that view. We performed two-interval, forced-choice contrast discrimination (pedestal contrast = 20%) and contrast detection (pedestal contrast = 0%) experiments for circular patches of sine-wave grating (spatial frequency = 1 c/deg; duration = 100 ms) with four different diameters (2.7° - 12.2°) and central fixation. We confirm that sensitivity improves with approximately the fourth-root of stimulus area at detection threshold (a log-log threshold slope of –0.25), but find large individual differences (IDs) for the suprathreshold discrimination task in a group of 11 observers. For several observers, performance was largely unaffected by area but for others, performance first improved (by as much as a log-log slope of –0.5) and then either reached a plateau or deteriorated again. All of the results were very well fit by extending a recent model of area summation (Meese, 2004, Journal of Vision, **4**, 930-943) to accommodate the multiple stimulus sizes used here. In this model, (i) excitation increased with the fourth-root of stimulus area for all observers, and (ii) IDs in the discrimination data were described by IDs in the relation between suppression and area. According to this formulation direct empirical observations are good approximations of: (i) the level of summation when the experiment is performed at detection threshold and (ii) the weight of suppression relative to excitation when the experiment is performed well above detection threshold. Supported by EPSRC grant GR/S74515/01.

Fixed or variable noise in contrast discrimination? The jury's still out…

Mark A. Georgeson & Tim S. Meese (Neurosciences Research Institute, Aston University, Birmingham B4 7ET, U.K.; E-mail: m.a.georgeson@aston.ac.uk)

The ability to distinguish one visual stimulus from another slightly different one depends on the variability of their internal representations. In a recent paper on human visual contrast discrimination, Kontsevich, Chen & Tyler (2002, Vision Research 42, 1771-1784) re-considered the long-standing question of whether the internal noise that limits discrimination is fixed (contrast-invariant) or variable (contrast-dependent). They tested discrimination performance for 3 c/deg gratings over a wide range of incremental contrast levels at 3 masking contrasts, and showed that a simple model with an expansive response function and response-dependent noise could fit the data very well. Their conclusion - that noise in visual discrimination tasks increases markedly with contrast - has profound implications for our understanding and modelling of vision. Here, however, we re-analyze their data, and report that a standard gain control model with a compressive response function and fixed, additive noise can also fit the data remarkably well. Thus these experimental data do not allow us to decide between the two forms of model. The question remains open. Supported by EPSRC grant GR/S74515/01.

The role of texture amplitude in shape from shading.

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When a textured surface is modulated in depth and illuminated parts of the surface receive different levels of illumination, the resulting variations in luminance can be used to infer the shape of the depth modulations – shape from shading. The changes in illumination also produce changes in the amplitude of the texture, although local contrast remains constant. We investigated the role of texture amplitude in supporting shape from shading. If a luminance plaid is added to a binary noise texture (LM) shape from shading produces perception of corrugations in two directions. If the amplitude of the noise is also modulated (AM) such that it is in-phase with one of the luminance sinusoids and out-of-phase with the other the resulting surface is seen as corrugated in only one direction - that supported by the in-phase pairing. We confirmed this subjective report experimentally using a depth mapping technique. Further, we asked naive observers to indicate the direction of corrugations in plaids made up of various combinations of LM and AM. LM+AM was seen as having most depth, then LM-only, then LM-AM, and then AM-only. Our results suggest that while LM is required to see depth from shading, its phase relative to any AM component is also important.

The effect of illusory brightness and illusory contours on the detection of target lines superimposed on an Ehrenstein figure.

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Evidence exists for subthreshold summation between physical targets and illusory contours (e.g. Poom, 2001, Vision Research, 41, 3805-3816), but Salvano-Pardieu et al (2001, Perception, 30, supplement, 37) were unable to support this using a four-armed Ehrenstein figure. The Ehrenstein illusion is produced by illusory brightness and illusory contours. This study investigated the effect of both of these on detection of a target line (four observers, 2-AFC staircase procedure). The target was either superimposed on the illusory contour or the target was collinear with two arms of the Ehrenstein figure, where the target was clearly superimposed on the bright illusory surface. The two target locations (contour or collinear) were presented in each of three inducer conditions (i) an eight-arm Ehrenstein figure (ii) dots replacing the arms of the Ehrenstein figure (iii) control - no cue to the spatial location of target. The results show no significant difference between the Ehrenstein or dot conditions with either contour or collinear targets. However, detection was significantly better in the Ehrenstein and dot conditions than in the control for both contour and collinear targets. A second experiment (seven observers, 4-AFC), with only contour targets, found that detection was significantly worse in the Ehrenstein condition than in the dot condition. These two experiments do not support the existence of subthreshold summation between illusory contours or illusory brightness and physical targets, but support the view that the improved detection of the target when superimposed on the Ehrenstein figure is due to reduced spatial uncertainty.

Optic flow in natural environments – a downunder perspective

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Optic flow generated by moving observers is crucial for navigation, and therefore has attracted many theoretical, psychophysical, and physiological studies about estimating egomotion parameters such as direction of heading from the structure of velocity distributions in artificial stimuli. Little is known, however, about the structure of optic flow under natural operating conditions. To address this issue, we recorded sequences of panoramic images along accurately defined paths in a variety of outdoor locations and used these sequences as input to a two-dimensional array of correlation-based motion detectors (2DMD model). We find that (a) motion signals are sparsely distributed in the visual field and represent local motion directions with considerable error; (b) motion signal distributions contain oriented patches of high energy (motion streaks); (c) a distinct, dorso-ventral topography reflects the distance anisotropy in the terrestrial environment; (d) the spatiotemporal tuning of the local elements of the 2DMD model has little influence on the structure of motion signal distributions; (e) environmental motion (unrelated to observer motion) is noisy throughout the visual field, with little spatial or temporal correlation, can therefore be removed by temporal averaging, and is small compared to image motion caused by observer movement; (f) spatial or temporal integration is required to retrieve reliable information on the local direction and size of motion vectors. These results raise a number of questions about the role of specific environmental and computational constraints in the processing of natural optic flow.

Visually-guided actions are dependent on luminance signals

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When a visual stimulus is continuously moved behind a small stationary window, the window is perceived to be spatially displaced in the direction of motion (DeValois and DeValois 1991 Vision Res **31** 1619-26). We showed that the magnitude of this illusion is more pronounced when assessed using a visuomotor (pointing) task than a perceptual task, and argued that this may reflect neural compensation for the physical displacement a moving object would undergo during delays associated with visuomotor processing (Yamagishi et al 2001 Proc R Soc Lond B **268** 973-977). Here, we report that this 'visuomotor illusion' is specific for luminance-modulated stimuli. Following the presentation of a smooth-windowed, horizontal grating 7.5 deg to the right of fixation for 500 ms, subjects were asked to judge its vertical position either by: (1) reporting its perceived position relative to an on-screen ruler, or (2) touching the screen with their right index finger (without visual feedback of hand position – 'open-loop pointing'). Both equiluminant red-green gratings and luminance modulated gratings were used, and the vertical position of each target was varied randomly between +/- 1.5 deg of the horizontal meridian. Note that the visibility of stimuli was matched using individual direction discrimination thresholds. Our results show that, while perceptual localization errors for luminance and equiluminance stimuli were similar, visuomotor localization errors were significantly greater for luminance than equiluminance stimuli. Differences in perceived speed cannot account for the differences observed in the visuomotor task. Our results support the idea that separate cortical pathways exist for visual perception and visually-guided actions, and that the latter are critically dependent on luminance signals.

Similar processing in visual search and motion perception

Scott-Samuel, N.E., Marsh, J.J. & Leonards, U. (Department of Experimental Psychology, University of Bristol, 8 Woodland Road, Bristol, BS8 1TN; E-mail: n.e.scott-samuel@bris.ac.uk)

We present evidence that similar processing underpins the analysis of both a well-established motion stimulus (the Ternus display), and a standard visual search display. Ternus displays were constructed, with Gabor patch elements and a 0ms interstimulus interval. From frame to frame, carrier orientation, spatial frequency or contrast were varied. Smaller inter-frame differences in each of these parameters resulted in the perception of element motion, larger ones gave group motion. The magnitudes of orientation, spatial frequency and contrast change at the transition point between the two percepts were far larger than normal discrimination thresholds for these parameters (8 deg orientation difference; 20% spatial frequency change; 50% contrast change), implicating high-level processing. To see whether other higher order visual processes might behave similarly, the same Gabor patches were then used in a visual search task, and the transition point from efficient to inefficient search was derived. The orientation, spatial frequency and contrast transition points observed for both types of display were strikingly similar. Combined with previous evidence that low-level motion processing plays no part in the analysis of Ternus displays (Scott-Samuel & Hess, 2001, Perception, 30, 1179-1188), these data suggest that the processes underlying the analysis of the Ternus display are high-level and spatial in nature, with perception driven not by just noticeable differences, but rather by sufficiently large differences to indicate meaningful change. The findings have implications both for pure (i.e. motion perception) and applied (e.g. dyslexia) research. In addition, the Ternus display could be used as surrogate for certain search paradigms, as both stimuli may tap into the same processes.

Accelerated classification images for the psychophysical investigation of visual search

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One application of the classification image (CI) technique is visual search (for background see Eckstein & Ahumada, 2002, Journal of Vision 2:2). Observers are requested to judge the presence or absence of a target embedded in noise. The properties of the noise associated with correct and incorrect responses can provide insight as to the underlying strategies deployed, showing how the observer weights the importance of different stimulus features in deciding if the target is present or not. A general drawback of this popular technique in its original form is that it requires the accumulation of a large number of data (to the order of several thousands of trials per observer).
We propose an extension to the CI technique which allows us to reveal more rapidly features used by observers in visual search tasks. Using eye tracking and a grid-like stimulus ensemble, the accumulation of results is accelerated in comparison to earlier methods by up to 2 orders of magnitude, whilst also providing compatibility with low accuracy eye trackers. Our method is faster due to two factors: firstly, using a grid of discrete candidates, one of which contains a centered target, the spatial jitter of features observed when single large noise images are used is avoided; secondly, in addition to obtaining hit and miss information, determined by whether the user selected the appropriate tile, a large number of false alarm cases may be assembled from all the tiles fixated en route to the observer's selection, and correct rejection cases from tiles never visited. We test run our method using 1/f noise, 3 human observers, and 2 target types at 200 trials per target. The CIs obtained show the efficacy of the proposed method in exposing the idiosyncratic search behavior of different human subjects, even with such a small number of trials.

Integration of spatial frequency information in localisation and discrimination tasks

Michael J Wright and Louise Lakha (Centre for Cognition and Neuroimaging, Brunel University, Uxbridge, Middlesex, UB8 3PH, U.K.' E-mail: michael.wright@brunel.ac.uk)

We ask how spatial frequency (SF) information may be combined across discrete temporal intervals in order to locate and identify targets. We have previously analysed SF comparisons across targets and distracters in simple Gabor arrays. (Wright MJ, Alston L, 2002, Perception, 31: 171-172). Here we extend our analysis to include summation between discrete frames separated by an ISI. Observers indicated the position of a target stimulus differing in SF from uniform distracter stimuli (localisation) and, in different blocks, whether the target was higher or lower in SF than the overall mean value (discrimination). In both types of task, a varying proportion of the target SF increment (the bias) was added to the distracters, in order to determine the interaction of target and distracter stimuli. The way information is combined across the elements in a single frame display was close to a signal detection theory (Max rule) prediction for localisation of an odd SF target but not for discrimination (Sum rule). Discrimination performance was improved in two-interval tasks more than localisation performance. Combination across frames was consistent with Minkowski summation for both localisation and discrimination. Experiments isolated the contribution of each frame, and of the difference between frames. The best fit to data was obtained if three rather than two sources of information were assumed to contribute to threshold: the signal in each of the two intervals, and the comparison of corresponding elements on the two frames. Thresholds were consistent with a high-level decision process rather than summation within high-order SF filters.

Geometric texton theory: The 1-D, 2nd order jet

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Much is understood of how quantitative aspects of image structure are measured by V1 simple cells, but less about how qualitative structure is determined from these measurements. Geometric Texton Theory (GTT) aims to describe this step from quantitative to qualitative. GTT (Griffin et al, 2004, Vision Research, 44, 407-421) proposes that qualitative feature categories arise through consideration of the maximum likelihood (ML) explanations of image measurements. It posits that a pair of output vectors of an ensemble of co-localized neurons signal the same feature category if and only if the corresponding ML explanations are qualitatively similar. We have studied the mathematics and image statistics relevant to GTT for the limited case of measurement by 1-D Gaussian derivative filters of up to 2nd order. Our mathematical analysis has identified the simplest explanations for measurements by such filters, while our empirical results have identified the ML. We find that the ML explanations are not the most simple under any of the definitions of simple that we examined. However, the ML explanations are simple and do have properties predicted by GTT. In particular they change rapidly and qualitatively for certain narrow regions of measurement space, while remaining qualitatively extremely stable between those transition regions. Three feature categories arise naturally from the data: light bars, dark bars and edges. The results are consistent with GTT.

Sensitivity to Colour Gradients and its Dependence on Complexity of Surround

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Colour gradients surround us in the natural world encoding crucial information about the geometry and reflectance of objects and light sources. Surround complexity might be an important cue for recovering this information by limiting the number of possible interpretations.

Consider a corner formed by a white and a green card. If the latter is directly illuminated the white card will display a colour gradient due to interreflection. By changing the position of the light source the gradient will change. How sensitive are we to these changes? Does sensitivity depend on the contents of the area surrounding the gradient?

The above stimulus configuration was simulated for a range of light source positions with RADIANCE (Ward, 1994, Computer Graphics Proceedings, Annual Conference Series, p. 459) yielding physically accurate results (Ruppertsberg & Bloj, 2004, 1st Symposium on Applied perception in graphics and visualization, Los Angeles, 169). In a roving 2-interval same-different design (Macmillan & Creelman, 1991, Detection Theory: A User's Guide) we measured d’ between the reference scene and all other scenes. Three conditions were tested: intact surround (corner displayed with other objects giving full scene information), scrambled surround (gradient surrounded by 1-by-1 pixel scrambling of intact surround preserving luminance and colour) and no surround (gradient in isolation giving no additional information).

For three observers and all conditions we found that sensitivity significantly increased as the illumination angle of the comparison scene differed from the reference. Sensitivity was the same for the scrambled and intact surround scenes and significantly higher than for the no surround condition. This does not support the hypothesis that a meaningful surround facilitates the discrimination of gradients, but implies that the improvement in sensitivity might be due to contrast effects.

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The unique hues revisited

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‘Unique hues’ were first mentioned by Hering who proposed that any hue can be described in terms of its redness or greenness and its yellowness or blueness; unique red and unique green are perceived whenever a putative yellow-blue mechanism is silenced; unique yellow and unique blue are perceived whenever a putative red-green mechanism is silenced.
Our aim was to characterise the cone inputs to the chromatic mechanisms that are silenced by the four unique hues by finding the null planes for each unique hue in differential LMS cone space. We report three main findings: (1) The loci of the unique hues do not coincide with the cardinal cone-opponent axes, confirming findings by Webster et al. (2000, JOSA, 17 (9), 1445-1455). These cardinal colour directions describe the chromatic tuning of neurones in the early visual pathway, namely the Laternal Geniculate Nucleus, but do not seem to correlate with higher-order colour mechanisms. (2) Unique red and unique green are not generated by silencing a single yellow-blue mechanism; two mechanisms with different cone inputs must be postulated to obtain unique red and unique green. In contrast, a single red-green opponent mechanism is sufficient to yield unique yellow and unique blue. (3) These three chromatic mechanisms (one red-green and two yellow-blue mechanisms) combine the differential L, M, and S cone signals linearly.

Distance judgements based on Rayleigh Scattering: The detection of colour changes with distance in blue-yellow opponent channels.

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Rayleigh scattering causes distant objects to appear bluer than their nearer counterparts. The phenomenon is exploited by landscape painters who add a blue tint to representations of more distant objects. Using calibrated cameras (Párraga, Troscianko and Tolhurst, 2002, Current Biology. 12, 483-487) we measured the chromatic properties of near and far surfaces in natural images of mountains, hills, meadows and railway tracks. RGB values for pixels were translated into cone-activity values and in turn these were translated into values in Blue-Yellow opponent space (BY = (S-Lum/2)/(S+Lum/2)). Regressions were calculated for each category of natural scene and the mean slope was derived (BY = 0.000068*meters) revealing an increase in blue pixel activity of approximately 235% over 4000 meters. In a psychophysical study the sensitivity of observers (n = 3) to these colour changes was measured. The results confirmed that observers could detect changes in colour caused by shifts in distance of as little as 200 meters. We conclude that while L and M cones have wavelength sensitivities optimised for the detection of fruit and for the removal of shadows (Parraga et al 2002), the relative wavelength sensitivity of the S cone results in a BY opponent system that is efficient at the discrimination of distance, even when all other cues are removed. This may be related to the benefits, on an evolutionary timescale, gained from having the ability to discriminate distances where other cues are removed, for example in savannah and desert.

Memory colours of real, familiar objects under changing illumination

Yazhu Ling and Anya Hurlbert. (Insititute of Neuroscience, Henry Wellcome Building for Neuroecology, University of Newcastle upon Tyne, NE2 4HH; E-mail: anya.hurlbert@ncl.ac.uk)

Colour constancy is a robust phenomenon most likely mediated by multiple mechanisms, operating at different levels in the visual system. In the natural world, visuo-cognitive factors such as object familiarity, colour diagnosticity and colour memory may also contribute to constancy. To investigate these factors, we have developed a setup which preserves the natural binocular and monocular cues to 3D shape, while allowing us to adjust the apparent colour of real objects. In this experiment, the observer's task was to report whether particular colours 'matched' particular objects under different illumination conditions. The objects were solid, matt-white-painted styrofoam fruits and vegetables arrayed on a white board (70cm x 50cm) contained within a black box (100cm x 80cm x 60cm) and illuminated by a hidden data projector, which the observers viewed through a fixed aperture. The surface colours of individual objects were applied via projected images and varied between trials. The observer's task was to respond whether the colours of targeted 3D objects were appropriate, or whether the colours of flat disks matched the verbally cued object (e.g. 'banana' or ' carrot'). The results: (1) observers accept a significantly larger range of colours as object-appropriate when they appear as surface colours of congruent 3D shapes, compared to flat disks; (2) for 3D shapes, but not disks, the range of accepted colours varies with illumination; (3) reaction times are faster for rejections and slower for acceptances, for flat disks, but not for 3D shapes. We conclude that 3D shape influences memory colour and colour constancy.

Leaky predictive coding: A subtractive and divisive fast/slow gain control model for contrast coding

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Background: The dynamic on-line adjustment of the visual system's internal settings to external stimuli is investigated. It is proposed that the observed effects of divisive and subtractive contrast gain control may be understood by an analysis of a leaky predictive coding strategy through an adjustment of the encoding and decoding weights. **Methods**: The model assumes that there exist three noise sources: input noise, channel noise and reconstruction noise. The purpose of the initial stage of coding is to reduce input noise, while at the same time provide an efficient representation for the signal to be transmitted. The purpose of the stage of de-coding is to recover the transmitted signal while maximally reducing the overall contribution made by both the input noise and channel noise sources in the decoding process. **Results**: Through the introduction of specific constraints on the system studied: for example, hard constraints on the available transmission channel variance and soft constraints on the coding weights themselves, it is shown that a communication system, if optimized online to reduce transmission noise may be developed that possesses both fast and slow components of divisive and subtractive gain control. More interestingly, the divisive component of the proposed coding strategy exhibits the interesting property of contrast facilitation close to threshold and contrast suppression at high contrast. **Conclusion**: The proposed model suggests that the fast components of subtractive and divisive contrast adaptation are driven by the need to minimize input and channel noise efficiently. The slow phase of contrast adaptation on the other hand is driven by unpredicted visual signals such that the environmental model of the visual signal exploited by the visual system is adapted to match with the input signal itself.

Attention modulates fMRI activation of motion and form sensitive areas

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It is known from fMRI experiments that coherent motion stimuli activate visual cortical areas including V5 and the MST complex, and that coherent form stimuli activate regions in the ventral and lateral occipital lobe, as compared with incoherent motion and form stimuli. [Braddick, O'Brien, Wattam-Bell, Atkinson and Turner, 2000; *Current Biology*, **10**, 731-734]. It is also known that selective attention to motion enhances activity in V5 and related areas [O'Craven, Rosen, Kwong, Treisman & Savoy, 1997; *Neuron,* **18**, 591-598]. The present study extends these findings using novel transparent (form + motion) stimuli constructed from orthogonal Glass patterns. The principle is that the stimulus remains identical while the observer attends either to the stationary or the moving pattern. Attention to motion or to form was initiated by a cue at fixation, and maintained by requiring the observer to classify the Glass pattern attended to as random, circular or radial. Brain images were acquired using a 3 Tesla fMRI scanner with an 8 channel array head coil and analysed using SPM. 192 whole brain volumes were collected in each of 2 sessions per subject [7 stimuli including baseline, presented in 4 x 13.16s randomised blocks each containing 7 scans]. Contrasts involving incoherent form versus motion showed no consistent effects of attention. Modulatory effects of attention were observed in V5 for attend coherent motion > attend coherent form, and in ventral occipital cortex for attend coherent form > attend coherent motion.

Progress towards a robotic active visual system

B Vincent, I D. Gilchrist, T Troscianko (Department of Experimental Psychology, 8 Woodland Road, University of Bristol, Bristol BS8 1TN, UK; e-mail: ben.vincent@bristol.ac.uk)

We report results from the first phase of a joint project between Bristol and Essex Universities in which we are developing an active, foveated vision system. Here, we discuss the development of a foveated vision system that is neurally wired by learning to encode natural images using a principle of energy efficiency. This approach is taken because the energy efficient coding approach can explain many aspects of retinal (Vincent & Baddeley 2003) and cortical coding (Olshausen & Field 1996, Baddeley 1996, Vincent 2004) and is sufficiently robust to cope with the foveated form of the visual input. This foveated vision system is then used to build a form of salience map model to test various ideas in active vision. This salience map is based on Itti & Kochs' (2000) model. However rather than hand-selecting input maps, we used the results of Tatler, Baddeley & Gilchrist (under revision) who calculate the optimal image features to predict fixation location. The foveated, energy-efficient, neurally grown, active vision system is compared to measures of human visual performance and eye movement behaviour.

Visually-induced motion sickness in the fore-and-aft axis

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Despite the predominance of forward motion in both real and simulated movement, few studies have investigated the provocativeness of visually simulated egomotion in the fore-and-aft axis (e.g., So et al 2001 *Human Factors* **43**(3) 452-461). In this study, seated subjects viewed monocularly random-dot displays which simulated observer motion through a volume of randomly positioned points (expanding/contracting radial optic flow). Two conditions were employed: i) forward translation at a constant velocity and ii) sinusoidally oscillating (0.025 Hz) forward-backward translation. According to the widely-accepted 'Sensory Conflict theory', the sinusoidally oscillating condition would be expected to generate visually-induced motion sickness. This is because self-motion cues provided by the visual system are not accompanied by an expected vestibular signal consistent with varying acceleration. On the other hand, at constant velocity, visual and vestibular self-motion cues are not in conflict since the vestibular system responds to accelerations only and hence, no vestibular signal is expected in this condition. However, according to the 'Subjective Vertical-conflict' model (Bles et al 1998 *Brain Research Bulletin* **47**(5) 481-487), which states that motion sickness only results when the subjective vertical deviates from the sensed vertical, neither condition should produce symptoms because the stimuli are neutral with respect to gravity. Preliminary results indicate that, although vection was experienced for approximately 50% of the total exposure time in both conditions, translation in the fore-and-aft axis caused little or no motion sickness. These findings conflict with Sensory Conflict theory predictions, and provide indirect support for the Subjective Vertical-conflict theory.

Human visual system functional range and some of its spatial-temporal characteristics.

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The Transcendental Psychology approach (Mirakyan, 1999, Outlines of Transcendental Psychology, Moscow, IPRAS) focuses on the way that visual representations need to be created over time. For example, even simple attributes, such as the perceived width of a line, change systematically when the stimulus is first presented. Such phenomena can provide important cues to the spatial and temporal properties of the representation process. We therefore investigated the temporal development of perceived line width by presenting contoured hexagons consisting of 0.3 degree lines at a range of short durations, and asking observers to estimate perceived line width by comparison with long duration figures. Our results confirm that perceived line width increases smoothly between 10 and 50 msecs, reaching a maximum rate of about 15 deg/s. This reveals a basic temporal limit to visual processing that can explain why the maximum perceivable speed is about 30-50 deg/s (objects must remain fixed for at least 10 msec for any representation to emerge), and why the maximum speed perceivable without blur is about 4-5 deg/sec (objects must remain fixed for at least 50 msec for the perceived width to stabilize). It may also explain other, apparently illusory, phenomena such as the flash-lag effect (Eagleman & Sejnowski, 2000, Science, vol 290), in which a stationary flash and a rapidly moving object in the same location appear to be spatially offset. The spatial uncertainty associated with a dynamically changing, rapidly moving object will produce a predictable shift in its perceived position.