The 13th AVA Christmas Meeting

Bristol
19th December, 2008

We would like to thank the following for serving as referees:

Roland Baddeley

Marco Bertamini

Tom Freeman

Mark Georgeson

Mike Harris

Keith Langley

Tim Ledgeway

William McIlhagga

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Simon Rushton

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Andrew Schofield

Nick Scott-Samuel

Josh Solomon

Tom Troscianko

Sophie Wuerger

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PROGRAMME
AVA Christmas meeting 2008

Merchant Venturers Building
Woodland Road
University of Bristol
Lecture Theatre 1.11/1.11a (talks)
Atrium (registration, posters and evening reception)

10.00 Registration and Coffee/tea

10.50 Welcome
Tim Meese and Tom Troscianko

SESSION 1: Chair:

11.00 Invited talk
Getting distracted: camouflage and attention
Innes Cuthill, T. Troscianko, E. Howell

11.30 What is binocular vision for? Clues from birds
Graham Martin

11.45 Our perceptual prior for orientation is strong, highly flexible (and confusing)
William Allen, Roland Baddeley

12.00 An information theoretic analysis of eye movements when viewing photographs: effects of task, image, scale and time
Roland Baddeley, Ben Tatler

12.15 Can a Bayesian model of perceived speed explain why pursued stimuli appear slower?
Rebecca Champion, Tom Freeman

12.30 Lunch and posters

SESSION 2: Chair:

1.30 **CRS Guest lecture**
Dynamics of population responses in visual cortex
Matteo Carandini

2.00 **Attention as Inference: Optimal feature integration in visual search**
Benjamin Vincent, Roland Baddeley, Tom Troscianko, Iain Gilchrist

2.15 **The N3+ model of human edge detection and optimal edge detectors**
William McIlhagga

2.30 **Energy versus Gradient models? Why one might prefer a hybrid instead**
Keith Langley, Veronique Lefebvre, Steve Anderson

2.45 **Breaking space: intransitivity of distance judgements**
Ellen Svarverud, Stuart Gilson, Andrew Glennerster

3.00 **Tea/Coffee and posters**

SESSION 3: Chair:

3.25 **Marr Medal Introduction**
Mark Georgeson

3.30 **Marr Medal talk: Petroc Sumner**
Rapid sensory influences on motor competition
Petroc Sumner, Aline Bompas

4.00 **Comparison of perceptual and motor decisions via confidence judgments and saccade curvature**
Pedro Cardoso-Leite, Andrei Gorea

4.15 **S cone signals invisible to the motion system can improve global motion extraction via grouping-by-colour**
Jasna Martinovic, Sophie Wuerger, Georg Meyer

4.30 **Global motion processing deficits in the elderly**
Claire Hutchinson, Harriet Allen, Tim Ledgeway, P.Gayle

4.45 **The sunset minutes**
Tom Troscianko, John Fennell

5.00 **Wine and posters**

POSTERS

(in alphabetical order)

1. **Guessing in an extended SDT model explains interval bias in 2AFC detection tasks**
   Alcalá-Quintana & García-Pérez

2. **The effect of eye-movements and surround motion on bistable plaids**
   Baker & Graf

3. **Dissociation between saccadic choice and latency: a challenge for race models?**
   Bompas & Sumner

4. **The influence of slant on perceived straight ahead.**
   Brandwood & Rushton

5. **Patients with discrete pulvinar lesions show contrast perception impairments in the periphery.**
   Budnik, Rafal & Sumner

6. **Adaptation to collinear pursuit and retinal motion reveals non-linear combinations of component motion aftereffects.**
   Davies & Freeman

7. **The Impact of Psychosocial Factors on Adaptation and Quality of Life in Elderly Patients with Visual Impairment**
   Dickinson, Trillo

8. **Seeing the past. Situation awareness is influenced by old information when workload is high.**
   Edgar, Catherwood & Melhuish

9. **Task-based analysis of an online map service with differing display types: Is there an effect of familiarity of location?**
   Gage, Dixon, Nikolov, Noyes & Groen

10. **Rightwards shift of attention late in a fixation during reading**
    Ghahghaei, Dubey, Davis, Fischer, & Linnell

11. **The effect of stimulus luminance on the spatial acuity of the hen (Gallus g. domesticus)**
    Gover, Jarvis, Abeyesinghe & Wathes

12. **Two different loci for processing luminance-modulated and contrast-modulated noise stimuli?**
    Hairol & Waugh

13. **Spatial frequency tuning of a contour-selective mechanism**
Hancock, McGovern & Peirce

14. **The view from the sidelines: salience, relevance and eye movement convergence while watching a football match**
Howard, Gilchrist, & Troscianko

15. **Change detection strategies in multi-modal and uni-modal human interaction**
Koesling

16. **Temporally low-pass adapting mechanisms lead to temporally high-pass distortions in tilt after-effects**
Lefebvre, Langley, & Bex

17. **Modelling saccadic decision-making**
Ludwig

18. **The spatial and temporal tuning of plaid-form selective mechanisms**
McGovern, Hancock & Peirce

19. **Saccadic eye movements as a measure of perceptual decision-making**
McSorley, McCloy, Cruickshank, & Inman

20. **Visual acuity at low illuminance and contrast in fog.**
Ozolinsh, Colomb, Ikaunieks & Fomins

21. **Emotion and motion in facial expressions modulate the attentional blink.**
Roesch, Sander, & Scherer

22. **Decoding psychophysical performance from multi-electrode array recordings in the mouse visual cortex**
Saleem, Lee, Apergis-Schoute & Schultz

23. **Extra-foveal processing in visual short-term memory: Facilitatory or inhibitory?**
Sapkota, Pardhan & van der Linde§

24. **A direct comparison of selective adaptation and multivariate pattern analyser methods in fMRI**
Sapountzis, Schluppeck, Bowtell & Peirce

25. **A visual search asymmetry for bandlimited two-dimensionality**
Solomon

26. **Transcranial magnetic stimulation (TMS) differentially affects 'signal' and 'noise' depending on stimulation intensity**
Stevens, McGraw, Ledgeway & Schluppeck

27. **Seeing colour while ignoring motion: selective feature-based attention**
Taya, Adams, Graf & Lavie

28. **A role for contour integration in biological motion processing**
Thirkettle, Scott-Samuel & Benton

29. **Crowding effects in suprathreshold discriminations of natural images**
To, Gilchrist, Troscianko, Lovell & Tolhurst

30. **Why did the zebra get its stripes?**
Watkins & Scott-Samuel

31. **Real-time computer vision with Ruby and libJIT**
Wedekind

ABSTRACTS

Getting distracted: camouflage and attention

Innes C. Cuthill*, Tom Troscianko & Emma Howell* (*School of Biological Sciences, University of Bristol, Woodland Road, Bristol BS8 1UG, UK
† Department of Experimental Psychology, Woodland Road, Bristol BS8 1TN, UK)

Camouflage, in animals or in military applications, comes in many forms. Background matching, or crypsis, minimises detection through the target falling (well) within the sampling distribution of background colours, textures, or features. Alteratively, or in addition, camouflage can impair target recognition, either through direct mimicry of an irrelevant background object, or the use of disruptive coloration to break up shape and form. In fact, several phenomena are grouped under the heading 'disruptive' coloration and these may exploit different perceptual mechanisms. For example, high contrast colour patches at the body's edge exploit edge detectors in the viewer's visual system to create false contours of higher salience than the weak (true) contours at the target's periphery (Stevens & Cuthill 2006, Proc R Soc B, 273, 2141–2147). Here, low-level visual processes are fooled. However, the pioneer of camouflage theory, Abbott Thayer (1909; Concealing-Coloration in the Animal Kingdom. Macmillan, New York) also used the term 'dazzle coloration' with respect to disruptive markings, and John Endler (2006, Proc R Soc B 273, 2425-2426), like many before, considered that "conspicuous elements distract the predator's attention". The counter-intuitive proposal is that conspicuous markings can aid concealment precisely because they attract attention (away from features that might identify the target). We review the literature on disruptive camouflage and present data from human visual search experiments that test the proposition of 'distractive camouflage'. We show that the effects depend crucially on the prevalence of both similar objects and features in the background, and the prior expectation of subjects undertaking the search task.

What is binocular vision for? Clues from birds

Graham Martin (School of Biosciences, University of Birmingham, Edgbaston, Birmingham, B15 2TT, UK; e-mail: g.r.martin@bham.ac.uk)

A large frontal binocular field, produced by widely-spaced forward-facing eyes with parallel axes and conjugate movements, is a significant feature of vision in only some vertebrates. In the majority of vertebrates binocular fields are quite different. In birds, for example, in which the eyes placed close together and project laterally from the skull, binocular fields are typically small, vertically long and narrow (Martin, 2007, J. Ornithol 148, 547-562). Furthermore, there seems to be an evolutionary trade-off between frontal binocularity and comprehensive vision and, due to eye movements, binocular fields can be spontaneously abolished or made asymmetric. What are the functions of binocular vision in such species? Stereopsis seems an unlikely function since gaining relative depth from small disparity cues is probably too slow a process to guide a fast manoeuvring animal (Davies & Green, 1994, Perception and motor control in birds: an ecological approach, 339-356. Springer). The spontaneous abolition of binocularity in many birds would suggest that each eye functions independently. It is proposed here that in the majority of birds, and perhaps in many other vertebrates, binocularity does not have a specific or special function. Binocularity is best viewed as a by product of the need to have a portion of each eye's visual field projecting in the direction of head movement (during

pecking, bill lunging, or locomotion) in order to gain one section of the field in which there is a symmetrically expanding optic flow field. Such fields specify the direction of travel and time to contact an object in front of the head. Thus in birds, and perhaps in other vertebrates, the function of binocularity may lie in what each eye does independently rather than in what two eyes might be able to do together.

Our perceptual prior for orientation is strong, highly flexible (and confusing)

William Allen, Roland Baddeley (Dept. Experimental Psychology, University of Bristol, 12a Priory Road, Bristol, BS8 1TU; e-mail: wa2649@bristol.ac.uk; roland.baddeley@bristol.ac.uk)

The Bayesian account of visual processing requires a "prior" model of the world to operate. Previously this prior has either been assumed to match the visual environment, or have a form that allows the matching of psychophysical data. Here we use a Markov-Chain Monte-Carlo based method to directly measure the prior: Subjects took a 'random walk' in orientation space by estimating the angle of an oriented stimulus. This estimation was then used as the stimulus angle on the next trial. After a number of trials, it can be shown that a subject's prior is a function of the observed sampling distribution of responses. In our first experiment, we measured subjects' priors for orientation. We expected to find orientation judgements to be biased towards the cardinal axes, reflecting the statistics of natural images. Instead, while many subjects showed this bias, others did not. Further experiments showed that initially presenting a number of stimuli at either horizontal, vertical, or uniformly distributed orientations before beginning the random-walk process, changed subjects prior drastically: instead of a strong bias toward the vertical and horizontal, all subjects showed evidence of a strong prior towards the obliques. This shows 1) strong priors operate in early vision, at least for orientation; 2) these priors do not always reflect the long-term statistics of the visual environment; instead, they seem highly flexible and can switch rapidly, i.e. a competitive prior (Yuille and Bülthoff, 1996, Ch.4 Perception as Bayesian Inference, Cambridge University Press). Despite reliable patterns in the data, we are not sure why subject's priors shift in the way observed: we can only rule out the most plausible suggestions.

An Information Theoretic analysis of eye movements when viewing photographs: effects of task, image, scale and time

Roland Baddeley[1], Ben Tatler[2] (Department of Experimental *Psychology* 12a, Priory Road, *Bristol*, BS8 1TU. E-mail: roland.baddeley@bristol.ac.uk; School of Psychology, University of Dundee, Park Place Dundee, DD1 4HN)

To provide a better understanding of fixation behaviour in natural settings, we develop an information theoretic framework for analysing the distributions of fixations when viewing natural scenes. The main (and non-trivial) problem with this approach is developing an efficient and (relatively) unbiased estimator of the entropy of fixation distributions. After numerous false starts, we show that a Bayesian estimator (the NSB estimator) is both efficient and unbiased when analysing eye movements distributions. Combing this technique with methods due to Garner and McGill (1956), we find a robust set of interactions between low level salience, high level task, time (fixation number), and spatial scale. Amongst the many results found, we show that low level salience operates at a relatively fine spatial scale (about a 13th of the size of the screen), whereas high level, task dependent control operates at a much lower spatial scale (about

a π of screen size). We argue that, correctly applied, an information theoretic framework provides a high flexible framework for answering many important questions about eye movements in natural settings, and does so with reasonably sized data sets.

Can a Bayesian model of perceived speed explain why pursued stimuli appear slower?
Rebecca A. Champion & Tom C.A. Freeman (School of Psychology, Cardiff University, Tower Building, Park Place, Cardiff, CF10 3AT. E-mail: championr@cardiff.ac.uk.)

Moving objects appear slower when tracked with a smooth pursuit eye movement (the Aubert-Fleischl phenomenon, AFP). This means that speed estimates during pursuit are lower than those during fixation. The question is "why?". We explored whether a Bayesian model incorporating a zero-motion prior, in world-frame coordinates, could explain this phenomenon. The model predicts that speed estimates during pursuit should be less precise than those accompanying fixation. We therefore measured speed discrimination thresholds for fixated and pursuit stimuli and compared them to the size of AFP (for observers with fixed head position). Stimuli consisted of a pursuit target surrounded by a random dot pattern. On fixation intervals, the pursuit target was stationary and the dot pattern moved within a stationary window. On pursuit intervals, pursuit target and dot pattern moved at the same speed. A 2AFC procedure tested three conditions: Fixation (2 fixation intervals), Pursuit (2 pursuit intervals) and Aubert (1 fixation and 1 pursuit interval). The results showed a classic AFP for all participants at all speeds. Fixated stimuli were consistently slowed by some 64% in order to match the perceived speed during pursuit. However, discrimination thresholds were not consistently higher for the Pursuit condition compared to the Fixation condition and relative thresholds were highly idiosyncratic. These results therefore do not support a Bayesian explanation based on a zero-motion world-centred prior.

Dynamics of population responses in visual cortex
Matteo Carandini (UCL Institute of Ophthalmology, University College London, 11-43 Bath Street, London EC1V 9EL, United Kingdom; E-mail: matteo@carandinilab.net)

The perception of visual stimuli is widely held to be supported through the activity of populations of neurons in visual cortex. Work in our laboratory seeks to record this population activity and to characterize its evolution in time. Our methods rely on optical imaging of voltage-sensitive dyes and on electrical imaging via multielectrode arrays. The results indicate that the visual cortex operates in a regime that depends on the strength of the visual stimulus. For large, high contrast stimuli, the cortex operates in a manner that emphasizes local computations, whereas for smaller or lower contrast stimuli the effect of lateral connections becomes predominant. In this interconnected regime, the population responses exhibit rich dynamics, with waves of activity that travel over 2-6 millimetres of cortex to influence distal locations. In the complete absence of a stimulus, these waves dominate, and are sufficient to explain the apparently erratic activity of local populations. These results indicate that two apparently contradictory views of visual cortex, one postulating computations that are entirely local and the other postulating strong lateral connectivity, are both correct. The cortex can operate in both regimes, and makes its choice of regime adaptively, based on the stimulus conditions.

Attention as Inference: Optimal feature integration in visual search

Benjamin T. Vincent[1], Roland J. Baddeley[2], Tom Troscianko[2], Iain D. Gilchrist[2] ([1] School of Psychology, University of Dundee, DD1 4HN; [2] Department of Experimental Psychology, University of Bristol, BS8 1TU; E-mail: b.t.vincent@dundee.ac.uk)

Despite embodying fundamentally different assumptions about attentional allocation, a wide range of popular models of attention include a max-of-outputs mechanism for selection. Within these models, attention is directed to the items with the most extreme-value along a perceptual dimension via, for example, a winner-take-all mechanism. From the detection theoretic approach, this MAX-observer can be optimal under a specific situation, namely when the degree of variability of target and distracter feature properties is the same. This will often not be the case in natural scenes: because a target's spatial extent is smaller then the whole field of view, then on average the variability of the target features will be different than the variability of the surrounding scene. This situation is also violated in psychophysical settings where feature variability of distracters is purposefully greater than that of targets (a distracter heterogeneity manipulation). The question arises, do humans utilise a sub-optimal max-of-output mechanism, or are we optimal? We derive a Bayesian maximum *a posteriori* (MAP) observer, which is optimal in both these situations. While it retains a form of the max-of-outputs mechanism, it is based on the maximum posterior probability dimension, instead of a perceptual dimension. We investigated human visual search performance for Gabor orientation using a yes/no procedure while adding external orientation uncertainty to distracter elements. The results are much better fitted by the predictions of a MAP observer than a MAX observer. We conclude that a max-like mechanism might well underlie the allocation of visual attention, but this is based upon a probability dimension, not a perceptual dimension.

The N3+ model of human edge detection and optimal edge detectors

W McIlhagga (Bradford School of Optometry & Vision Science; E-mail: w.h.mcilhagga@bradford.ac.uk)

The N3+ model is a very successful model of human edge detection (Georgeson et al. 2007, JoV 7(13):7 1-21). However, the N3+ model uses a 3rd derivative operation, and was not designed with noisy images in mind, so its performance degrades when noise is added.

Here I show that the N3+ model is the noise-free limit of an optimal edge detector. The optimal detector looks for edges in a background consisting of (a) white noise and (b) other edges and image features, modelled as brown noise. The optimal edge detector can be factored into a whitening filter and a detection filter. The whitening filter is a smoothed derivative operation. The detection filter is a linear unbiased filter optimized for (i) signal-to-noise and (ii) localization and smoothness (Canny, J. 1986, IEEE PAMI, 8:679-714). If there is no rectification following the whitening filter, the optimal detection filter looks like a gaussian. If there is half wave rectification following whitening (as in the N3+ model) the optimal detection filter looks like a second derivative because of the unbiasedness criterion, and combined with the whitening filter yields a smoothed 3rd derivative operation.

In addition, because the whitening filter discounts the background, the derived optimal edge detector adapts to changes in the image, such as increased blur (Webster et al. 2002, Nature Neuroscience, 5 839–840).

Energy versus Gradient models? Why one might prefer a hybrid instead

Langley, K.*[%], Lefebvre, V.* & Anderson, S.J.[§] (*Dept. Psychology, University College London, London, UK. [§]Neurosciences, School of Life & Health Sciences, Aston University, Birmingham, UK. [%]E-mail: k.langley@ucl.ac.uk)

When processing the responses of oriented filters on route to the detection of spatial orientation, two computational approaches are commonplace, namely, energy and gradient models. In comparing their different assumptions, we exploited the steering theorems of Freeman and Adelson (IEEE, PAMI, 891-906, 1991), which led us to a combined (energy/gradient) hybrid model. This hybrid model is derived from a compressive (decorrelating) transformation that operates on the responses of orientation tuned filters and may lead to an efficient signal representation when detecting one as opposed to many locally oriented image structures. A spatial orientation vector is detected using equivalent computations to those advocated by second-order gradient constraints. In comparing the properties of the hybrid model with energy and gradient models, we note: (i) the application of first-order orientation constraints, when combined with higher-order image derivatives, may lead to a biased estimator for spatial orientation; (ii) unabated, the gradient model predicts phase dependent adaptation effects; (iii) the energy model fails to represent spatial phase information; and (iv) the energy model assumes that the oriented filter responses are uncorrelated (independent) and potentially inefficient. The hybrid model on the other hand, retains spatial phase information, exploits correlations across oriented filters, assumes that local image phase depends upon local orientation, is easily computed from the squared/rectified responses of oriented filters, and finally, may be quantified by the application of Baye's chain rule.

Breaking space: intransitivity of distance judgements

Ellen Svarverud[1], Stuart J. Gilson[2] & Andrew Glennerster[1] ([1]School of Psychology and Clinical Language Sciences, University of Reading, Earley Gate, Reading RG6 6AL, UK; [2]Department of Physiology, Anatomy and Genetics, University of Oxford, Parks Road, Oxford OX1 3PT, UK. E-mail: e.svarverud@reading.ac.uk)

Many experiments support the idea that observers generate a distorted representation of space, but the proposed transformation between physical and perceived space is generally a simple homography (i.e. a 1:1 mapping between points). Here, we show that perceived space can 'break' in such a way that the perceived distances D_1, D_2, D_3 of three objects can, at the same time, obey both $D_1 > D_2 > D_3$ and $D_1 < D_2 < D_3$. We demonstrate this in the unusual situation of an expanding virtual room (Glennerster et al, 2006, Current Biology 16(4), 428-432), which appears stable to observers despite large changes in size. In an immersive virtual reality environment, observers in a brick-textured room viewed a reference square in one interval and judged whether a comparison square in a second interval was closer or farther away. On some trials, the virtual room, which was visible throughout, expanded between intervals. When the square was adjacent to the side wall, room expansion had a greater effect on distance judgements than when the square was placed in the middle of the room. By measuring distance matches for objects placed in different locations, with and without room expansion, we could confirm the paradoxical, intransitive distance ordering described above.

Rapid sensory influences on motor competition

Petroc Sumner & Aline Bompas (School of Psychology, Cardiff University, UK; E-mail: sumnerp@cardiff.ac.uk)

It is widely accepted that visual signals can automatically activate potential saccade plans, and that competing plans inhibit each other. It is also usually assumed that as activity favouring one saccade grows, inhibition of competitors becomes stronger, predicting that competitors would have little effect if one plan has a clear head-start. However, Reingold and Stampe (J Cogn Neurosci 14, 371, 2002) found that large but irrelevant visual flashes can have a dramatic effect on the saccade latency distribution even when presented late, dramatically reducing the number of saccades executed in a time window between 70 and 150 ms post-flash. We replicate this effect using small spatially discrete stimuli, and find that it is precisely time-locked to distractor onset. Moreover, it occurs for contralateral but not ipsilateral distractors, suggesting that it is produced by spatial motor competition, not interrupted execution as originally proposed. Thus visual stimuli appear to gain rapid access to the saccadic competition and decision stage, and exert an important influence even when other saccade plans have a clear head-start.

Comparison of perceptual and motor decisions via confidence judgments and saccade curvature

Pedro Cardoso-Leite & Andrei Gorea (Laboratoire Psychologie de la Perception, Université Paris Descartes& CNRS, 45 rue des Saints Pères, 75270 Paris cedex 06, France; E-mail: pdrcardoso@gmail.com)

A major challenge in cognitive sciences is the appraisal of the relationship between perception and action and of the subtending biological processes. Here we address this general issue by investigating the link between the subjective visibility of close to threshold distractors and the trajectory parameters of saccades directed to a highly visible target. This study investigated the effects on perceptual and motor decisions of low-contrast distractors, presented 5° on the left and/or the right of the fixation point. Perceptual decisions were assessed with a Yes/No (distractor) detection task. Motor decisions were assessed via these distractors' effects on the trajectory of an impending saccade to a distinct imperative estimulus, presented 10° above fixation 50 ms after the distractor(s). Results show that saccades curve away from distractors only when observers report them to be present(perceptual Hits and False Alarms). Furthermore, saccade deviation is correlated (on a trial-by-trial basis) with the inferred internal response associated with the perceptual report: the stronger the distractor-evoked perceptual response, the more saccades deviate away from the distractor. Also, in contrast with a supersensitive motor system, perceptual sensitivity is systematically higher than the motor sensitivity derived from the distributions of the saccades' curvatures. When both distractors are present (and straight saccades are expected), the sign of saccades' curvature is correlated with observers' perceptual bias/criterion. Overall the results point to a strong perceptual-motor association and demonstrate that saccade trajectories betray observers' perceptual state.

S cone signals invisible to the motion system can improve global motion extraction via grouping-by-colour

Jasna Martinovic, Sophie Wuerger, Georg Meyer (School of Psychology, University of Liverpool, UK; Email: jasnam@liv.ac.uk)

In natural visual environments colour and motion direction can be correlated as different parts of a moving object may be of similar colour. The human visual system utilises motion-colour correlations through attentional mediation but the precise nature of the mechanism that guides this process remains unknown. In this study, we dissociated colour and motion information by using a two-coloured random dot kinematogram (RDK) wherein coherent motion and motion noise differed from each other only in their S-cone component (S-cone increment and decrement). Spatial and temporal parameters were set so that global motion direction processing relied solely on the L-M component. Under these conditions, S-cone isolating signals can only be used for motion detection but not for global motion discrimination (Ruppertsberg et al, 2003, Vis. Neurosc. 20, 421-428). Thus, S-cones would only provide information on colour appearance. In the behavioural experiment, participants were asked to discriminate between coherent and random motion and d' was measured for uncorrelated, uncued correlated and cued correlated conditions. With colour and motion correlated, more efficient segregation of coherent motion from motion noise occurred; performance further increased when observers were cued to the signal colour. In the electroencephalographic experiment, participants discriminated direction of motion for uncued correlated and cued correlated conditions. Cueing a specific colour modulated the N1 component of the event-related potential, with sources in visual area MT. We conclude that S-cone signals invisible to the motion system can influence the analysis by direction-selective mechanisms through grouping of local motion signals by colour; this grouping mechanism is under attentional control.

Global motion processing deficits in the elderly

Hutchinson, C.V. [a], Allen, H.A. [b], Ledgeway, T. [c] and Gayle, P. [b]
([a] School of Psychology, University of Leicester, UK; [b] School of Psychology, University of Birmingham, UK; [c] Visual Neuroscience Group, School of Psychology, University of Nottingham, UK; E-mail: txl@psychology.nottingham.ac.uk)

This study compared the effects of age on the perception of translational, radial and rotational global motion patterns. Motion coherence thresholds (corresponding to 79 % correct direction-discrimination performance) were measured for judging the direction of each motion type as a function of dot contrast in ten young (mean age = 21 years, S.D = 2.8) and ten elderly (mean age = 73 years, S.D = 3.4) participants. Results were similar for all three types of global motion. Global motion coherence thresholds decreased as dot contrast increased, asymptoting at high dot contrasts. Despite qualitatively similar patterns of results in all cases, coherence thresholds were higher in elderly compared to young participants. This equated to global motion impairment in the elderly of a factor of around 2, characterised by a shift along the horizontal axes (dot contrast). The present study has shown that translational, radial and rotational global motion perception is impaired in the elderly. The findings also suggest that age-related changes in global motion perception may be driven principally by deficits in contrast encoding, rather than by deficits in motion integration. This implies that early visual areas such as striate cortex may be particularly susceptible to age-related deterioration, the effects of which feed into extrastriate visual areas.

Tom Troscianko: The sunset minutes

Tom Troscianko, John Fennell (Department of Experimental Psychology, University of Bristol, Bristol BS8 1TU; tom.troscianko@bris.ac.uk)

Sunsets appear beautiful, but little is known about the underlying visual processing. Near sunset, the sky near the sun is red due to Mie scattering, while the solar disk is less intense and redder due to Rayleigh scattering. We simulated various atmospheric conditions in the lab, using a projector to generate a simple horizon-based landscape with a large extent of sky, and a powerful spotlight to generate a simulated solar disk. Subjects viewed each scene for three seconds. Sixteen sky colours were presented, of which two corresponded to noon and sunset skies. They were matched for luminance and perceived saturation. Other, unnatural, colours were used as foils. Two solar elevations were used: 2.7 and 9.2 deg above horizon. A mobile eye tracker recorded fixation. Subjects rated scene pleasantness, and the subjective size of the sun. The results surprisingly suggest that aesthetic quality is primarily determined by the elevation of the sun, rather than the chromatic or intensity parameters of the scene – thus, the redness of the sky or the sun, and the luminance of the solar disk are not predictors of aesthetic quality. Fixations are made to an annulus around the solar disk, and the mean radius of this annulus predicts perceived beauty - at low elevation, fixations are made closer to the solar disk and the solar disk is judged to be larger. The findings suggest that aesthetic quality may be related to a dynamic interaction between the opposing demands of salience and repulsion from strong sources of light.

Guessing in an extended SDT model explains interval bias in 2AFC detection tasks

R Alcalá-Quintana, M A García-Pérez (Facultad de Psicología, Universidad Complutense, Madrid, Spain; E-mail: ralcala@psi.ucm.es)

In a recent paper, Yeshurun et al (2008, *Vis Res* **48** 1837–1851) provided compelling evidence against the standard SDT model for detection by showing that interval bias frequently occurs in 2AFC detection experiments. In their discussion, they argued that guessing might play a role in observers' responses, although they did not elaborate on this idea. In this study we extend the SDT model to allow for guessing along the lines suggested by Kaernbach (2001, *Percept & Psychophys* **63** 1377–1388) and we assess the validity of the amended model through simulations and an empirical test. The extended model considers an indifference region around the null value of the decision variable such that the observer "guesses" when the decision variable on a given trial lies in this region. This framework requires a modified 2AFC task where observers indicate which interval contains the signal or, alternatively, indicate that they would have to guess on that trial. There are three parameters in the model (sensitivity, width of the indifference region and finger error rate) that can be estimated with the help of catch 2AFC trials (i.e., trials without a signal) intermixed with regular 2AFC trials presenting the signal in one interval. According to our simulation results, the amended model allows for accurate estimation of the actual *d*' of the observer as an uncontaminated measure of sensitivity. The model also fits adequately data from a contrast detection experiment and it accounts for interval bias in 2AFC tasks. Thus, its validity is supported by our current results.

The effect of eye-movements and surround motion on bistable plaids

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Perceived motion of drifting plaid stimuli is bistable over a wide range of component angles and spatial frequencies (Hupé, J-M. & Rubin, N., 2003, *Vision Res*, 43: 531-548). Perception alternates between coherent pattern motion and transparent component motion. Given previous findings associating saccades with percept transitions for some bistable stimuli (van Dam, L.C.J. & van Ee, R., 2006, *Vision Res*, 46: 787-799), we explored the relationship between perceived plaid motion and eye-movements in ten observers. Besides a standard plaid motion condition, during which observers were instructed to fixate centrally, we also included two surround motion conditions (moving dots with speed and direction consistent with the coherent or transparent percept), and two guided eye-movement conditions, where observers tracked a moving fixation point. Observers reported their percept continuously as coherent or transparent using a mouse (60*s* trial duration). Behaviourally, surround motion and guided eye-movements biased the proportion of coherent/transparent percepts by 5-10%. This occurred largely through extending the durations of percepts directionally congruent with the surround motion or guided eye-movements. Saccades were longer and more numerous in the surround motion or guided eye-movement direction. For all conditions, a number of perceptual transition reports were preceded by blinks, giving a measure of observer response lag (500-1000ms). Saccades congruent with percept direction showed a different pattern, following perceptual transitions. We conclude that i) percept changes elicit eye-movements in the direction of the percept, ii) saccades can prolong an existing percept and iii) surround motion might capture eye-movements, which in turn influence perception.

Dissociation between saccadic choice and latency: a challenge for race models?

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According to the dominant models of saccadic decision, both saccade latency to one visual target and choice between two possible targets are predicted by the same factor – how soon activity for a particular response reaches threshold in an action planning area (Carpenter & Williams, Nature 1995). Accordingly, whatever the reason that observers are biased in favour of one response in a choice, race models predict that a) response time should be shorter for the preferred response and b) the exact choice bias should be predicted by the distributions of response times to the different alternatives.

In monocular viewing conditions, observers look preferably at stimuli presented in their temporal hemifield when given the choice between temporal and nasal stimuli (Posner & Cohen, Tutorials in motor behaviour, Amsterdam, 1980). However, despite the prediction of race models, there seems to be no latency asymmetry, neither in our replication of this effect (Bompas et al., J. Neurophysiol. 2008) nor in the previous literature (Honda, Vis. Res. 2002).

We have reanalysed our data employing a well-known race model (LATER) to fit our latency distributions individually for nasal and temporal targets. Using these fitted parameters, we simulated the race and predicted choice for bilateral targets. The model predicted a mean choice asymmetry of only 53%, significantly different from the 64.5% we measured ($p<0.003$). To obtain such a choice asymmetry, a latency difference of 36ms on average would have been

necessary (a difference reached by only 2 of 21 participants), while we measured only 5 ms difference.

The influence of slant on perceived straight ahead.

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Visual context is known to influence the perception of straight ahead (SA). Estimates of SA in the presence of a slanted surface are usually drawn to the closer side of the surface (Perrone, 1982, *Perception*, **11**, 641-654). We investigated this influence in two experiments. In both experiments participants stood two metres from a surface slanted 15° or 30° about a vertical plane. Experiment 1 (n=15) required participants to make a visual judgement of SA by indicating when a pointer was directly ahead of them, and a proprioceptive judgement by pointing SA in the absence of any visual input. Neither visual nor proprioceptive perception of SA was drawn towards the closer side of the surface as previously reported: Interestingly, both visual and proprioceptive SA were biased (by approx 10°) towards the further side of the surface. Employing a similar design Experiment 2 (n=19) investigated whether the bias in proprioceptive SA is due to observers pointing to a remembered visual location. Naïve participants were required to point SA both before and after visually locating SA, and also after memory for the visual location of SA had decayed. Results suggested that proprioceptive error could not be explained by the influence of a visual memory of the scene indicating that these two measures are independent.

Patients with discrete pulvinar lesions show contrast perception impairments in the periphery.

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We examined the contributions of the human pulvinar to low-level visual processing. The pulvinar is known to have anatomical connections to visual and frontal areas (Leh et. al. 2007, Eur J Neurosci. 24, 2954-60), and has been proposed as a sensory gating system involved in attentional and visual functions (Rafal & Posner, 1987, Proc Natl Acad Sci. 84, 7349-53; Ward & Arend, 2007, Brain, 130, 2462-9). We measured discrimination thresholds for fovea, left and right (13^{o} in periphery) during fixation in four patients with pulvinar lesions and healthy age matched participants. We employed Gabor patches with vertical or horizontal orientation and varied contrast using a two-alternative forced-choice staircase method (three-down, one-up, contrast adjustment ratio of 1.2). All four pulvinar patients showed relative impairment for the periphery, but not fovea, when compared with healthy controls. Thus, damage to the pulvinar appears to affect low-level visual perception, possibly due to a reduced ability to attend to the periphery.

Adaptation to collinear pursuit and retinal motion reveals non-linear combinations of component motion aftereffects.

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Previous work shows that when retinal motion and pursuit eye movement are orthogonal, the motion aftereffect (MAE) that results is a linear vector sum of a classical retinal MAE and an 'extra-retinal' MAE related to the eye-movement system (Davies & Freeman, 2008, *Journal of Vision*, 8, 670). Here we investigate collinear combinations of retinal motion and pursuit. In the Pursuit condition, the adapting stimuli consisted of a moving pursuit target and a surrounding random dot pattern producing retinal motion in either the same or opposite direction. In the Fixation condition, the pursuit target remained stationary and the dot pattern moved as before. The post-adaptation test consisted of a single fixation point in an area not coincident with the previous dot pattern. In separate sessions, observers judged the direction or speed of any MAE they experienced. Perceived direction was assessed using an adjustable rod that could be rotated in the direction of the MAE. Perceived speed was assessed using the same device, this time as a speedometer. In both cases, perceived direction and perceived speed were calibrated against physical motion prior to the collection of data. The results showed very few reports of MAE in the Pursuit condition that contained retinal motion in the opposite direction, or the Fixation condition. Conversely, most observers reported salient MAE when retinal motion moved in the same direction as pursuit. Unlike orthogonal adaptation, this suggests that simultaneous adaptation to collinear pursuit and retinal motion produces non-linear combinations of component MAEs.

The Impact of Psychosocial Factors on Adaptation and Quality of Life in Elderly Patients with Visual Impairment

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Quality of Life (QoL) questionnaires which deal with functional vision and adaptation have become common outcome measures for assessing the effectiveness of rehabilitation in visually impaired patients. The hypothesis of this study was that patients' realistic acceptance of their visual impairment and their QoL was determined by psychosocial factors, such as religious beliefs, personality, general health (physical and mental), social support, friends and family, financial status or other non-optical factors such as understanding of their eye condition, than it was by rehabilitation strategies. Seventy four patients over the age of 65 completed telephone interviews of previously validated questionnaires and simple lifestyle questions. Additional personal information was obtained from the hospital records. These data was analysed with Spearman's rho looking for correlation between the different variables. Correlation was found between QoL and numbers of friends and family, Positive Social Interaction support, Emotional/Informational support and the use of magnifiers when related to near vision. The findings show that apart from the number of friends, family and some aspects of social support, psychosocial factors do not appear to play a significant role in QoL. The use of magnifiers appears only to influence QoL when related to near vision activities.

Seeing the past. Situation awareness is influenced by old information when workload is high.

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Seamon *et al.* (Seamon, Berko, Sahlin, Yu, Colker, Gottfried, 2006, *Memory*, 14(4), 415- 423) have demonstrated that, if individuals are pressured at recall, 'false' memories may spontaneously return. This study investigated whether, under conditions of high cognitive load, perception of a situation could be influenced by previously presented (conflicting) information.

Participants were shown a series of four video clips of a car journey. Prior to viewing each clip, participants read a description of the journey. The descriptions and the video clips were congruent except in five instances where the two differed. Participants were run in either a high- or low-workload condition which were identical except that, in the high workload condition, participants were required to generate and verbalise random numbers. Having viewed the video clips, participants then answered twenty true/false statements that tested their knowledge of information present in each of the four clips.

The responses to the statements were analysed using signal detection theory to obtain a measure of 'situation awareness' (SA - how well they were aware of what had happened in the clips) and 'bias' (a tendency to either accept or reject information) (Edgar, Edgar & Curry, 2003, *Proceeding of the Human Factors and Ergonomics Society 47th Annual Meeting*). Analysis of variance suggested that there was no significant difference between the SA scores in the high and low workload conditions ($F(1,46)=2.34$, $p=0.13$). There was, however a significant difference in the bias scores between the two conditions ($F(1,46)=4.43$, $p=0.04$), suggesting that filtering of information was more 'lax' in the high-workload condition. Consistent with this finding, when the material in the video clip and the previously read passage was not congruent, there was significantly more intrusion ($F(1,46)=15.01$, $p=0.00$) from material in the previously read passages when the workload was high.

Task-based analysis of an online map service with differing display types: Is there an effect of familiarity of location?

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With technological advances leading to a growing use of online route planning and satellite navigation systems, the use of electronic maps has become a regular occurrence for many people. However, little research has as yet been undertaken investigating the use of maps in navigation or way finding tasks, let alone the use of satellite navigation systems or, for example, Google maps for these purposes. An eye tracking study was carried out, aiming to investigate the effects of using electronic map displays (available at http://maps.google.co.uk) of differing complexities on the realisation of navigation tasks in familiar and unfamiliar locations. Participants performed 3 different map-reading tasks (planning a route, finding a location, and following instructions to an end point) in both a familiar (Bristol) and an unfamiliar (Rome) location. We measured task accuracy and time spent on the tasks, in 3 different map conditions; regular map, satellite and overlay. A significant effect of familiarity was found, suggesting that in familiar locations people show a faster and more accurate performance when using regular maps as opposed to unfamiliar locations where the satellite map appeared to lead to improved

performance compared with the other map types. Such findings, representing a naturalistic task using map software commonly used in everyday life, and varying in complexity, means that we can investigate how humans interact not only with maps, but also the circumstances in which particular map types are beneficial in accomplishing different navigation tasks.

Rightwards shift of attention late in a fixation during reading

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The spatio-temporal allocation of attention during reading was investigated using a dual task. Participants were presented with single sentences and required (1) to read them for comprehension, and (2) to respond to gaze-contingent probes that were briefly superimposed on a single character in the sentence. Using this paradigm with speeded probe *detection*, Fischer (1999) showed attentional benefits near the location of a forthcoming saccade target late in a fixation during a search task but *not* during reading (*The Quarterly Journal of Experimental Psychology* **52A(3)** 649-677). To see whether this finding could be extended to reading, we modified the secondary task to require unspeeded *discrimination* of probes (that were oblique lines oriented at a horizontal angle of either 45° or 135°). Probes appeared after the eye landed on a pre-defined but unpredictable frequency-controlled word at different spatial offsets from fixation location (0 or 6 characters right or left of fixation) and temporal offsets from fixation onset (40ms, 90ms, 110ms, 130ms and 180ms). Between 130 and 180 ms after fixation onset, probe discrimination on *high-frequency* words (>100/million) increased 6 characters to the right of fixation but decreased at fixation. Over the same timecourse, probe discrimination on *low-frequency* words (<12/million) increased at fixation and decreased right of fixation. This is compatible with a shift of attention from fixation to the forthcoming saccade target late in a fixation when the fixated word is high in frequency, but a recall of attention to fixation for low-frequency words that require more processing.
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The effect of stimulus luminance on the spatial acuity of the hen (*Gallus g. domesticus*)

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The spatial contrast sensitivity of the domestic fowl has previously been measured at two different stimulus luminances (Jarvis et al, *Vision Research* in press) but the luminance dependence of spatial vision in the hen has not been investigated comprehensively. This information is needed to show how the visual system of this species operates from scotopic through to photopic conditions. The aim of this experiment was to measure spatial acuity for a large range of stimulus luminances in the hen. An operant conditioning technique was used to determine the acuity of seven hens over a range of stimulus luminances from 0.06 to 57.35 cd m^{-2}. The hen had a much lower overall visual acuity than the human at all luminances, e.g. an acuity of 6.42 and 60.00 c deg^{-1} at the highest luminance of 57.35 cd m^{-2}; and 3.20 and 20.50 c deg^{-1} at the lowest luminance of 0.06 cd m^{-2}, respectively. Overall, the relative intra-species variation of acuity was similar; acuity was fairly constant at medium to high luminances, but

reduced rapidly at low luminance in both the hen and the human. An interesting finding, however, was that over the photopic luminance range 1.79 to 57.35 cd m^{-2} the change of acuity for the hen was 1%, compared to 33% for the human. Current MTF-based theoretical models indicate that both optical and retinal sampling factors affect acuity, but neural noise is also significant. The Rovamo-Barten model variant can account for the observed behaviour of acuity as a function of luminance.

Two different loci for processing luminance-modulated and contrast-modulated noise stimuli?

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Lateral interactions across space for the detection of luminance-modulated (LM) or contrast-modulated (CM) blobs show similar regions of masking and facilitation. However they can be different when test and flanking blobs do not match in type, a finding inconsistent with the notion that "uncertainty reduction" underlies facilitation for detection (Hairol & Waugh, 2008, *JOV*, 5, 182a). We aim to elucidate possible neural mechanisms that underlie lateral spatial interactions. LM and CM noise blobs were constructed by adding or multiplying random-dot dynamic noise with a Gaussian. Detection thresholds were measured for a test blob, with and without visible flanking blobs, for a range of separations (0-6deg). The flanking blobs were the same type as the test blob, or of different type. The size of the blobs was also varied (SDs = 0.125°, 0.25° and 0.5°). We found a similar pattern of results for 111 and 222 stimuli, where the spatial extent of lateral interactions in degrees was slightly shorter for CM stimuli, irrespective of blob size. The relative amplitude of facilitation increased with decreasing blob size for most arrangements and the separation at which peak facilitation occurred, scaled with blob spread (at 4-6 SDs). However, detection thresholds for an LM blob flanked by CM blobs (212) showed several notable differences. In combination with our earlier findings, these results suggest that neural interactions underlie some lateral interaction effects. The different results obtained for blobs not matching in type are not easily explained, without engaging forward and backward processing between two loci.

Spatial frequency tuning of a contour-selective mechanism

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We have previously used a method of compound adaptation to demonstrate contour-specific aftereffects, consistent with a mechanism selective for simple contours (Hancock & Peirce, 2008, *Journal of Vision*, 8, 11). Observers are adapted on one side of the vertical meridian, to two sinusoidal gratings oriented at ±20 degrees from horizontal and presented together so that they form a contour (a downwards pointing chevron). On the other side the same two component gratings are presented alternately. Under these conditions, a straight probe stimulus appears more concave after prolonged exposure to a convex contour than to its constituent elements alternating, indicating an aftereffect to the contour stimulus over and above the tilt aftereffects generated by its parts. Here we investigated the characteristics that govern these contour-selective mechanisms In Experiment 1, the adapting stimuli had a fixed spatial frequency (SF) and the test stimuli varied in SF. The aftereffect was found to be clearly tuned for the spatial

frequency of the adapting stimulus relative to that of the test, with the greatest aftereffect occurring when the adapting and test stimuli were identical. However, in Experiment 2, the aftereffect remained robust to relatively large differences in spatial frequency of the two components comprising the contour. These results are explored in terms of the possible role of the contour mechanism in perceptual binding of local contour elements into curves.
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The view from the sidelines: salience, relevance and eye movement convergence while watching a football match
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Eye movements have been used to investigate the allocation of attention over time in various sporting contexts such as steering during motor racing (Land & Tatler, 2001, Current Biology, 11, 1215-1220) and hitting the ball in cricket (Land & MacLeod, 2000, Nature Neuroscience, 3, 1340-1345). Such studies reveal the presence of a visuo-motor buffer of around half a second to a second and some have suggested that the magnitude of this buffer should be constant across experts and novices (e.g. Land and Furneaux, 1997, Philos Trans R Soc Lond B Biol Sci., 352(1358): 1231–1239). We previously reported that such a constant buffer could not account for expert-novice differences observed during a CCTV monitoring task (Howard et al., 2008, Perception 37 ECVP Abstract Supplement, pp.108). We here examine the temporal relationship between eye movements and manual responses while relative experts and novices watch a football match. Observers used a joystick to continuously indicate the likelihood of an imminent goal. The stimulus was a real 5-a-side football match, video-taped in an outdoor urban context. It was, therefore, representative of real world inspection tasks in which non task-related salient events frequently occur. We performed correlations between manual responses and the between-subjects variability in eye position. To examine the magnitude of a visuo-motor buffer, we repeated these correlations at all possible temporal lags between these two measures and searched for the maximal negative correlation coefficient. We find lags much longer than would be expected simply from a constant one second buffer.
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Change detection strategies in multi-modal and uni-modal human interaction
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Human communication is not only verbally driven, but often involves gestures, mimics and gaze contact between people interacting with each other. The present study aimed at identifying efficient strategies in change detection tasks that two partners collaboratively accomplished. Furthermore, we investigated how the presence/absence of specific communication modalities affected these strategies. In the first experiment, subjects acted in a face-to-face situation, each of them viewing stimuli on an assigned monitor that the partner could not see. Subjects had to identify a single mismatch between their displays by mutually describing the stimulus (verbal plus non-verbal communication condition). In the second experiment, a screen was placed

between subjects so that they could only verbally communicate. Detection times and eye movement parameters (fixation numbers, saccade amplitudes, fixation durations) were analysed along with video and audio footage. Results indicated, for example, that visually scanning the stimulus in several stages with increasingly detailed verbal descriptions was significantly quicker than in-depth descriptions in only one, slow-moving pass over the stimulus. The absence of non-verbal communication in the behind-screen condition had little effect on overall change detection time. When verbal descriptions of one partner conflicted with the visual percept of the other partner, however, significant increases in gaze-contact frequencies and durations were detected (face-to-face condition). These coincided with a reduction in the time it took to resolve this specific conflict. Findings thus suggest a preferable, efficient change detection strategy and indicate that gaze contact can further increase efficiency in particular situations in human interaction. What exactly gaze contact conveys is open to discussion and currently under investigation.
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Temporally low-pass adapting mechanisms lead to temporally high-pass distortions in tilt after-effects
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The perceived orientation of a test pattern can be distorted following adaptation to a tilted adapting pattern. We examine the magnitude of such Tilt After-effects (TAEs) as a function of both adaptor and test temporal frequency (TF) to determine the spatio-temporal tuning of the underlying mechanisms. In successive 2.5s periods, subjects adapted to 60% contrast 2 c/deg sinusoidal gratings, of varying orientation (7.5 – 82.5^{o} counter-clockwise from vertical) and TF (0.4 – 38 Hz). Test stimuli were sinusoidal gratings across a range of TFs (0.4 – 38 Hz), whose contrast was either: (i) fixed at 30%, or (ii) rescaled as a fixed proportion of threshold contrast. Subjects reported whether the test grating was oriented either clockwise or counter-clockwise from vertical. TAEs generally decreased as adaptor TF increased and monotonically increased as test TF increased. TAEs were highly correlated ($r = 0.94$) in constant and re-scaled contrast test conditions. The adaptation effects observed as a function of test TF cannot be wholly accounted for by variations in perceived contrast. We explain the decrease in TAE with adaptor TF and the increase in TAE with test TF by an adaptive reduction in the temporal bandwidth of orientation tuned mechanisms.
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Modelling saccadic decision-making
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In Ludwig et al. (2005 *Journal of Neuroscience* **25** 9907-9912) observers discriminated between two patterns with contrasts that were re-sampled every 25 ms from two Gaussian distributions with different means. Correlating the temporal noise in contrast with the landing position of the first saccadic eye movement suggested that observers make their decision where to look first on the basis of a visual integration epoch of ~100 ms, despite mean saccade latencies on the order of

~300 ms. These data suggested that saccadic decisions were based on temporal integration to a deadline, rather than to a criterion level of evidence. Importantly, the deadline did not appear to be adjusted on a trial-by-trial basis according to the quality of the sensory evidence.

Here, I formally compare three different accounts of these findings. All models assume that decision-making is based on temporal integration of a time-varying internal response to the noisy contrast sequence. The models are distinguished by their stopping rule: 1) Deadline: integration stops when a randomly varying deadline is reached; 2) Threshold: integration stops when some criterion level of evidence has been accumulated; 3) Time-varying threshold: essentially a hybrid model, in which the criterion gradually decreases over time (thus acting as a deadline).

The inclusion of a temporal filter resolves the puzzling difference between a short visual integration epoch and the much longer movement initiation time. Both the deadline and time-varying threshold models outperform the standard integration-to-threshold model. These results demonstrate the importance of internal deadlines in simple sensori-motor decisions.

The spatial and temporal tuning of plaid-form selective mechanisms

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The presence of neural mechanisms selective to particular combinations of Fourier energies, namely plaids, has been shown using a compound adaptation paradigm (Peirce & Taylor, 2006). We used a variant of this method to investigate the dependencies of these mechanisms on the spatial and temporal properties of a stationary plaid pattern. Participants compared the contrast of a target probe in one visual hemi-field to a fixed reference probe in the other, following a period of adaptation to a plaid or its components respectively. In Experiment 1, adapter stimuli had a fixed spatial frequency (SF) of 1.26 c/deg, while probe stimuli ranged between 0.4–4.0 c/deg. Our results showed that compound adaptation was tightly tuned to the adapting SF, with diminished adaptation effects when the probe was less than one octave from that of the adapter. Experiment 2 examined the effect of altering the SFs of the gratings comprising the plaid on selective adaptation. Compound adaptation was strongest when the components shared the same SF and was markedly decreased when they differed. In Experiment 3 we systematically varied the temporal onset of the components comprising the plaid adapter. We found a non-linear decrease in compound adaptation; small temporal separations of the components led to large decreases in adaptation with greater separations resulting in smaller decrements. Together these findings suggest that the mechanisms behind plaid detection are sensitive to small changes in spatial and temporal properties of the stimulus. This may impact on the perceptual binding of components as a single plaid texture.

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Saccadic eye movements as a measure of perceptual decision-making

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We have examined the processes involved in decision-making using saccadic eye movements. These explicit behavioural metrics can be readily tied to established neural correlates. Saccade

dynamics and metrics (i.e., the trajectory, landing position and latency of the movement) can be used to elucidate the processes involved in
decision-making because these aspects of saccades are known to reflect neural activation associated with the level of evidence for perceptual motor decisions. The eye movements of participants were recorded as they were asked to saccade to one of two peripheral stimuli (left and right) on the basis of a random dot motion coherence patch shown centrally. The level of coherence was varied. Participants moved their eyes to a target on the basis of the direction of the perceived motion within the patch. We found that correct performance decreased as motion coherence diminished. Saccade landing positions and trajectories were also found to become more affected by the non-target location, i.e., with decreasing motion coherence strength they were drawn toward the non-target location. Thus as the decision became more difficult to make (i.e., the strength of motion coherence decreased) the influence of the other possible choice (i.e., the other target location) became more apparent in the eye movement response. We suggest that the extent of this is a direct behavioural measure of the relative neural activation associated with each visual stimulus' location which in turn is a measure of activation associated with decision-making.
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Visual acuity at low illuminance and contrast in fog

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We did experiments in the Clermont-Ferrand artificial fog chamber with and without the presence of fog (visibility V≥7m, mean water droplet size ca. 2 μm) using colour E-letter optotypes on a black background of RGB monitor. The fog decreased both the Michelson contrast of stimuli and luminance from: 32 to 5.2cd/m^2 for red (R=255) optotypes , 97 to 14.5cd/m^2 for green (G=255) optotypes, and 12.2 to 2.1cd/m^2 for blue (B=255) optotypes. The lowest VA measured without fog was for blue optotypes, which had at all fog densities the lowest luminance measured by a calibrated Minolta chromameter. Next we equalized the luminance values for red and green optotypes to those of blue optotypes. This produced a substantial decrease in VA for red and green optotypes, particularly in fog. However, subjects' VA for red and green optotypes remained higher than that for blue optotypes. Comparing results of studies without and in the presence of fog for various luminance colour stimuli we make suggestions. The main reasons for VA differences for diverse colour optotypes and of deterioration of VA in fog are: a) the luminance, and b) the Michelson contrast of the stimuli. The central retina involved in the perception of blue stimuli close to the acuity threshold subtends up to 10x10arcmin area. That is smaller than the CIE standard observer visual field (1-4)$^\circ$ for determination of colour matching functions. Furthermore, this region of retina consists mainly of L and M cones and therefore it is less sensitive to blue stimuli. This reduces the effective luminance of very small blue stimuli. The impact of spectral dependence of scattering on the difference in VA for blue and red optotypes appears to be of little importance owing to the large size of the scatter media.

Emotion and motion in facial expressions modulate the attentional blink.

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The attentional blink (AB) refers to that period of time (200-400 ms) during which the cognitive system is processing a first target (T1), thereby unable to process a second target (T2) (Raymond et al, 1992, J Exp Psych, 18, 849-860). It unfolds over time, probing the competition between incoming stimuli during each stage of early visual attention. We used the AB to examine how static and dynamic emotional facial expressions direct attention. In experiment 1, T1 was a neutral face. T2 was either a fearful, happy or neutral face, and was either static or dynamic--the expression unfolded from 0 to 100%. Participants performed a gender decision on T1, and reported whether they perceived a second face. We used curve-fitting techniques (Cousineau et al, 2007, Can J Exp Psyc, 60, 175-189) to analyze aspects of the data related to the ignition of the blink and its duration. We show that (1) emotional faces suffer from this effect earlier, and that (2) it lasts for a shorter period of time compared to neutral faces. (3) Dynamic facial expressions alleviate the AB more than static faces. Experiment 2 addressed the effect of the motion contained in dynamic emotional facial expressions. T1 was a neutral face. T2 was a fearful static, dynamic or scrambled-dynamic face--tailored to show scrambled configural and featural information, avoiding emotion recognition while displaying the same intrinsic motion as dynamic facial expressions. Results confirmed the AB was modulated by emotion and not simply by dynamic targets. These findings suggest that emotional salience plays a critical role in attentional resource allocation during early stages of visual attention.

Decoding psychophysical performance from multi-electrode array recordings in the mouse visual cortex

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Understanding how perception emerges from neural population activity is a central problem in neuroscience. The mouse has been of much recent interest as a model for vision research, due to advances in genetic technology; if murine psychophysical performance can be related to neural activity, it will be possible to genetically manipulate the circuitry underlying perception. In this study we predict the contrast sensitivity curve for C57BL/6J mice as a function of spatial frequency, using recordings of neural activity in the primary visual cortex. We presented a set of full-field vertical sine wave gratings of different spatial frequencies and contrasts monocularly; the same set of stimuli (approximating those used to characterise behavioural performance by Prusky & Douglas, Vision Research 2004 44:3411) were presented at all recording sites in all animals. Single-unit recordings were made using a 16-channel multi-electrode array. On each experimental trial, a spike count response vector $\mathbf{r}$ is observed (one dimension for each recorded cell). To estimate the psychophysical performance of an ideal observer of the neural spike trains, we used a Maximum A Posteriori decoder: on each trial the stimulus is selected according to the rule $s = \mathrm{argmax}\{P^*(\mathbf{r}|s)P(s)/P^*(\mathbf{r})\}$, where the conditional response probability matrix $P^*(\mathbf{r}|s)$ is obtained by compiling the vector $\mathbf{r}$ over all neurons regardless of recording location or animal, and shuffling out noise correlations. Neurometric functions are formed by comparing decoded

and actual stimuli. Preliminary results from 15 neurons indicate that population (rather than single unit) decoding is required to predict behavioural contrast sensitivity.

Extra-foveal processing in visual short-term memory: Facilitatory or inhibitory?

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The utility of extra-foveal processing in visual short-term memory (VSTM) has received relatively little investigation, despite its potential importance in understanding scene memory. This study examined extra-foveal processing in VSTM for object-position binding in two forced-choice recognition experiments. Unfamiliar, nonverbal 1/*f* noise discs served as stimuli, minimising confounds arising from visual long-term memory recruitment and stimulus verbalisation. Four observers viewed 5 equally spaced 2 deg stimuli presented in a ring (13 deg), either serially (experiment 1) or simultaneously (experiment 2). Start position was randomised and pre-cued with a spatial probe. Subsequent stimuli were viewed consecutively in a clockwise direction. An auditory prompt sounded every 650ms such that, in experiment 1, it coincided with the onset of the next stimulus and the offset of the previous stimulus, and, in experiment 2, reminded observers to saccade to the next stimulus. At test, in both experiments, a target stimulus was displayed at the screen centre. Observers were required to identify the spatial position that the target stimulus had occupied in the preceding study display (5AFC). Position choices were annotated with numbered discs. Presenting stimuli simultaneously was found to increase overall hit rate by 21% above serial presentation [$t(3)=6.27$, $p<0.01$]. Interestingly, this effect varied with stimulus recency: for the earliest three stimuli fixated, the simultaneously display was found to be facilitatory; for the fourth stimulus fixated, no difference was observed; for the fifth (final) stimulus fixated, the simultaneous display was inhibitory (verified by 95% confidence intervals). Start position had no significant effect.

A direct comparison of selective adaptation and multivariate pattern analyser methods in fMRI

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A number of fMRI studies have attempted to measure the selectivity of cortical responses on a scale smaller than the spatial resolution of the acquired data (the voxel size) using either fMRI adaptation or multivariate pattern analysis (MVPA). The former utilises the fact that prolonged presentation of a particular stimulus results in relatively selective reductions in response to that stimulus. The latter aims to use the characteristic pattern of activity across voxels in the region of interest, thought to arise from the uneven distribution of neuronal subpopulations across the cortex.

Given that both approaches aim to quantify neuronal selectivity on a sub-voxel scale, we sought to compare the techniques directly. First, we tested whether the results from the methods agree; whether visual areas that show substantial orientation-specific adaptation also exhibit high

classification accuracy. Second, we wanted to know which technique was most sensitive in detecting increasingly small differences in orientation between target stimuli. Data were acquired for three subjects on a 3T Philips Achieva (3mm isotropic voxels, TR 1.5s, TE 40ms).

There was very good agreement between the methods in the measurement of orientation selectivity. Adaptation selectivity and MVPA performance were both greatest in early visual areas (V1-3) and decreased progressively in higher-order regions. MVPA performance remained above chance for all pairs of orientations tested, whereas the selective adaptation failed to distinguish stimuli that were less than 45° apart.

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A visual search asymmetry for bandlimited two-dimensionality

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Search asymmetry is a litmus test for basic visual features (Treisman & Souther, 1985, J Exp Psychol Gen, 114, 285-310). The letter Q is thought to contain a basic feature because i) it can be found quickly, no matter how many O's it is hiding amongst and ii) it is much harder to find an O amongst Q's. I tested the possibility that a basic visual feature is created when two orthogonal Gabor patterns are superimposed to form a "plaid." I found large effects of set size on reaction time whenever observers tried to find a Gabor hiding amongst plaids. Set-size effects were much smaller when observers tried to find a two or four-cycle/degree plaid that was hiding amongst its component Gabors. The implication is that these plaids contain a basic visual feature, i.e. one capable of guiding visual search (Wolfe & Horowitz, 2004, Nature Reviews Neurosci, 114, 285-310), which is not present in its component Gabors. This feature may be the "intrinsic two-dimensionality" that Barth et al (1998, Journal of the Optical Society of America A, 15, 1723-1732) have argued is extracted from the visual intensity map. Mixed-frequency plaids did not pop out from their component Gabors. This last result suggests that the visual system separates intrinsically two-dimensional image regions (e.g. corners and junctions) from intrinsically one-dimensional image regions (e.g. straight edges) after the scene is segregated into parallel spatial frequency channels.

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Transcranial magnetic stimulation (TMS) differentially affects 'signal' and 'noise' depending on stimulation intensity

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Transcranial magnetic stimulation (TMS) has been widely used to causally investigate visual processing, but the precise mechanism behind TMS disruption is uncertain. For example, one view is that the "virtual lesion" paradigm reduces the effective signal strength, which can be likened to a reduction in perceived visibility. Alternatively, other evidence suggests that TMS induces neural noise, thereby reducing the signal-to-noise ratio, which results in an overall increase in discrimination threshold (JND). To resolve this issue, we measured the influence of single-pulse TMS over area V1 during an orientation-discrimination task for four participants. Specifically, we determined orientation JNDs for Gabor patches whilst varying the size of the

envelope, carrier contrast, duration and TMS intensity. Results showed that delivery of a TMS pulse produced a uniform reduction in perceived stimulus visibility for all observers. In addition, an overall increase in threshold (JND) was also observed for two observers, but this effect disappeared when TMS intensity was reduced. We found that the phosphene threshold, the minimum magnetic field strength that reliably elicited illusory flashes of light on 50% of trials, was not a good indicator of sensitivity to a TMS-induced change in JND. Instead a more reliable predictor of discrimination performance was the orientation-based dose-response function. Therefore, single-pulse TMS can both reduce signal strength (perceived visibility) and induce task-specific noise, but these effects are separable, dependent on TMS intensity and individual susceptibility.
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Seeing colour while ignoring motion: selective feature-based attention
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Attending to a particular location can reduce the motion aftereffect (MAE) measured at an unattended region, suggesting that spatial attention can modulate motion processing (e.g. Chaudhuri, 1990, *Nature*, **344**, 60-62). Additionally, it has been suggested that co-localised features (e.g. colour and motion) are bound together pre-attentively (e.g. Blaser et al 2000, *Nature*, **408**, 196-199). We investigated whether attending to a particular feature can modulate the MAE when the attended and unattended features are co-localized. Observers adapted to an expanding pattern of isoluminant coloured dots. During adaptation, they performed either a motion or a colour discrimination task. The resultant MAE was larger when observers attended to stimulus motion than when they attended to stimulus colour. We also measured MAEs using stimuli in which motion and colour were attributed to perceptually distinct surfaces. Small portions of a static colour-patterned background were visible through an expanding pattern of circular 'windows'. We again found larger MAEs when attention was directed to motion (in this case the moving windows). More importantly, attentional modulation of the MAE was larger than in the previous experiment, suggesting that observers were better able to selectively attend to one feature. These results suggest that feature-based attention mechanisms can select a particular task-relevant feature at the expense of irrelevant co-localised features. Furthermore, selection is more efficient if the attended and unattended features belong to different surfaces. These findings contradict the notion that feature binding is pre-attentive and automatic. (239/250 words in maximum)
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A role for contour integration in biological motion processing
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The heightened ability of humans to perceive the characteristic motion of humans and animals, even from points of light marking only the major joints, has led to suggestions of specialised perceptual mechanisms for biological motion. Recent work in the field has focused on the contribution of form and motion information to such mechanisms. While biological motion

perception has been shown not to rely on the local motions of individual dots, the motion relationships between dots have been suggested to be a counterpart to the static form information expressed by the configuration of the dots. This 'opponent motion', expressed through the integration of a number of dots' local motion signals - especially those of limb pairs – has recently been suggested as critical to processing. By creating a point light walker (PLW) composed of Gabor patches instead of dots and yoking the orientation of each Gabor to the path of its opponent motion we aimed to manipulate the strength of the opponent motion signal. Subjects were more sensitive to biological motion when the component Gabor carriers were oriented orthogonally, rather than collinearly, with their opponent motion path. This could readily be explained by proposing a greater opponent motion signal in the orthogonal condition. However we found the same advantage for orthogonal orientation of Gabor carriers in static presentations. Such a carrier orientation improves contour integration for static form, and we suggest that it is this cue that plays the dominant role in our biological motion task.

Crowding effects in suprathreshold discriminations of natural images

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We investigated crowding effects in central and peripheral vision in two suprathreshold discrimination experiments. Observers rated the differences between two small patches of natural images that were presented sequentially. The targets pairs, that were presented alone or amongst four flankers, were either displayed at fixation or at 16 degrees eccentricity in the lower right field. In Experiment 1, the four flankers were identical to each other - either the same as one of the target images (SAME) or completely different (DIFF) - and were located at 5.2, 6.6 or 8.2 degrees (centre-to-centre) away from the target. In Experiment 2, the DIFF distractors were different to the targets and to each other, and were located at 5.2, 8.2 and 11.2 degrees away from the targets. Results from the two experiments were generally consistent: foveally, crowding effects were either very small or absent but, in the periphery, crowding was present in both the SAME and DIFF conditions at close proximities; however the effects for SAME were usually larger. These findings show that crowding effects demonstrated using simpler stimuli, such as Gabors (e.g. Põder & Wagemans 2007, *Journal of Vision*, 7, 1-12), can be reproduced with discrimination tasks using natural images. We postulate that the enhanced crowding effects in the periphery with similar flankers can be attributed to an increased likelihood of mismatched feature comparisons.

Why did the zebra get its stripes?

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Field observations and anecdotal reports suggest that zebra stripes help to conceal individuals amongst the herd, but this has not been demonstrated empirically. Ljetoff *et al.* (2007, Annals of Zoology Fennici, 44, 368–376) proposed that stripes, rather than camouflaging individuals amongst the group, act to amplify weaker, less fit individuals who move oddly. However, such an effect would also highlight younger foals who, by virtue of their immaturity, do not move in

the same way as adults but are equally fit in their reproductive potential. This appears implausible. We tested whether zebra stripes act to conceal younger, and therefore smaller, members of a group when grazing or escaping a predator. Subjects indicated which of two herds of larger patterned rectangles contained a smaller rectangle in a spatial 2AFC task with feedback. In Experiment 1, each herd consisted of 5, 10 or 15 monochrome spotted or striped elements moving at a scale-adjusted speed of 1mph. Accuracy and reaction times were recorded. For smaller herds, pattern had no effect; for larger, more typical, herd sizes accuracy was lower and reaction times slower for stripes than for spots. In Experiment 2, herds moved at either 1 or 30mph (grazing and flight speeds, respectively). There were slower reaction times and increased errors for stripes when compared with spots, and also for faster conditions when compared with slower. These data are consistent with strong selective pressures on the configuration of zebra patterns and suggest one of their successful functions is concealment for young individuals within a herd.

Real-time computer vision with Ruby and libJIT

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Many image processing algorithms can be broken down into atomic operations on arrays. There are unary operations such as additive inverse, absolute value, or square-root and binary operations such as addition or multiplication. While the arrays typically have elements of a single type, this element-type may be a signed or unsigned integer with 8, 16, 32, or more bits, a floating point number, or a complex number. A computer vision library thus needs to implement binary operations for various combinations of element-types. Furthermore binary operations can occur as array-array-, array-scalar-, or as scalar-array-operation. This kind of requirements make it very hard to write a computer vision library in a statically typed language such as C++. However a naive implementation in a dynamically typed programming language such as Ruby will not satisfy real-time constraints. However recently the DotGNU project has released libJIT which is a just-in-time compiler library for i386, x86-64, and other processors. The combination of Ruby, libJIT, and other free software allows interactive development of real-time algorithms in an unprecedented way.