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APPLIED VISION ASSOCIATION

NEWSLETTER

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APPLIED VISION ASSOCIATION
10 KNARESBOROUGH PLACE
LONDON SW5 OTG
Tel: 0171-373-7765 Fax: 0171-373-1143

COMMITTEE OF MANAGEMENT

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email: I_MOORHEAD@dra.hmg.gb

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email: karen.carr@src.bae.co.uk

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email:J.P.Harris@reading.ac.uk

Newsletter: Dr Mark Scase, Dept Human Communication, De Montfort University, Scraptoft, Leicester, LE7 9SU. Tel. 0116 255 1551
Fax. 0116 257 7708
email: mscase@dmu.ac.uk

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email: s.j.anderson@rhbnc.ac.uk

Dr Tim Meese, University of Aston
email: t.s.meese@aston.ac.uk

Dr Barnaby Reeves, 72 Saint Mary's Road, Oxford, OX4 1OB. Tel. 01865-250963

Dr Steve Taylor, 40 Pinewood Road, Ferndown, Bournemouth, BH22 9RR. Tel. 01202 861480

AVA CORPORATE MEMBERS:

British Telecom Research Laboratories, Martlesham Heath, Ipswich, Suffolk IP5 7RE. Contact: Dr D Travis.

Data Cell Ltd., Hattori House, Van Wall Business Park, Maidenhead, Berks., SL6 4UB. Contact: Mr A Washbourn.

Institute for Human Factors TNO, P.O.Box 23, 3769 ZG Soesterberg, The Netherlands. Contact: Dr A van Meeteren.

National Illumination Committee of Great Britain, c/o CIBSE, Delta House, 222 Balham High Road, London SW12 9BS.

Netherlands Ophthalmic Research Institute, Postbus 12141 1100 AC, Amsterdam, The Netherlands. Contact: Dr T. J. T. van den Berg.

Pilkington Optronics, Glascoed Rd.,St Asaph, Clwyd, LL17 0LL Contact: Mr J. Foley.

Sowerby Research Centre, British Aerospace, P.O.Box 5, Filton, Bristol BS12 7QW. Contact: Dr KT.Carr.

Deadline for copy for the next Newsletter - 20th December 1996

EDITORIAL

This is my first issue as Newsletter Editor. Graham Edgar has done a splendid job over the years editing this newsletter and I hope I will be able to keep up the high standard. At a recent meeting of the Executive Committee of the AVA it was decided to publish all of the abstracts for AVA meetings in the newsletter irrespective whether the meeting organiser had arranged publication elsewhere. That way AVA members could use the newsletter as a source for all AVA meeting abstracts rather than having to search through a number of journals. In this issue there are the abstracts of the last AVA scientific meeting, AVA'96 at Reading. If you have any comments on the newsletter, want something included (or left out) then do contact me: mscase@dmu.ac.uk

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

Noticeboard

Geoffrey J. Burton Memorial Fund

The fund was established in 1986 with the aim of providing financial assistance to students (in non-established or fixed term posts) travelling to conferences or meetings at which they will be presenting a paper or poster. Donations to the fund can be directed to the AVA secretariat and cheques etc. should be made payable to “The Geoffrey J. Burton Memorial Fund”.

The maximum award to any one individual is £200 and awards can be made for any conference in the calendar year in which the award falls (1997 in this case).

Applications can now be made for any conferences in 1997, although a decision on the distribution of the award(s) will not be made until the AGM of the AVA in 1997.

Full details of the GJB Memorial Fund are contained in the January issue (No. 112) of the Newsletter.

AVA on the World Wide Web

The Applied Vision Association now has its own world wide web pages at:

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

The pages contain details of who is on the committee, contact emails, AVA meetings and links to other vision related pages.

AVA and OPO Subscriptions

Membership for 1996/1997 is the same price as last year. However, the price for OPO subscriptions has increased slightly. Those members who pay by standing order please don’t forget to amend your standing order accordingly.

Obituary

Professor GD Sullivan

Geoff Sullivan died in August, at the age of 52, just over a year after he had been appointed to a personal chair of computational vision at the University of Reading. Over more than a decade, through their long-established collaboration, Keith Baker and he built up their Intelligent Systems Research Group into an internationally-renowned centre for research and development in machine vision, especially the problem of object recognition. Geoff was active nationally as Treasurer of the British Machine Vision Association, as well as on research council committees. Through his links with the BMVA, and through his contributions at our meetings, he was a good friend of the AVA.

Although he was a professor in a Department of Computer Science, Geoff's many interests included biological, as well as machine vision. After reading mathematics at Oxford, he took the MSc conversion course in Experimental Psychology at the University of Sussex. He stayed on at Sussex as a research student (though he never submitted a thesis: all his papers were destroyed in a fire towards the end of his studentship), and later as a research fellow. He later moved (with Keith Baker) to Plymouth, and subsequently to Reading. Two of the papers on human vision from his time at Sussex (one on 'contrast constancy' with Mark Georgeson, and one on vernier acuity with Keith Oatley and Stuart Sutherland) have become classics. His lecture courses to computer science students at Reading included much material on human vision, and he was always ready to try to link computer science and biology.

Geoff was a keen supporter of the internal vision research seminars in the Psychology Department at Reading. Sometimes he could appear too keen, and had to be dissuaded from taking over other people's presentations ! He could seem somewhat intimidating to research students presenting for the first time: you needed to know him to realise that he could be just as tough on his own ideas when he thought they were in error.

Ideas came easily to Geoff. He was a genuinely creative scientist, though he could be impatient with some of the ground-rules that psychologists have set out for their discipline. He had little time for the Analyses of Variance and all the control conditions which form a tedious if essential part of cognitive psychology. The document which I wrote before this one was the final report to the funding body of a project which we had together, and which he never saw. It would have been a different and a better report for his input, but it would also have been more fun to produce. The details of first and second drafts would have been thrashed out over a pint of beer after work, just as we thrashed out the ideas that got us the grant in the first place.

Geoff's funeral brought together an enormous range of people reflecting his different interests. Fellows of the Royal Society, to be sure, but also friends with whom he went walking or played his viol (an instrument which he had made himself). The untimely death of a vibrant and talented person made the occasion especially poignant. In the case of some academics, the difference between life and death would be scarcely a JND: Geoff Sullivan was about as far from that as you could get.

John Harris

Mark Georgeson adds:

Geoff and I were research students together at Sussex in the early 70's - a very exhilarating time and place to be doing vision research. Geoff was my de facto supervisor, and I learned an enormous amount from him about psychophysics, systems theory and electronics - but even more importantly perhaps I acquired a view on how to tackle research problems and how to argue. Fierce argument was a feature of Sussex life then - scientific debates seem much tamer now. The fire (mentioned above) nearly consumed my thesis work as well as Geoff's, and the contrast constancy data were saved only by the then normal practice of keeping data (hand-written) in thick ledger-type notebooks. The fire ate through the thick covers, but didn't do much to the pages inside. Visual de-blurring was saved; I have the charred remains to this day as a reminder of the personal and scientific inspiration I received from Geoff.

Geoff was always interested in visual technology as well as biological vision. I recall how he was struck one summer by the difficulties TV cameras face when a strong shadow is cast across the scene, such as the shadow of the stand falling across the court at Wimbledon. The camera has limited dynamic range and cannot set the exposure appropriately for the dark and bright parts of the scene at the same time. Geoff realised that the camera needed local adaptation, rather than a global exposure setting, and promptly set about building an image-processing circuit that would implement lateral inhibition, and so compensate for regional differences in illumination. The prototype device worked rather well, but unfortunately the BBC could not be won over, and the idea was lost to the world.

In the mid-70's the super-nova of David Marr burned brilliantly in vision research. Marr's seminal Royal Society papers were encouraged and to some extent shaped by Stuart Sutherland, and so Marr visited Sussex on one or two occasions. These visits, and Marr's early MIT technical reports, had a major impact on the way Geoff began to think about visual processes, and his transition from working in human vision to active research in machine vision can be traced to these influences. It was clear to him that important ideas were emerging very rapidly in machine vision, and that they could be tested and developed without the tedious difficulties of psychophysical experiments. Geoff was won over, and his career in computational vision had begun. Our ways parted soon after, but we kept in touch, and I shall miss him greatly.

References to some of Geoff Sullivan's work on human vision:

Sullivan G D, Georgeson M A & Oatley K (1972) 'Channels for spatial frequency selection and the detection of single bars by the human visual system'. Vision Res. 12, 383-394.

Sullivan G D, Oatley K & Sutherland N S (1972) Vernier acuity as affected by target length and separation. Perception & Psychophysics 12, 438-444.

Georgeson M A & Sullivan G D (1975) Contrast constancy: deblurring in human vision by spatial frequency channels. J. Physiol. 252, 627-656.

Sullivan G D (1983) Perceptual filters. In Braddick O J & Sleigh A C (eds.) "Physical & Biological Processing of Images", pp.115-126. New York: Springer-Verlag.

AVA books for sale

The AVA has a number of new books for sale from conferences that it has organised over the years.

The cost for each book is £15 (including postage in the UK) for AVA members or £20 for non-AVA members. If you are outside the UK then add £5 per book to each of the prices above.

Payment can be by cheque or postal order in UK pounds (sorry, no credit cards) to “Applied Vision Association”. Send your payment with the order to:

AVA Secretariat,
Applied Vision Association,
College of Optometrists,
10 Knaresborough Place,
London SW5 OTG.

Books available:

Gale, A.S., Astley, S.M., Dance, D.R. and Cairns, A.Y. (1994) **Digital Mammography**. Elsevier (424 pages).

Gale, A.S., Freeman, M.H., Haslegrave, C.M., Smith, P. and Taylor, S.P. (1988) **Vision in Vehicles II**. North Holland (420 pages).

Gale, A.S., Brown, I.D., Haslegrave, C.M., Kruysse, H.W. and Taylor, S.P. (1993) **Vision in Vehicles IV**. North Holland (355 pages).

Brogan, D., Gale, A. and Carr, K. (1993) **Visual Search 2**. Taylor and Francis (477 pages).

Meeting Report

Visit to the Bristol Exploratory

On the evening of October 17th, 26 AVA members and guests visited the Bristol Exploratory, the interactive science centre at Temple Meads station. The exhibits (or Plores) are housed in the old engine house, designed by Isambard Kingdom Brunel. During the evening, Professor Richard Gregory FRS, whose brain-child the Exploratory is, and who has provided much of the driving force behind its development, spoke to us about the ideas behind the centre and outlined its history, in a fascinating talk in which he shared his enthusiasm for science and for explaining science. The audience was impressed by some of the statistics in the talk, especially mention of the £42,000,000 which has been raised to build and equip a new Exploratory in a purpose designed building. However, this did not stop them tackling with enthusiasm the buffet supper and wine which followed, or from Exploring the exhibits and chatting for the rest of the evening. We are very grateful to Professor Gregory and to the Exploratory staff for their contributions to an enjoyable evening. One member of the committee was so impressed that he raised the possibility of another similar event, perhaps at a London museum, and was even heard to say that he would be prepared to organise it. The rest of the committee is urging him on. Watch this space for news of more AVA social events with added science!

Locus Questions in Vision

18th December, 1996

The Applied Vision Association (AVA) will be holding a one-day meeting in the Department of Vision Sciences at Aston University (UK) on Wednesday 18th December.

The cost:

The cost of registration will be £14 sterling (£8 for students) and cheques should be made payable to "Applied Vision Association". Foreign visitors may delay payment for registration until the day of the meeting. The registration fee will cover: tea/coffee, lunch time buffet and fruit juice or wine in the early evening.

The Department:

The Department of Vision Sciences, headed by Prof David Foster, is the largest Optometry Department in the UK. It is situated at the heart of Aston's attractive landscaped campus which is itself in central Birmingham.

For further information, the Department's web address is:
http://www.vs.aston.ac.uk/

Further details:

For further information, payment of registration fees, or requests to be included on the mailing list, please contact:

Dr Tim Meese (AVA)
Department of Vision Sciences,
Aston University,
Aston Triangle,
Birmingham,
B4 7ET
UK
E-mail: t.s.meese@aston.ac.uk

Preliminary Programme

Locus Questions in Vision

Department of Vision Sciences, Aston University, r102.

Wed 18th December.

10.30-11.00: Arrival and refreshments.

11.00-11.45: M. A. Georgeson. “Locus hocus-pocus: towards a functional architecture for early spatial vision.”
11.45-12.00: M. Lages & M. Treisman. “Visual memory for orthogonal spatial frequencies.”
12.00-12.15: P. W. McOwen & A. Johnston. “Evidence for perceptual grouping indicates a late rather than an early site supporting transparent motion.”
12.15-12.30: J. J. Kulikowski & A. Robson. “Low-contrast stimuli activating parvo- and magno- streams.”

12.30-1.30: Lunch.

1.30-2.15: N. J. Wade. “Frames of reference in vision.”
2.15-2.30: N. Bruno & M. Bertamini. “On the status of a ‘proximal’ stage in vision.”
2.30-2.45: A. Sahraie, L. Weiskrantz, A. Simmons, S. C. R. Williams, J. L. Barbur. “Conscious & unconscious processing of visual signals: Psychophysical & fMRI studies.”
2.45-3.00: J. Moreland & C. Alexander. “Which part of the field matters in colour matches?”

3.00-3.30: Tea and biscuits.

3.30-3.45: S. Mackie & M. R. Baker. “Using the Pulfrich effect to compare luminance-dependent processing delays in colour vision.”
3.45-4.00: A. Wilkins. “Pattern glare, reading and chromaticity.”
4.00-4.15: L. M. Doherty & D. H. Foster. “The effect of line length on oriented-line-target detection in early vision.”
4.15-4.30: J. P. Harris, C. I. Attwood & G. D. Sullivan. “Learning to search for 2D and 3D targets defined by edges and by

shading."

4.30-4.45: E. Ashbridge, V. Walsh & A. Cowey. "A study of visual search using Transcranial Magnetic Stimulation of the parietal cortex."

4.45-5.00: V. Walsh & A. Ellison. "Locus of learning in visual search."

5.00->: Wine and posters, including:
M. Wright. "Does analysis of relative visual motion require two computational stages or three?"
I. E. Holliday, S. J. Anderson & G. F. A. Harding. "Magnetoencephalographic (MEG) evidence for non-geniculostriate visual input to human cortical area V5."
A. Todman & E. Claridge. "Low-level grouping mechanisms for contour completion."

AVA '97

Image Quality

9th - 11th April 1997

University of Abertay, Dundee

CALL FOR PAPERS

The 1997 Annual Meeting of the Applied Vision Association will be based around the themes of image quality, image attributes and image coding.

KEYNOTE SPEAKER : ANDREW WATSON (NASA AMES RESEARCH CENTRE)
Talk : Image Quality (Geoffrey J Burton Memorial Lecture)

Image quality may not determine but it can limit human visual information processing. Many with a superficial understanding of the area view image quality as largely redundant because of improvements in display technology and image processing.

However, medical, military, office and other forms of imaging technology suggest this is far from the truth. At its limits human vision is far better than the quality of images provided by monitors in office document processing systems and the effects of temporal quality on performance is currently under examination. In military and medical imaging designers are seeking to enhance visualization of unnatural images to aid detection, discrimination and recognition. Temporal and spatial image qualities are also of interest to the clinician because patients may experience a loss of certain image qualities which the clinician must interpret in terms of behavioural sequelae.

The Applied Vision Association has four broad areas of interest for this meeting. Applied research in imaging/product design, academic research on the effects of image quality in normal and disordered vision, modelling of the effects of image quality on visual performance and an open contributions section. It is expected that the presentations on the 10th April will largely consist of industrial and governmental presenters discussing applied problems and the academic and clinical papers will appear on the 9th and 11th of April.

Open contributions will be accepted, on any vision-related topic. In addition to talks, a poster/demonstration session (combined with a reception) is planned, for which submissions from post-graduate students would be especially welcome. The AVA committee intends to offer one or more prizes of 50 pounds (depending on the number and quality of submissions) for the best post-graduate/post-doctoral posters or demonstrations.

Please send abstracts (200-300 words, deadline 6 December 1996) and expressions of interest to:
N.B. Send your own full postal address, telephone, fax and e-mail.

Dr M.J. Cook,
Division of Psychology,
School of Social Science,
University of Abertay Dundee,
Bell Street,
Dundee,
DD1 1HG

Tel: 01382 308749
Fax: 01382 308877
e-mail: m.cook@river.tay.ac.uk

Meeting Abstracts
AVA ’96 From Sensation to Visual Perception
University of Reading 1st - 3rd April 1996

A model for controlling eye movements in multi-fixation search.

I. Th.C. Hooge and C. J. Erkelens
Helmholtz Instituut, Princetonplein 5, Utrecht University, 3508 TA Utrecht, The Netherlands.
Fax: +31 30 2522664; Email: i.hoogefys.ruu.nl

During multi-fixation search the visual system and the motor system work in close co-operation. During fixation the foveal target has to be analysed, the peripheral field has to be sampled and a new eye movement has to be prepared. We present a schematic model which describes multi-fixation search in large displays. The model is based on recent experimental results. The visual field of the model contains a foveal and a peripheral part. Foveal analysis provides two kinds of information. Firstly, it decides whether the target is present at the fovea or not (WHAT). Secondly, it gives information about the time needed to analyse foveal targets (WHEN). Peripheral analysis provides potential targets for eye movements (WHERE). Peripheral and foveal analysis occur in parallel. Fixation durations are pre-programmed. Thus, the duration of a fixation does not directly depend on the time needed for the analysis that occurs during that particular fixation. Timing of saccades is based on cognitive factors such as strategy, prior experience and estimated difficulty of the foveal analysis. So, foveal search indirectly affects fixation durations, peripheral search does not. In the case of a recognised target the WHAT system sends a signal to the saccade generator to stop the production of saccades. Due to pre-programming of fixation durations the “cancel” signal may reach the saccade generator too late. These late cancellations result in return saccades. The model adequately describes relationships between performance, distributions of fixation durations and occurrences of return saccades in multi-fixation search.

Making Sense of Sensors: An Exploration into the Effects of Stimuli and Sensor Design on Active Fixation

H. Tunley and D.S. Young
School of Cognitive and Computing Sciences, University of Sussex, Falmer, Brighton, Sussex BN1 9DQ, UK

Purposive visual system design currently provides solutions to useful but contrained visually-guided tasks such as determining time to contact or egomotion. Restricting the design process to the visual control of simpler behavioural subtasks such as these will arguably allow the development of a

clearer understanding of the kinds of information which are pertinent to more general applied vision systems. However, despite emphasis on the importance of input information as a guide to action, little attention has been given to the design of the active sensor picking up this information, or the fact that careful consideration of its design could greatly enhance efficiency by supplying information in a more useful form for the visual system.

The work described here is an example of this purposive/active approach which concentrates on the design of an actively-fixating sensor working with moving random-dot pattern (RDP) stimulus. The use of RDP allows a constrainable (but wide) range of spatial frequency detail to be used which can be manipulated by altering the dot sizes and the degree of gaussian filtering, as well as the inter-frame displacement. The sensor design variation lies in the degree of non-uniform sampling it carries out. By altering the relative size of the central, uniformly-sampling 'foveal' region a design can be created which effectively turns the sensor from a purely uniform-sampling sensor to a anthropomorphic log-polar sampling sensor, with a number of hybrid designs in between. Examining the fixating abilities of each sensor for a range of spatial-frequency-varying RDP, and using psychophysical results from the motion perception of RDP as a guide, allow conclusions to be drawn concerning the most promising sensor design to work in a given visual environment. Results suggests that a pure uniformly-sampling sensor places unneccessarily strong constraints upon the kinds of stimuli which can be reliably tracked, whilst hybrid designs perform better over a wider spatial frequency range.

Does the level of attentional processing differentially affect adaptation to moving stimuli?

M.S. Georgiades and J.P. Harris
Department of Psychology, University of Reading, Whiteknights, Reading RG6 6AL, UK

The mechanisms of attention in early visual processing were investigated by studying attentional effects on adaptation to moving stripes. It is already known that, when subjects have to report the identity of changing digits at the fixation point, movement aftereffect duration is reduced compared with when they are not required to process the digits (1). In the present studies, subjects fixated a sequence of changing digits at the centre of a rectangular window of high contrast drifting stripes. The stripes were of one of 2 spatial frequencies: higher (2 c deg^{-1}) or lower (0.5 deg^{-1}). Attentional load was varied by presenting an unchanging zero as the fixation point (normal), or a sequence of digits which the subject had to report them aloud as they changed and selectively to respond to either a 4 or a 7 with a 'YES' (diverted), or a similar sequence without the need to report or respond (passive attention). The duration and velocity (measured by matching) of MAEs were measured as indices of the effects of attention on adaptation. The effects of diverting attention were greater for the higher than for the lower spatial frequency, suggesting that the processing of finer spatial detail requires more attention than of coarser detail. MAE velocity and duration were progressively reduced by increases in attentional-cognitive load. Enlarging the blank window around the fixation digits reduced the effects of all attentional conditions, suggesting that the attentional effects are strongest close to the fixation point. Control experiments showed that the effects of reporting the digits on adaptation did not reflect unusually precise fixation, since moving the fixation digit randomly to different locations reduced rather then enhanced MAEs. The results confirm that diverting attention can affect motion-sensitive mechanisms which are thought to occur early in visual processing, and suggest that withdrawal of attention preferentially affects higher spatial frequency processing.

1. A. Chaudhuri (1990) Nature, 344, 60-62.

The additive effect of higher-order influences on the visual accommodation response

G.K. Edgar and C.A. Reeves
Sowerby Research Centre, British Aerospace (Operations) Ltd., FPC 267, PO BOX 5, Filton, Bristol, BS12 7QW, UK.

The visual accommodation response appears to be driven by both visual (blur) cues and also higher-order influences such as perceived distance and mental effort. The aim of this study was to examine whether the two higher-level influences mentioned above have an additive effect on the accommodation response. Perceived distance was manipulated by superimposing one stimulus on top of another so that occlusion cues would suggest that the superimposed stimulus was closer. A mental processing task (subtracting seven from a two digit number) was also used that could be dependent on the superimposed stimulus (the information was presented visually) or independent of it (the information to be processed was presented aurally).

The data suggest that both the superposition of stimuli and the mental processing task could, independently, affect the level of accommodation and that, when the two elements were present together, the effects on the accommodation response were additive. The data further suggest that the combined effects of different higher-order influences may be mediated by attentional factors.

Spatial filters, zero-crossings and the tilt aftereffect.

Mark A Georgeson[1] & Tim S Meese[2]
[1] *School of Psychology, University of Birmingham, Birmingham B15 2TT, U.K.*
[2] *Department of Vision Sciences, Aston University, Birmingham B4 7ET, U.K.*

The perceived structure of plaids suggests that oriented edges in these 2-D images are found at the location of zero-crossings (ZCs) in a neural response array ('neural image') which is formed as the sum of the outputs from different oriented filters (1). The summation across oriented filters emulates circular filtering and the model behaves like the Marr-Hildreth model (2), correctly extracting vertical and horizontal ZCs from plaids that contain only oblique Fourier components. This contrasts with the orthodox view that orientation is encoded by the peaks of activity across a set of oriented filters (3). This view makes incorrect predictions for plaids, but accounts well for tilt illusions and the tilt aftereffect (TAE) where the response distribution is shifted by adaptation (4). On the ZC account, however, no TAE is predicted because vertical ZCs would remain vertical in the neural image, no matter how the sensitivity of the filters was affected by adaptation. A revision of the ZC model is clearly required.

After adapting to gratings, we found that the ZCs of a plaid appeared to tilt, or shift in their relative positions, in the way that would occur if the Fourier components of the plaid were physically rotated. That is, both the orientation and position of parts of the plaid's components appear to be shifted by adaptation, and the global change in ZC pattern is a direct consequence. We outline a model with the following stages: (i) Oriented spatial filters compute a Gabor or other wavelet transform of local, overlapping patches of the image; (ii) Adaptation distorts this transform (as in the orthodox account), and hence distorts the geometry of each patch; (iii) After inverse transformation, the patches are summed together across space to form a neural image, with adjustment of patch positions to maximize the contrast energy (and hence the overall coherence) of the neural image; (iv) ZCs are found in the neural image. In this model adaptation alters only the sensitivity of the tuned filters, but because of the positional adjustment (or 'jiggling'), distortion of the local patches is expressed in the global ZC pattern. The natural role for 'jiggling' may be to correct for spatial error (receptive field 'scatter') in the mapping from retina to cortex (5).

1. Georgeson, M. A. Proceedings of the Royal Society B 249, 235-245 (1992).
2. Marr, D. and Hildreth, E. (1980) Proc. Roy. Soc. Lond. B207, 187-217.
3. Sekuler, R. & Blake, R. Perception (3rd ed.) New York: McGraw-Hill. (1994).
4. Coltheart, M. Psychol. Review. 78, 114-121 (1971).
5. Hubel, D.H. and Wiesel, T.N. J. Comp. Neurol. 158, 295-306 (1974).

The Linearity of Early Visual Analysis

K.Langley[1], D.J.Fleet[2], and P.B.Hibbard[1]
[1]*Department of Psychology, University College London, Gower Street, London WC1 6BT, U.K.*
[2]*Departments of Computing Science and Psychology, Queen's University, Kingston, Ontario, Canada.*

Early stages of visual processing are often modelled as linear, although nonlinearities are known to exist. A central issue concerns the stage at which such nonlinearities become significant. Subjects were adapted to a high contrast sinusoidal grating followed by a brief presentation of a contrast modulated test pattern. Thresholds for the detection of the contrast modulation (the beat) were measured. Results show that threshold elevation depends significantly on differences in orientation and spatial frequency between the adapting grating and the principal Fourier frequency (carrier) of the test pattern. Moreover, our data also suggests that the mechanism that mediates contrast detection is itself spatial frequency tuned with a peak tuning frequency at around 0.425 cycles per degree. The data are consistent with a model in which the contrast beats are processed by a frequency-specific manner, after an initial stage of frequency- and orientation-specific linear filtering.

Incorporating models of early vision processing into virtual reality

M. Reddy
Department of Computer Science, University of Edinburgh, JCMB 1408, King's buildings, Mayfield Road, Edinburgh, EH9 3JZ, UK

Recent models of early visual processing espouse a computational approach to vision. Such computational theories can in principle be implemented on a computer system to demonstrate their utility and efficacy. However with the development of computer graphics technology, another form of computer simulation can be envisioned: that is, to visually experience the effects of a model. Thus, a model of human early visual processing has been incorporated into a real-time, 3D graphics system; commonly referred to as virtual reality (VR). Specifically, it will be demonstrated how models of spatiotemporal contrast sensitivity can be encoded efficiently into a VR system. With this knowledge, the VR system can then decide to remove certain regions of detail from a scene which it believes to be sub-threshold (based upon attributes of the model such as its velocity, eccentricity, distance, orientation etc.). Effectively, by degrading the sensations which are presented to the visual system, we can investigate the information that is available to the higher vision processes. Also, because the inherent latencies of contemporary VR systems are aggravated by the amount of detail in a scene, this also has the

potentially beneficial effect of improving the interactivity of VR technology. However, it is hoped that the development of this kind of tool will not only produce a more efficient interactive graphics system, but also provide a flexible mechanism to evaluate models of threshold vision in a simulated, real-world and full-colour environment.

Modelling retino-cortical image-conditioning to achieve automatic recognition

N.D. Haig, D.J. Main and I.R. Moorhead
WX1 Dept (Blg Q7), Defence Research Agency, Fort Halstead, Sevenoaks, Kent TN14 7BB, UK

Many attempts have been made to achieve automatic recognition. Most of the methods attempted, usually in the fields of physical optics or computer-based image processing, were rigid and mechanistic. This inevitably led to difficulties with scaling or orientation, or the techniques otherwise lacked tolerance of variable imaging conditions.

In considering the demands upon a recogniser, we concluded that the Self-Similar Stack model of human vision (1) is ideally configured as the front-end image conditioner for an automatic recognition system. The salient reasons for this are, firstly, that this model, which mimics some of the requisite mechanisms of human retinal vision, is simple to program recursively. Secondly, it acts as an automatic normalisation device that feeds the conditioned signals into arrays of small neural networks. We have found that such conditioning is necessary for the stable operation of such simple nets. These nets act in a similar way to the primary visual cortex, which also operates on similarly conditioned neural signals, and selects arrays of primitive features in natural images.

The system, as constructed so far, will be described and its activities illustrated by a comparison of the input image features and the output coding of those features. The results of some parametric optimisation experiments will be shown, together with assessments of the efficiency of the feature extraction processes. Full recognition has yet to be achieved, as the system is still incomplete, but we will briefly discuss the proposed way ahead.

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The functional role of neuronal synchronization in a large-scale network model of visual processing

R Goebel

Max Planck Institute for Brain Research, Deutschordenstr. 46, D-60528 Frankfurt/Main, Germany

We present a neurobiologically motivated network model that specifies in detail plausible computational mechanisms for the segmentation, selection, and recognition of objects. A major goal of this work is to analyze putative functions of neuronal synchronization within a large-scale network model performing complex visual tasks. The model consists of 12 simulated modules which are organized into two main processing routes, the ‘where-pathway’ dealing with location information and the `what-pathway’ computing the shape and attributes of objects. Invariant object recognition is supported through the segmentation of the visual field into distinct entities. In order to represent different segmented entities at the same time, the model uses a powerful oscillatory binding mechanism. Connections between the where-pathway, the what-pathway and short-term memory modules lead to a flexible cooperation between different functional subsystems resulting in complex overall behavior including top-down segmentation, texture segregation, spatial and object-based attentional selection, visual search, position- and size-invariant shape recognition, structure-from-motion and attentional selection of different levels of hierarchical stimuli. The model delivers an explanation of many experimental findings made both in physiological recordings from the visual cortex and in psychophysical studies.

Neglect phenomena in a neural network model of visual attention and object recognition

J Schwarzbach[1] & R Goebel [2]

[1]*Institute for Psychology, Technical University, Spielmannstr. 19, D-38106, Braunschweig, Germany*

[2]*Max Planck Institute for Brain Research, Deutschordenstr. 46, D-60528, Frankfurt am Main, Germany*

In unilateral neglect patients fail to respond appropriately to stimuli presented on the side of space contralateral to their lesion. Neglect can be caused by lesions in different neural areas e.g. frontal, parietal, and subcortical. Among the many symptoms of neglect ,extinction after double simultaneous stimulation is the most persistent. In extinction, patients can detect a single stimulus in the affected contralesional halfspace, but the same stimulus seems to disappear when it is flanked by a second stimulus or distractor on the ipsilesional side. We simulated extinction in a neural network which was either damaged in the modules corresponding to the pulvinar nucleus in the thalamus (SELECTION-MAP) or areas 7a and LIP in the parietal lobe (M-

7A, M-LIP). Our aim is to discuss neglect phenomena (especially extinction) in terms of visuospatial attention which can be characterised in our model as biased competition of candidates for object recognition taking place on the SELECTION-MAP. Spatial competition is influenced by stimulus parameters (saliency) and activity of modules corresponding to parietal areas: an attentional vector on M-LIP and spatial 'markers4' on M-7A. Activity of M-LIP can be influenced by task demands or a spatial short term memory simulated in modules corresponding to areas in the frontal lobe. Damaging SELECTION-MAP leads to a direct competitional disadvantage for stimuli represented in the affected area. Unilateral damage on M-7a leads the attentional focus on M-LIP to be attracted to the intact side (biased exploration, incomplete representation of space) although some residual activity of neglected information can be found in the object recognition module corresponding to the inferior temporal lobe (M-IT). Attentional cueing results in a normal performance of the damaged model for valid and to a specific deficit for invalid spatial cues. We propose a tentative explanation of so called 'extinction-like reaction time patterns' not due to a defective disengagement mechanism but a difficulty to attract spatial attention.

To see or not to see: on unilateral hysterical blindness

M.O. Scase[1] and M.C. Lawden[2]

[1]*Department of Human Communication, De Montfort University, Leicester, LE7 9SU, UK*

[2]*Department of Neurology, Leicester Royal Infirmary, Leicester, LE1 5WW, UK.*

We report the curious case of a 27-year-old woman, SB, who reported that over a two week period the vision in her left eye deteriorated from normal to no perception of light. Clinical examination revealed no obvious pathological cause for her unilateral loss of vision. There was no clear evidence either of a psychiatric disorder that may have precipitated hysteria or of any reason that SB may be malingering to gain some advantage by pretending to be visually defective. Visual evoked potentials produced by a reversing checkerboard pattern were normal both in amplitude and latency. Results from a lumbar puncture were normal. An MRI scan did not show any lesion in SB's brain. Optokinetic nystagmus was normal in both eyes. Snellen visual acuity was 6/6 in the right eye but not measurable in the left eye. Similarly, near vision was not measurable in the left eye but N5 in the right eye. Luminance and chromatic sensitivity was assessed psychophysically by measuring increment thresholds to white and red flashes of light, respectively. Motion sensitivity was assessed by measuring motion coherence thresholds for moving random dots. A two-interval forced-choice procedure with the method of constant stimuli was used and data were plotted as a psychometric function. Results from SB's right eye were normal with data for correct responses at approximately 50% (chance performance) for low-intensity stimuli rising to 100% correct for high-intensity stimuli, corresponding to stimuli below and above threshold respectively. Data from SB's left eye for low stimulus intensities were approximately 50% correct as would be expected. For high stimulus intensities, there was evidence that performance was much less than chance. This result for high stimulus intensities is consistent with SB giving incorrect responses suggesting a diagnosis of unilateral hysterical blindness. Furthermore, the strongest evidence to suggest that this was a case of hysterical blindness was that SB had functioning stereoscopic depth perception as assessed by the Lang Stereo Test and TNO Test for Stereoscoptic Vision: SB was able to detect disparities as small as 120 sec arc. Theoretical mechanisms of hysterical blindness will be discussed.

Extension of the mLGN hypothesis of dyslexia?

J. Iles, V. Walsh & A. Richardson.
Department of Experimental Psychology, University of Oxford, Oxford OX1 3UD,UK.
e-mail: Vincent.Walsh@psy.ox.ac.uk; Tel:01865 271359; Fax: 01865 310447

Dyslexia is a developmental disorder affecting up to 10% of the population who, despite adequate intelligence, education and opportunity, have a specific disorder in reading. In addition to the evidence that phonological deficits underpin some aspects of dyslexia there is also increasing evidence that some dyslexics have low level visual deficits, for example in coherent motion perception. Correspondingly in the magnocellular layers of lateral geniculate nucleus (mLGN) of dyslexics one sees smaller cells and less organization than in the mLGN of control brains. However, it is difficult to relate the simple properties of mLGN cells to the complex requirements of reading. Given the antomical continuity between a sub-population of mLGN cells and the parietal cortex, one might expect subjects with deficits related to mLGN dysfunction to be impaired on tasks which require the kinds of visuospatial attention to which parietal cortex contributes. To examine this possibility we tested three groups of subjects on eight visual search tasks: a control group of normal reading ability; a dyslexic group with elevated motion coherence thresholds (MD); a dyslexic group with normal motion coherence thresholds (nonMD). On all tasks the MD group were significantly slower than the controls and slower than the nonMDs. The results were not a consequence of simple motor reaction times (RT). On all tasks the MDs showed the same pattern of RTs as the controls and nonMDs (i.e. all groups performed the same tasks as parallel or serial), suggesting that there was no qualitative difference in the strategies used by the groups. On two of the tasks there was an interaction between group and number of distractors. Two tasks were designed to incorporate components of reading operations but the MD's deficits were not exacerbated on these tasks. It appears that there is some continuity, or correlation of deficits in a subgroup of dyslexic subjects (MDs) but it does not necessarily follow that the deficits are related to specific reading disorder.

Sensitivity to expressive signals from the human face: Psychophysical and neuropsychological investigations

J. Jenkins, V. Bruce, A. Calder and B. Craven
Department of Psychology, University of Stirling, Stirling, FK9 4LA, UK
Fax: +44 1786 467641; E-mail: jaj1@stir.forth.ac.uk

We investigated sensitivity to facial expressions using both a 2-AFC and a signal detection paradigm. The task required discrimination between an expression (one of: happiness; sadness; anger; disgust; fear and surprise) and a neutral face of the same actor. Manipulating the viewing distance revealed different signalling strengths for the 6 expressions tested. The detection threshold for happiness and surprise was reached at an equivalent viewing distance of 40m. This contrasts with Hager & Ekman's prediction (1) that these expressions would be identifiable at distances up to and perhaps exceeding 100m. At this viewing distance, the face subtends 0.086 degrees of visual angle. Sadness is least reliably recognised with performance fluctuating around chance for all but the shortest viewing distance (10m). The experiment was repeated with the full greyscale images rotated by 180 degrees. Performance was severely impaired with chance levels being reached for all expressions between 20 and 30m indicating the processing of the stimuli as faces and not just complex stimuli since inversion only trivially effects image properties.

In a 6 way forced choice expression naming task, controls identify the exemplars of the image set with 100% accuracy. S.E., a post-encephalitic patient with bilateral amygdala damage showed a severe impairment in the labelling of fear in the forced choice task, (comparable to that obtained by Young et al using the Ekman faces set) and impaired ability with the expressions of disgust and sadness in a free naming task. However, S.E.'s performance in the psychophysical expression discrimination task was comparable to that of controls suggesting that his difficulties lie in the *interpretation* of facial expressions rather than in face pattern perception.

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Would a colour by any other name be found as fast…?

S.J. Guest and D.L. Van Laar
Department of Psychology, University of Portsmouth, King Charles Street, Portsmouth, PO1 2ER, UK

Maximally discriminable colour sets are often used in computer displays to facilitate task performance. Such sets are usually derived by ensuring high minimum and high average perceived differences between pairs of colours within the set. These differences are identified by a metric known as ΔE. If the smallest ΔE in the set is greater than a critical value, then all discriminations will be equally fast (1). Many algorithms exist to ensure colour sets have the required minimum value (2,3). Ensuring this minimum value in any set of colours becomes more computationally intensive, the greater the set size.

Recently it has become apparent that choice-reaction times to colours do not depend only on the physical differences between colours, but also on the names of the colours (4). This points to a possible inadequacy in current colour set production methods since the effect of colour name boundaries is rarely taken into account. Incorporating knowledge of name boundaries in the production of colour sets may mean that they have lower ΔE values than those based purely on physical colour differences, but have similar or superior performance on name related tasks.

In order to investigate this possibility, subjects took part in a colour naming and colour search task. Sets of highly nameable colours were generated from a previous study (5). Reactions to these colours were compared with ΔE matched sets and maximally discriminable sets in both of which nameability was not constrained.

It was found that nameability was an important factor in name based search and identification tasks. The results of the experiment will be discussed in the light of an updated physiologically plausible model (6) linking colour language to colour discrimination.

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Colour constancy as a function of typical hues

J. J. Kulikowski, Z. Al-Attar and H. Vaitkevicius
Visual Sciences Laboratory, Department of Optometry & Vision Sciences, UMIST, P.O.Box 88, Manchester M60 1QD, UK.

Colour constancy differs for various hues (1,2). This is important since colour constancy and hue categories are subserved by different stages of processing (3). We investigated colour constancy for 40 Munsell hues presented in succession, using successive matching, when illumination changed from standard daylight white illuminant C to either tungsten (A) or green G (close to orthogonal on the u'/v' plane). Typical hues (red, yellow, green, blue and violet) were also obtained for all subjects under these illuminants, using the task analogous to testing for unique hues. Colour constancy is locally better for typical, or categorical hues, as though the main colour categories were pivotal reference points. When the degree of colour constancy was conveniently expressed in terms of a relative measure (Brunswick ratio), it showed maxima around the typical hue regions. Subsequently, the dominant wavelengths of hues were estimated. The degree of colour constancy and typical hues could then be compared and correlated with the standard spectral sensitivity curve and the averaged centroid colour obtained using a double 2-alternative forced-choice method (4,5).

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Estimating surface colour under varying illumination

G.D. Finlayson
Department of Computer Science, University of York, Heslington, York YO1 5DD,UK

Many computational theories of surface colour estimation have been proposed to account for the visual phenomenon of colour constancy. To deliver good estimations, each theory begins by making simplifying assumptions about the world. The realism of the assumptions determines the value of the theory. Two of the most common assumptions made are that each scene is illuminated by a single light source and that the colour of the light is well described by a linear model. We propose that neither of the assumptions are realistic and assume their opposite in developing a new theory of surface colour estimation.

We argue against the idea that each scene is illuminated by a single light source simply because it does not represent the world in which we live. Multiple light sources are the norm. For example, in the outside environment there are two spectrally distinct light sources, the sun and sky, and indoors, light is generally a combination of artificial and daylight illuminants. Moreover in both cases interreflected light (light reflected from other surfaces) contributes to the illumination at each point. We argue against a linear model of light colour not because it is insufficient but rather for the opposite reason; a linear model is infact over general. In particular, we show that while a linear model adequately describes light colour, a non-linear model with fewer parameters is equal to the task.

Based on the non-linear model of light colour we develop a new algorithm for surface colour estimation. Simulation experiments demonstrate that the algorithm can reliably estimate surface colour so long as there is at least one surface in every scene illuminated by two lights. Estimation performance is excellent and surpasses, by a large measure, existing computational theories.

Spatial separation and the motion aftereffect

N.J. Wade[1], M.T. Swanston[2] and I. Rogers[1]
[1]*Department of Psychology, Dundee University, Dundee DD1 4HN, Scotland;* [2]*School of Social Sciences, University of Abertay Dundee, Dundee DD1 1HG, Scotland.*

The motion aftereffect (MAE) reflects both early and late processes in vision: adaptation is local and early, whereas the MAE is dependent on the global structure of the test pattern[1]. That is, if adaptation is to two moving gratings flanking a stationary central grating, an MAE is seen in the central grating if two gratings surround it, but in the flanking gratings when they are themselves surrounded in the test stimulus. We report two experiments which examined the spatial range over which the early adaptation process operates. MAEs were generated after the method described by Swanston and Wade[2]: exposure to two peripheral, laterally moving gratings induces an MAE in a central test grating, when three stationary gratings are presented as the test pattern. In Experiment 1 the peripheral test gratings were in the same position as the adaptation gratings, but their separation from the central grating was increased from 0.5 to 5 deg. The durations of MAE did not decline with increasing separation between the inducing and induced gratings. In Experiment 2 the peripheral test gratings were either in the same location as adaptation, or separated by 2.7 or 5 deg from it. The MAE duration decreased monotonically with increasing separation of adaptation and test gratings. The results are interpreted as indicating the envelope of action over which adaptation operates.

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The second-order mechanism cannot detect direction at threshold

A.T. Smith & T. Ledgeway
Department of Psychology, Royal Holloway, University of London, Egham, Surrey TW20 0EX, UK; E-mail: a.t.smith@rhbnc.ac.uk

It is well known that for first-order motion (e.g. a drifting grating) direction of motion can be detected at threshold i.e. if a drifting grating is visible at all then its direction is discernible. We have investigated whether this is also the case for second-order motion. We measured thresholds for identifying the orientation and direction of a drifting 1 c/deg sinusoidal contrast modulation. The contrast envelope was shaped in both space and time. Thresholds were measured in terms of contrast modulation depth. Various drift speeds and carrier contrasts were tested. Two different types of carrier were employed: dynamic broadband noise and static high-pass filtered noise (static broadband noise causes first-order artifacts (1)). For both types of carrier, direction thresholds were consistently higher than orientation thresholds (with a static noise carrier the two thresholds were similar, as they are for first-order motion). The modulation depth needed to identify the direction of motion of a drifting contrast envelope is typically around 50% higher than that needed to identify its orientation. This result suggests that second-order motion is detected by a mechanism which cannot identify direction at threshold and which is therefore distinct from that which detects first-order motion.

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Detection of motion-in-depth and frontoparallel motion amidst static noise dots

J. M. Harris[1] and S. P. McKee[2]
[1]*Centre for Neuroscience, University of Edinburgh, Crichton St., Edinburgh EH8 9LE, UK*
[2]*Smith-Kettlewell Eye Research Institute, 2232 Webster St., San Francisco, CA 94115, USA*

Image motion is detected at a very early stage of visual processing. Detecting an object moving in three dimensions is a more complex process, not least because under some circumstances the eyes can provide very different motion signals. For example, if a point moves directly towards the observer it will generate equal and opposite horizontal motions in the two eyes. This study investigated whether the visual system has independent access to the basic monocular motion signals when an object moves directly towards the observer.

The stimulus comprised an array of stationary points, randomly scattered throughout a cylindrical volume (axis along the depth-dimension). A centrally positioned bright dot served as the fixation point. Stimuli were shown in two intervals, one of which also contained a single target point moving directly towards the observer. We measured target detection as a function of the number of noise dots in the cylinder. In a control condition, observers viewed a single binocular half-image, in which the dots were positioned in a single plane and the target motion was horizontal. The extent of monocular horizontal displacement was equal in the control and motion-in-depth conditions.

For the control condition, the target was easy to detect, even for large numbers of noise points. For motion-in-depth, it was much harder to detect the target, even in the presence of only 8 noise dots. However, when a small amount of horizontal motion was added to the target, it became very much easier to detect. This finding suggests that the visual system does not have independent access to monocular motion signals when they are combined for motion-in-depth detection. Further, the effectiveness of static noise dots in masking the motion suggests that motion-in-depth may be detected using static disparity information rather than motion information.

The effect of positional jitter on coherence thresholds in quantised random dot kinematograms

S.P. Tripathy and H.B. Barlow
Physiological Laboratory, University of Cambridge, Cambridge DB2 3EG, UK
e-mail: st210@cus.cam.ac.uk; hbb10@cam.ac.uk
TEL: 01223 333887, FAX: 01223 333840

Using a 2-AFC direction-discrimination paradigm, coherence thresholds for detecting motion in two-frame random dot kinematograms were measured for human observers and calculated, or obtained by simulation, for the ideal detector. Statistical efficiency depends on the square official threshold/human threshold, and we have found that it approaches 50% under conditions matched to the properties of the motion detecting system (1). These conditions occur when the dots are restricted to positions on a coarse uniform grid ('coarse quantisation'). Using a finer grid has little effect on coherence thresholds for humans, but rapidly improves those for the ideal, so efficiencies fall as the grid becomes finer. We suspect the low efficiencies observed when quantisation is not coarse reflect the inability of the human coherent-motion detecting system to utilise precise positional information. We therefore examined the effect of varying the positional precision of the displays directly.

Quantised stimuli that had yielded the highest efficiencies in previous experiments were used, with the difference that the position of each dot was perturbed by a small amount of positional jitter. We hope that the change of coherence threshold with increasing jitter will enable us to estimate the amount of 'intrinsic jitter', or positional uncertainty, in the coherent-motion detecting system, and preliminary results indicate that it is very large. This fits in with the coarse orientation and velocity tuning observed neurophysiologically.

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Controlling heading during locomotion: Steering to a different paradigm

J.P. Wann[1] and S. Rushton[2]
[1]*Department of Psychology, University of Reading, Whiteknights, Reading RG6 6AL, UK Email: J.P.Wann@reading.ac.uk*
[2]*Department of Psychology, University of Edinburgh, 7 George Square, Edinburgh EH8 9JZ, UK Email: Simon.Rushton@ed.ac.uk*

A question germane to most forms of locomotion is how can we control our direction of motion when we are looking at a point other than where we are heading (1, 2). Linear translation across a ground plane produces a radial expansion of texture elements within the visual field. If an observer fixates a target other than at the focus of expansion, and tracks that target with eye movements, then a rotational component is introduced into the retinal flow field. In such a case there has been disagreement as to whether the optical flow field provides sufficient information to discern the direction of egomotion when the rotational component is large (3-6). There is, however, a further shortfall noted by Nakayama (3) who suggested 'As yet, however, researchers have not gone beyond these psychophysical observations to show that animals actually use this information to perform real locomotor tasks'.

Previous studies have used psychophysical judgements of heading direction under passive movement, and the debate has centred upon whether heading judgements are robust in the presence of rotations of the order of 5 deg/s (3-6). The rotation component is a function of depth and orientation of the fixation point and locomotor velocity, such that 5 deg/s would occur when travelling at 5m/s and fixating a target 20m ahead at an eccentricity of 20 deg.

We presented human participants with a simulator task where gaze was directed to an eccentric target, and participants were required to actively adjust their locomotor heading to approach this target. The crucial difference between a passive-judgement task and an active-steering task is that, in the latter, participants no longer need to decompose the flow pattern into radial and rotary components, but are simply required to perceive the direction in which they should steer to null the rotary component.

We found that participants could adjust their heading to an accuracy of under 1.5 degrees, without access to non-visual information specifying gaze. Of particular interest was the observation that participants were able to steer on course, without encountering rotations of 5 deg/s. This suggests that what is important is that locomotor animals are sensitive to small degrees of rotational asymmetry in the vector flow field that will allow them to adjust heading early during the approach trajectory and hence avoid high degrees of rotation that occur at greater eccentricities.

A second finding was that participants were unable to effect this level of control if the rotational asymmetry was, in part, due to motion of the target across the ground plane, suggesting that non-visual information specifying gaze direction may be necessary to steer towards moving targets.

These findings question whether the psychophysical techniques used previously (3-6) reflect upon the control of steering in natural contexts, and suggest that a paradigm shift is required for future investigations of the role of vision in the control of animal locomotion.

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What information are higher-level motion processes receiving ?

C.W.G.Clifford & K.Langley
Department of Psychology, University College London, Gower Street, London WC1E 6BT, UK.

In the H1 neuron of the fly, the response to a maintained motion stimulus decreases over time while increased sensitivity to variations in speed around the maintained level is reported (1). We investigate the form and time course of motion adaptation, comparing the psychophysical performance of human subjects with existing electrophysiological data on insect vision.

Firstly, we investigate the effect of adaptation duration on absolute sensitivity to motion. Subjects are required to perform a 2AFC speed discrimination between a stimulus maintained at a constant velocity and a short burst of a comparison stimulus. Secondly, we investigate the effect of adaptation duration on sensitivity to modulation of velocity around the adapting level. Subjects are required to carry out a 2AFC detection of a brief sinusoidal modulation of the velocity of one of a pair of stimuli maintained at the same constant velocity. For both speed discrimination and velocity modulation detection tasks, psychometric functions were measured for a range of adaptation durations. The perceived speed of a maintained motion stimulus is found to decrease as a function of adaptation duration. Sensitivity to modulation of the velocity of a maintained motion stimulus is found to increase as a function of adaptation duration.

The form and time course of the sensitivity changes are comparable with existing evidence of motion adaptation in the fly, suggesting that adaptation to motion in the human visual system performs a similar function to that in the fly. We propose that, in both cases, adaptation serves to improve the transmission of novel motion information along the visual pathways at the expense of maintaining an accurate representation of the unchanging components of the stimulus. By sacrificing absolute sensitivity to motion for relative sensitivity in this way, the adapting system can be seen as devoting a greater bandwidth to the transmission of changes in the motion signal (2). Such a coding strategy would facilitate the computation of higher-order properties of the motion signal through subsequent processing.

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Thresholds for detecting change in shape

M.J. Wright and K.N. Gurney
Department of Human Sciences, Brunel University, Uxbridge, Middx UB8 3PH, UK

Koenderink (1) suggested that the decomposition of optic flow might be accomplished in part by mechanisms sensitive to changing orientation giving an approximation to the rotation component, 'curl' and to changing relative orientation giving an approximation to the deformation component, 'def'. Over the last two years we have presented evidence for specialised motion mechanisms sensitive to changing orientation. Our present experiments, on the other hand, provide no compelling evidence for a special mechanism for analysing changes in relative orientation. One of the simplest stimuli that possess the attribute 'shape' is a plaid consisting of two identical grating components. We may vary the 'shape' of plaid blobs or diamonds by varying the angle between components. In a single-interval, two-alternative, forced-choice procedure, the subject's task, on any trial, was to detect a change in the angle between the components. In order that the task should not be soluble by detecting the rotation of a single component, a random orientation change was added equally to both components. This effectively makes the task into a discrimination between rigid (no change in relative orientation) rotation of the plaid. The subject attends to the 'blobs' or 'diamonds' of the plaid and reports whether they change shape as well as moving. Minimum thresholds were 1-2 deg; i.e. 4-8 times higher than for discrimination of the clockwise or anticlockwise rotation of a single component of the same plaid. The task is rather difficult, the problem being that the 'blobs' or 'diamonds' seem to change shape even when they rotate rigidly. Inspection of the psychometric function confirms this: it is asymmetric; there is a tendency to misidentify rigid rotations as nonrigid. Further experiments confirm that detection of changes in relative orientation is disrupted by common added rotation. This is evidence against a specialised 'def' detector based on orientation change, and against the rotational invariance of dynamic shape changes. The addition of common added translation also affects 'shape change' discrimination in plaids, whereas the detection of component rotation is almost completely immune to translation noise. This may indicate that simple directional mechanisms contribute to the 'shape-change' discrimination task but not the 'rotation' discrimination task.

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Masked and unmasked grating detection and orientation discrimination in normal and amblyopic observers

A.J. Simmers[1], B.T. Barrett[2], M.J. Cox[2] and L.S. Gray[1]
[1]*Vision Sciences, Glasgow Caledonian University, Glasgow, UK*
[2]*Department of Optometry, University of Bradford, Bradford, UK*

The aim of these experiments was to investigate the interactions between spatial frequency channels in normal and amblyopic observers. Grating detection and orientation discrimination performance were compared. In addition the effect of a low spatial frequency mask upon grating detection was examined.

All stimuli consisted of monocularly viewed sinewave gratings (75% contrast) of variable spatial frequency. Five normal subjects and five amblyopic observers participated in the experiments. In one temporal 2-AFC task (grating detection), the subject was required to detect the interval in which a grating (vertical or horizontal) was present. A second temporal 2-AFC paradigm was employed (orientation discrimination) in which a vertical grating was presented in one interval and a horizontal grating in the other. The task of the subject in this case was to identify the interval containing the horizontal grating. Grating detection was measured in the presence and absence of a low spatial frequency mask of the same physical contrast and orientation. The spatial frequency of the mask was always one-third the spatial frequency of the test grating, and both the stimulus and the mask had random phase.

The reductions in orientation discrimination found for the amblyopic observers were predictable from their reduced grating detection performance. The presence of the mask reduced grating detection performance by 15-30% in all subjects tested. There was no difference in the effect of the mask in the amblyopic subjects when compared to the normals.

Amblyopes showed no extra loss in orientation discrimination tasks or in masked grating detection tasks relative to normal observers. These results provide no evidence for abnormal interactions in amblyopic observers.

Binocular image integration and stereopsis: A subjective analysis

H. Burns
8 Buttercup Close, Plough Lane, Wokingham, Berkshire, RG40 1QZ, England.

Binocular-rivalry plays a significant part in integrating the two eyes' images to perceive just one. Two hundred and thirty five years ago DuTour (1760) is

reputed to have asked “Pourquoi un objet sur lequel nous fixons les yeux paroit-it unique?”. With care in following this system of subjective binocular visual analysis, that question can be answered in many, if not in most respects.
In 1962 I searched for evidence of end-to-end linkage of the visual fields, using red/green Barlite goggles to view a wide, flat-white featureless ground. With red before the right eye, bi-nasal-retinal dominance was initially apparent, but unstable trans-retinal rivalry supervened centrally, anchored by stable peripheral-temporal fields of the uncorresponded nasal retinae. Other instabilities were noted. Turning the eyes to the right, the nose-contour was either seen, with the binocular field to its left dominated by the left eye, or suppressed, with right eye dominance extending well beyond the midline. Fixating a free-space object, e.g. a pencil, the binocular rivalry was stabilised significantly, though not completely.
Crovitz and Lipscomb (1963) reported Köllner’s (1914) observations of binocular colour rivalry, including an initial fleeting sensation of binasal hemianopia. They had repeated his experiments tachistoscopically, enhancing and prolonging the effect by foveally combining thin vertical black strips on the coloured lenses. I had noted that, with my single free-space object, overconvergence strengthened bi-nasal-retinal dominance. Underconvergence caused bi-temporal-retinal dominance, each crossed image creating radiating induction, with continued bi-nasal-retinal dominance peripherally. I introduced a second, then a third object in turn, all in the mid-line. The outermost image still radiated dominance outwardly and inwardly, whilst the intermediate ones showed only inwardly radiating dominance.
The vertical bisector of a red (right) and green area was observed whilst bi-foveally projecting, with quick side to side saccades, in over- and under-convergence, between and beyond each edge-image. Central-field bi-nasal retinal dominance persisted with bi-nasal uncrossed diplopic edge-contour images and bi-temporal dominance with bi-temporal crossed edge-contour images, the retina imaging the right-hand edge-image dominating more of the binocular ground between the disparate images as bi-foveal projection approached the left-hand image, and vice versa. When the bi-foveal projection point moved beyond either image, that image suffered some suppression, and left the more peripheral image dominant.
A complex series of observations followed, with the introduction of an object, first vertical, then tilted, against the vertically bisected red/green background, then both object and edge-contour tilting at different angles relative to one another, from which it was apparent that the term bi-nasal is only appropriate physiologically rather than physically.
Panum’s Limiting Case exhibited an inherent tendency to unstable stereoscopic signature of the single uncombined line-image. Observations revealed that a monocular image B possesses its own natural stereosign with reference to a binocular fixation object A on the horopter, and depends on the eye in which it is formed. Natural stereosign is assumed to be present when

the eye in which the image is formed receives the oculo-motor impulse for transfer of fixation, a normal fixation transfer to that monocular image taking place without change of stereosign. The eye receiving the oculo-motor impulse is assumed, at that time, to dominate the area of binocular-image-ground between that monocular image and the fixation point. When a second, disparate image of B was added, to the same side of, but further away from the fixation object, it imparted its stereosign to the first (inner) image and kept its own. Fixation transfer to either of the disparate images resulted in fusion. With greater disparity, the inner image at times reverted to its own natural stereosign, doubtless due to binocular rivalry changing background dominance. This instability results from un-natural attention factors, and is certainly the cause of the erratic deviations characterising many horopter determinations.
The fact that binocular rivalry can change the stereosign of a single monocular image with respect to the fixation point, or that the addition of a second (disparate) image, further removed from the fixation point than the first one, changes the stereosign of the inner one from its natural sign, means that one can consider factors such as aniseikonia, and the Pulfrich Phenomenon in a different light.

Contrast invariance in human pattern discrimination

R. Näsänen, H. Kukkonen, and J. Rovamo
Department of Optometry and Vision Sciences, University of Wales, College of Cardiff, Redwood Building, King Edward VII Avenue, Cardiff CF1 3XF, UK

It is well known that some pattern discrimination thresholds (e.g. orientation and spatial frequency discrimination) are constant over a wide range of stimulus contrasts. This suggests that at the decision level the signal-to-noise ratio (the mean of the decision variable per its standard deviation) is independent of the contrast of the external signal. This could be explained in two ways. Firstly, the pattern discrimination mechanisms could be sensitive to contrast and be followed by multiplicative noise so that with increasing contrast the noise magnitude increased in the same proportion. Secondly, the pattern discrimination mechanism followed by additive noise could be invariant as to the contrast of the signal but sensitive only to its spatial structure. We tested these hypotheses by measuring pattern discrimination thresholds using stimuli whose contrasts were randomised from one exposure to another. If pattern discrimination mechanisms were sensitive to contrast, the variance of their response would increase resulting in an increase of pattern discrimination thresholds. Thresholds were measured for orientation discrimination of gratings and size discrimination of a facial image as a function of the range of contrast randomisation. The mean Michelson contrast was 0.5 and the randomisation range varied from 0 to ± 0.4. Pattern discrimination thresholds were found to be independent of contrast randomisation in both tasks. This finding, thus, supports the hypothesis that pattern discrimination is performed by mechanisms that code stimulus form independently of contrast.

Centroid analysis predicts visual localisation of first- and second-order stimuli

P.V. McGraw[1], D. Whitaker[1], I. Pacey[2], and B. Barrett[1]
[1]*Department of Optometry, University of Bradford, Richmond Road, Bradford BD7 1DP, UK*
[2]*Department of Vision Sciences, Aston University, Aston Triangle, Birmingham B1 7ET, UK*

The aim of this study was to investigate the characteristics which determine the perceived location for first-order (luminance-defined) and second-order (contrast-defined) stimuli. Perceived Vernier alignment of asymmetric Gaussian-windowed stimuli was measure in 3 experienced and 1 naive observer. The asymmetric Gaussian blobs are similar to convention Gaussian blobs, but have different space constants each side of the vertical midline. These stimuli have the advantage of being continuous in the spatial domain and having well-defined and well-separated characteristics such as luminance peak and centre-of-mass (centroid). The three blobs were identical apart from the fact that the polarity of asymmetry of the central blob was reversed. In order to maintain perceptual alignment, a horizontal shift of the central blob is required, and the magnitude of this shift represents the perceived offset. Results for both luminance- and contrast-defined stimuli are well described on the basis that the centroid of the stimulus envelope represents the spatial primitive which determines perceived visual location. Perceived location of certain types of contrast-defined stimuli was shifted slightly beyond that predicted by the centroid of the Gaussian window. This small departure is probably related to the phenomenon of 'irradiation' in which the perceived size of objects depends not only upon their luminance polarity, but also on their first- or second-order nature.

Visual attention over depth and motion in unilateral neglect

S. Rushton[1] and J.P. Wann[2]
[1]*Department of Psychology, University of Edinburgh, 7 George Square, Edinburgh EH8 9JZ, UK. Email: Simon.Rushton@ed.ac.uk*
[2]*Department of Psychology, University of Reading, Whiteknights, Reading RG6 6AL, UK*

Depth and motion appear to have a privileged status with respect to visual attention. This is best demonstrated by the findings of Nakayama & Silverman (1) and McLeod, Driver & Crisp (2) on conjunction searches. The selective

impairment of perception dependent upon the motion (e.g.3) and depth (e.g.4) attributes of objects provides evidence for the anatomical and functional separation of processing of objects differing along these dimensions.

Unilateral visual neglect manifests as a deficit of attention, that is in the absence of visual field deficits, objects in the field contra-lateral to the lesion are ignored. An intriguing interaction between motion and neglect has been demonstrated by Mattingley, Bradshaw & Bradshaw (5) who observed changes in bias on a line bi-section task when moving dots were super-imposed on the test materials. Several simple explanations for such an interaction would be: dragging the eye (optokinetic nystagmus) or attention in the direction of dot motion; the invocation of different perceptual-attentional systems because of the addition of a movement attribute to the test element (relative motion against the background flow); a reduction in attentional bias between the neglected and non-neglected fields due to visual motion acting as common stimulus for attention across the whole test display.

The first and third of these maybe investigated by contrasting response to translational and random walk (no global motion) displays. The second through the use of a modified cancellation task: Effects of element density and number have been reported such that the neglect of targets in the contra-lateral field reduces with sparse element displays. If it is possible to group elements by depth or motion attribute and then attend selectively to a particular group then the number of omissions on a cancellation task should drop.

Single case study results failed to produce changes in line-bisection bias with superimposed motion. Preliminary results also suggest no reduction of neglect following the division of the elements of stimulus array by adding a motion or depth attribute. Despite the null results, we propose that a principled breakdown of the potential effects of depth and motion is essential to disambiguating findings in this field and the tests outlined afford this level of analysis.

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Perception of partly occluded objects by young chicks

L. Regolin[1] & G. Vallortigara[2]
[1]*Department of General Psychology, University of Padua, Via Venezia 8, 35131 Padua, Italy*
[2]*Department of Philosophy and History of Science, University of Udine, Via Antonini 8, 33100, Udine, Italy*

The world surrounding us is mostly made of opaque objects which partly occlude each other, but human visual perception hardly suffers when objects are partly hidden since the parts that are directly visible usually suffice for recognition of the whole object. The fundamental perceptual process of "amodal" completion (1,2) generates a genuine phenomenal presence of the nonvisible parts. It is unclear, however, whether amodal completion occurs at all in other species: Studies on visual discrimination learning have revealed that animals usually attend to parts and features of the discriminative stimuli rather than to globalobject properties (3). We provide here the first demonstration of recognition of partly occluded objects in a bird species, the domestic chick Gallus gallus, using the naturalistic setting made available by filial imprinting, a process whereby young birds form an attachment to their mother, or some artificial substitute. In a first series of experiments we reared newborn chicks singly with a red cardboard triangle, to which they rapidly imprinted and which they therefore regarded as a true social partner. When chicks were three-days old they were asked to choose between a pair of stimuli composed of either isolated fragments or occluded parts of the imprinting stimulus. Stimuli were equated on features (e.g. area) which the birds might use to make a discrimination. Chicks consistently chose to associate with complete or with partly occluded versions of the imprinting object rather than with separate fragments of it. Similarly, in a second series of experiments, chicks reared with a partly occluded triangle chose to associate with a complete triangle rather than with a fragmented one, whereas chicks reared with a fragmented triangle chose to associate with a fragmented triangle and not with a complete one. Newborn chicks thus appear to behave as if they could experience amodal completion.

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Differences between human scotopic spectral sensitivities in the long-wavelength region

D.A. Palmer and J. Mellerio
School of Biological & Health Sciences, University of Westminster, 115 New Cavendish Street, London, W1M 8JS,UK

Lamb (1) demonstrated over a wide range of species and receptor types a common photoreceptor response when plotted on a logarithmic scale against the reciprocal wavelength, provided this was normalised with respect to the wavelength of maximum sensitivity.

He showed this applied to Crawford's averaged data (2) for human scotopic spectral sensitivities. However, Crawford's averages were derived from data for 50 observers, 15 of whom made two sets of measurements by different methods. All these data were published as tables, and when these are examined, it is found that there are considerable differences between the individual responses; in the shapes, the wavelength of maximum response and the slopes in the long-wavelength region.

Even when reduced to a common maximum by Lamb's method of plotting, the differences in slope remain. These features are shown in both sets of those data relating to the same individuals, so they probably represent personal characteristics. Why these individual departures from the interesting Lamb model arise remains to be explained.

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Visual adaptation to dichoptic brightness disparity induced by artificial anisocoria and neutral density filters

E.S. MacMillan, L.S. Gray, and G. Heron
Department of Vision Sciences, Glasgow Caledonian University, Cowcaddens Road, Glasgow G4 0BA, UK

Previous work has shown adaptation to interocular brightness differences induced by neutral density filters. The purpose of this study is to investigate the time course of visual adaptation to interocular brightness differences created by artificial anisocoria and neutral density filters.

Various levels of anisocoria were created using prosthetic contact lenses (clear pupil, occlusive iris) in subjects previously dilated with 10% phenylephrine. Neutral density filters were employed to produce similar levels of interocular brightness difference under two conditions: (1) with fixed artificial pupils and (2) mobile pupils. Interocular brightness matches were obtained every 15 minutes over a 3 hour period, using a simultaneous interocular brightness matching technique.

There was a significant difference in the initial level of interocular brightness difference achieved due to anisocoria and neutral density filters ($p<0.01$);

the brightness differences were smaller in the anisocoric condition. With time the interocular brightness difference caused by the neutral density filters was found to adapt to reach a level similar to that of the anisocoria condition. The induced interocular brightness difference in the anisocoric condition was found to be invariant over the 3 hour test period.

Adaptation to interocular brightness differences induced by neutral density filters in this present study concurs with previous reports. The level of adaptation can be anticipated by Fechners' paradox. Brightness matches found with artificial anisocoria are predictable when the Stiles-Crawford effect (Type 1) and Fechners' paradox are taken into account.

Computer simulation of interactions responsible for length and width tuning in the striate cortex

S.A.J. Winder
Science Research Foundation, 10 Priory Road, Bristol, BS8 1TU, UK

This presentation describes a simulation of the long-range inhibitory interactions that produce end-stopping, surround-stopping and side-stopping in the primary visual cortex. Unlike previous models, but in line with recent understanding, the approach used here incorporates a divisive rather than a subtractive influence from the receptive field surround, and includes phase independent inhibition from a neural pool with broad orientation and spatial frequency selectivity. This approach is successful at producing realistic tuning for stimulus length and curvature without the problems of false responses or critical dependencies on stimulus position that other researchers have experienced. The simulated interactions also give rise to saliency effects, such as an enhancement of the cortical response to a texture element differing in orientation from its surrounding texture. Additionally, the population orientation estimate given in response to a single pattern element is biased by the presence of suitably oriented surround elements. The resulting orientation tilt illusion can be readily perceived and is reproduced faithfully by the computer simulation.

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References supplied (as usual!) by:

Chris Dickinson

Meetings Calendar

1996

Dec. 18	*Locus Questions in Vision*. Dept. Vision Sciences, Aston University, UK. Contact: Dr Tim Meese, Dept. Vision Sciences, Aston University, Birmingham, B4 7ET. E-mail: t.s.meese@aston.ac.uk (**ad** 4/10/96).
Dec. 19-20	*Framework for immersive virtual environments (FIVE).* Pisa, Italy. Contact: Lorna Kyle, Dept. Computer Science, Queen Mary and Westfield College, London, E1 4NS. E-mail: lorna@dcs.qmw.ac.uk (**ad** 30/6/96)

1997

February 12-13	*Knowledge-based vision in man and machine.* The Royal Society, London. Contact: 0171 839 5561 http://www.royalsoc.ac.uk/rs/
March 24-26	*Visual Scales: Photometric and Colorimetric Aspects*. NPL, Teddington, Middlesex. Contact: Dr Julie Taylor, 0181 943 6539 Abstract deadline: 31 December 1996
April 9-11	*AVA'97 Image Quality.* University of Abertay, Dundee, UK. Contact: Dr Malcolm Cook, University of Abertay, Bell Street, Dundee, DD1 1HG, email: m.cook@river.tay.ac.uk Abstract deadline: 6 December 1996
May 11-16	*ARVO* Fort Lauderdale, USA http://www.arvo.org Abstract deadline: 6 December 1996
September 14-17	*Vision in Vehicles 7*, Marseilles, France. Contact: 01332-622287, email: avru@derby.ac.uk Abstract deadline: 14 February 1996