



# The 2013 Young Vision Researchers' Colloquium

## Programme

<b>9:00</b>	<b>Registration, Tea &amp; Coffee, put up posters</b>
<b>9:30</b>	<i>Welcome:</i> Professors Dylan Jones, OBE - Pro Vice-Chancellor, College of Biomedical and Life Sciences, Cardiff University; Dave Bull - Director BVI, University of Bristol; John Wild - Local Host
	<b>Session 1, Chaired by Professor Dave Bull</b>
<b>9:50</b>	<i>A biologically motivated visual recognition system (that works very well)</i> Tim Volonakis, University of Bristol
<b>10:10</b>	<i>Collagen Distribution and Fibre Orientation in the Human Optic Nerve Head</i> Hannah Jones Cardiff University
<b>10:30</b>	<i>Classification of diseased RGCs in the rat,</i> James Tribble, Cardiff University
<b>10:50</b>	<i>Haidinger's brush: characterizing human polarization sensitivity,</i> Juliette McGregor, University of Bristol
<b>11:10</b>	<b>Tea &amp; Coffee</b>
	<b>Session 2, Chaired by Dr Tony Redmond, Cardiff University</b>
<b>11:30</b>	<i>The neural substrate of saccade generation under different levels of cognitive control</i> Andreas Jarvstad, University of Bristol
<b>11:50</b>	<i>Saccade-like behaviour in the fast phases of optokinetic and infantile nystagmus,</i> James Harrison, Cardiff University
<b>12:10</b>	<i>Visual acuity in infantile nystagmus in the absence of image motion</i> Matt Dunn, Cardiff University
<b>12:30</b>	<b>Lunch &amp; Posters</b>
<b>13:30</b>	<b>Keynote:</b> <i>Rethinking visual search</i> Dr Johan Hulleman, University of Manchester
	<b>Session 3, Chaired by Professor Innes Cuthill</b>
<b>14:20</b>	<i>Integrated Registration, Segmentation and Interpolation of Sparse Medical Data,</i> Adeline Paiment, University of Bristol
<b>14:40</b>	<i>Assessment of ocular cell-matrix interactions in three-dimension,</i> Elena Koudouna, Cardiff University
<b>15:00</b>	<i>Concealment constrained by culture: the evolution of human camouflage,</i> Laszlo Talas, University of Bristol
<b>15:20</b>	<b>Tea &amp; Coffee</b>
	<b>Session 4, Chaired by Professor John Wild, Cardiff University</b>
<b>15:40</b>	<i>Determinants of the conscious perception of afterimages,</i> Georgina Powell Cardiff University
<b>16:00</b>	<i>Investigating avian magneto reception using head movements in Homing pigeons</i> John Barnes, Cardiff University
<b>16:20</b>	<i>Single image plane detection for robot navigation</i> Osian Haines, University of Bristol
<b>16:40</b>	<i>Exploring reference frames using motion after-effects</i> Brice Dassy, Cardiff University
<b>17:00</b>	Wine and cheese. Prize giving by Professor Gary Baxter, Head of School of Optometry and Vision Sciences
<b>17:30</b>	Musical Entertainment by UCAN and drinks reception
<b>18:30</b>	<b>Departure</b>



Bristol Vision Institute would like to thank the local organiser of the 2013 Young Researchers Colloquium: Dr Jon Erichsen & local host, Professor John Wild, School of Optometry and Vision Sciences, Cardiff University.



# Key-note, Johan Hulleman, University of Manchester

## Biography



Johan Hulleman completed his PhD at the University of Nijmegen, investigating the perception of regularity in 2D shapes. After a stint at the Dutch National Statistics Office, he returned to academia to undertake a post-doc on figure-ground perception in Glyn Humphreys' laboratory at the University of Birmingham. Three years later, he accepted a Lectureship at the University of Hull and, recently, he moved across the Pennines to the University of Manchester.

Johan's current research interest is in the area of visual search. How do people scan their environment when they are looking for something? He tries to answer this question by monitoring the eye movements of participants while they search simple displays. Applications are plentiful. Whether it is a radiologist studying CT-images, a vintager harvesting grapes or a security guard examining a baggage scan, they all engage in visual search tasks.

## Abstract

Research into visual search has been governed by several implicit assumptions that were introduced at the inception of visual search as a research topic and that have wielded their influence ever since. This talk explores the assumptions that explaining the difference between flat and steeper slopes is the key to understanding visual search, and that search proceeds on the basis of individual items. Both are found wanting.

In the talk, a different way of thinking about visual search is proposed, that takes eye movements as its starting point, lets the distance into the periphery at which a distinction between target and distractors can still be made determine how many fixations are needed and suggests that, rather than information about individual items, information pooled across items is used to guide target-present and target-absent responses



## **Abstracts for oral presentation (in order of presentation)**

### ***A biologically motivated visual recognition system (that works very well)***

**Tim Volonakis, School of Experimental Psychology, University of Bristol**

How do we calculate the visibility of a range of objects when placed in a scene? Psychophysical testing is the most straightforward method, but given a large variety of objects, this is often impractical. An alternative is to design a classifier and then measure its ability to identify objects. Ideally this classifier should be 1) simple, 2) understandable, 3) be an ideal observer for a given environment (so that working out when and why it does not work is simplified), 4) be based on our knowledge of low level vision, and 5) actually work well as a classifier. We have designed such a classifier using a simple three stage process. Firstly, the image is processed by a standard log Gabor wavelet filter bank to capture the early linear properties of the visual system. Importantly, we also process the outputs of this filter bank to capture the non-linear properties of cortical area V1: contrast normalisation and local energy estimation. This has the side effect of turning small metric distortions in the object into Gaussian variation in the representation of the local phase and energy. After modelling each object's image features using the mixture of probabilistic principal components density estimation technique, recognition is achieved by using Bayes' rule to identify the object of highest posterior probability. We find that this simple classifier works very well, achieving state-of-the-art or better performance on a number of standard vision benchmarks (Georgia Tech, JAFFE and AT&T). We also know why: by careful choice of pre-processing, the difficult problem of learning an invariant representation is turned into the simple problem of estimating the parameters of a multivariate Gaussian distribution. We are currently evaluating whether the model is not only good at recognising objects, but also does so in a similar way to humans.

### ***Collagen Distribution and Fibre Orientation in the Human Optic Nerve Head***

**Hannah Jones, School of Optometry and Vision Sciences, Cardiff University**

To analyse fibrillar collagen distribution and fibre orientation within the human optic nerve head (ONH), focusing mainly on the lamina cribrosa (LC) which is the proposed site of damage in glaucoma.

Using second harmonic generation (SHG) microscopy and small angle light scattering (SALS) the distribution and orientation of fibrillar collagen was visualised and preferred fibre orientation and degree of fibre alignment (DOFA) were calculated in ONH sections from donor eyes.

SALS showed close agreement with projections of SHG image stacks. Within the LC the preferred fibre orientation depicted the hour glass connective tissue architecture characteristic of the regional poles. In the ONH canal DOFA was greatest in the LC (0.2, where 0 is random and 1 perfect alignment) when compared to pre-LC and post-LC regions. LC fibre alignment was significantly lower ( $p < 0.05$ ) than the high scleral DOFA (0.6) measured adjacent to the ONH canal. This high DOFA was likely due to the highly aligned, circumferentially orientated fibrillar collagen depicted in the SHG images.

Conclusions: The strength of fibre alignment at the level of the LC may be important in regulating ONH displacement in response to changes in intraocular pressure (IOP). The highly aligned, circumferential scleral fibres may provide a further protective

mechanism in reducing IOP-related expansion of the ONH canal. Such findings are crucial for the development of finite element models which will further our understanding of ONH biomechanics and predisposition of elderly eyes to glaucoma.

### ***Classification of diseased RGCs in the rat***

**James Tribble, School of Optometry and Vision Sciences, Cardiff University**

Retinal ganglion cell (RGC) degeneration is a hallmark of glaucoma and other retinal diseases. Study of structural changes to the RGC is potentially confounded by the natural variability in RGC morphology. We demonstrate a classification system to categorise RGCs based on primary and secondary dendrite parameters that appear more stable under disease.

The eyes of 20 Brown Norway retired breeder rats were enucleated and the retinas dissected and flat mounted. 140 RGCs were labelled with lipophilic fluorescent dyes through use of a gene gun and images captured using a confocal microscope. RGCs were classified according to current methods. In order to define new classification criteria 9 variables of primary and secondary dendrites were measured and principle component analysis (PCA) and discriminant analysis conducted.

PCA separated RGCs through 3 components comprising size, branching density and asymmetry of the dendritic tree respectively. The larger symmetrical RGCA and RGCC cells were separated from the smaller asymmetrical RGCB and RGCD cells. RGCA were separated from RGCC cells based on the higher branching density of RGCC cells.

Discussion: We demonstrate the classification of RGCs using dendrite features that are relatively resistant to early degenerative events and provide criteria to quantify the confounding effects bias in the analysis of RGCs in retinal disease.

### ***Haidinger's brush: characterizing human polarization sensitivity***

**Juliette McGregor, School of Biological Sciences, Bristol University**

From the zenith of the clear blue sky at sunset to the ubiquitous liquid crystal display (LCD), sources of polarized light are everywhere. Yet our ability to observe the polarization state of light with the naked eye, alone, is little known, even amongst the scientific community.

When exposed to a source of linearly polarized light, the observer sees a faint visual phenomenon consisting of a yellow hourglass flanked by blue and purple regions. This image extends for a few degrees around the fixation point and fades in a couple of seconds if the angle of polarization is not altered. The phenomenon is referred to as 'Haidinger's brush' after the mineralogist who first reported it (Haidinger, 1844). Whilst considerable effort has been directed toward testing polarization vision in other animals, the limits of human polarization sensitivity remain largely uncharacterized. By adapting the psychophysical techniques developed to study polarization sensitivity in aquatic animals (Temple et al., 2012) we can, for the first time, characterize the levels of polarization sensitivity in the healthy human.

By removing the front polarizer from a LCD, we are able to turn patterns normally visible in greyscale into polarization patterns with no luminance contrast. Greyscale contrast is replaced by contrasting e-vector angles. Haidinger's brush can then be continuously refreshed by presenting spatially and temporally varying polarization

angles (e.g. a flashing checkerboard stimulus). This enhances the salience of the stimulus. Whilst Haidinger's brush, itself, is a subtle effect, dynamic polarization patterns are easily visible to all healthy observers.

The degree of polarization refers to the relative proportion of polarized light as a percentage of the total light signal. Light emerging from a polarizing filter or a computer screen is almost 100% polarized, whereas light from the zenith of the sky at sunset is no more than 75% polarized. We have developed a psychophysical forced-choice test which, by varying the degree of polarization of the stimuli, allows the determination of the polarization sensitivity threshold for each individual.

Averaging the degree of polarization threshold for 38 participants in this study produced a mean value of 67 +/- 13%. The only comparable experiment carried out on vertebrates found that rainbow trout (*Oncorhynchus mykiss*) are capable of detecting a minimum degree of polarization of 75% (Hawryshyn & Bolger, 1990). This raises questions about the interpretation that polarization sensitivity in animals is necessarily of behavioural relevance.

Current evidence strongly suggests that human polarization sensitivity is produced by the spatial arrangement of macular pigment molecules in the Henle fibre layer of the retina, selectively attenuating 460 nm (blue) light and producing the sensation of yellow. If this is the case, reduced polarization sensitivity may be associated with lower macular pigment levels. In future work, we hope to test this hypothesis. Establishing a clear link between the salience of the entoptic phenomenon and macular pigment density could bring the 170 year controversy surrounding the biophysical origins of Haidinger's brush to an end. Furthermore, reduced macular pigment density has been observed in donor eyes of patients with age-related macular degeneration (AMD) (Bone et al., 2001).

If a clear link between polarization sensitivity and macular pigment levels can be demonstrated, it may be possible to use reduced polarization sensitivity as an early stage diagnostic indicator for AMD.

### ***The neural substrate of saccade generation under different levels of cognitive control***

**Andreas Jarvstad, School of Experimental Psychology, University of Bristol**

Using fMRI, we investigated the neural substrate of saccade generation in four conditions requiring different levels of cognitive control. In Condition 1, participants generated a saccade to a single target, which requires only a simple mapping between the stimuli and response. In Condition 2, two stimuli were present, one high and one low contrast. Participants were instructed to saccade to the brighter stimulus, this introduces selection to the task. In Condition 3, the displays were identical to Condition 2, but now participants were instructed to saccade to the low contrast stimuli, introducing a need to inhibit the non-target stimuli. Condition 4 used the same displays but participants were instructed to freely choose a target on each trial. We used saccade contingent displays to exactly match visual stimulation across conditions and used a continuous saccade paradigm which eliminated the need for return saccades. Changes in the level of cognitive control were associated with: differential levels of activity within the saccade circuit; the recruitment of additional brain areas and task-dependent changes in functional connectivity. We find similarities, but also differences, between our results and anti-saccade fMRI studies.

***Saccade-like behaviour in the fast phases of optokinetic and infantile nystagmus***  
**James J. Harrison, School of Psychology, Cardiff University**

The fast-phases of optokinetic nystagmus (OKN) and infantile nystagmus syndrome (INS), which reset the position of the eye during nystagmus, are often assumed to be saccadic eye-movements. This assumption is based largely upon the observation that fast-phases of OKN and INS have a similar main sequence to saccades; and that saccades and fast-phases are generated by overlapping neural pathways. However, whether fast-phases have functional similarities to saccades has never been tested experimentally. We tested this hypothesis using the saccadic inhibition paradigm; whereby the onset of an irrelevant distractor stimulus delays saccades which would otherwise have occurred around 100ms later. We found that the saccadic inhibition effect also occurs for the fast-phases of both OKN and INS. This implies that the generation of fast-phases is subject to the same processes as saccades, and is further evidence that there is similarity between these eye-movement types. These results may help to elucidate the neural pathways responsible for the fast-phases of nystagmus, which could have implications for our understanding of how the oculomotor system in those with INS relates to the oculomotor system in the rest of the population.

***Infantile nystagmus is associated with a reduction in visual acuity (VA), even in the absence of co-existing pathology***

**Matt Dunn, School of Optometry and Vision Sciences, Cardiff University**

The purpose of this study was to assess the extent to which motion blur induced by the eye movements contributes to this visual impairment. Since the intended outcome of most therapies for nystagmus is a reduction in eye movement intensity, the result of this study defines the maximum possible benefits (to VA) that these interventions can provide. Resolution thresholds were measured in subjects with infantile nystagmus and controls, under flash and constant illumination conditions. Black & white gratings were viewed and illuminated by either an incandescent lamp or multiple xenon flashes, sufficiently brief to eliminate image motion. Subjects reported tilt of the gratings to determine resolution threshold. Thresholds were determined for gratings oriented about the horizontal and vertical axes in order to investigate orientation sensitivity. As expected, acuity thresholds under constant illumination were consistently much poorer for nystagmats than controls. However, in contrast to the control subjects, nystagmats' acuity for near-vertical gratings was worse than near-horizontal. Although the flash caused VA to worsen in controls, VA in nystagmats did not change for either the horizontal or vertical condition. Our results suggest that the acuity deficit in people with idiopathic infantile nystagmus is not due to motion blur induced by eye movements. Therefore, reduced VA must be due to amblyopia and/or undetected pathology. This suggests that therapies to slow the eye movements have limited potential for improving vision.

***Integrated Registration, Segmentation and Interpolation of Sparse Medical Data***  
**Adeline Paiment, School of Engineering, University of Bristol**

We address the three inherently related problems of *registration*, *segmentation* and *interpolation* which arise when modelling from 3D and 4D sparse volumes. Such sparse volumes are commonly encountered in medical imaging, e.g. cardiac MRIs are made up



of 2D slices that have large inter-slice spacing in order to reduce the acquisition time and patient discomfort. These datasets commonly suffer from significant misalignments, due to different volumes of air in the lungs and patient's movements. Therefore, the 2D slices need to be registered prior to any further analysis, and segmentation is required to partition the 3D or 4D space between objects of interest and background. The inter-slice gaps make this segmentation even more complicated and data must be interpolated in order to reconstruct a more representative volume. Clearly, the success of one stage (registration, segmentation or interpolation) depends on the accuracy of the other stages. Traditional approaches perform the three stages in sequence, thus failing to exploit their interdependency. In addition, methods which interpolate a 3D volume from 2D images are commonly limited to stacks of parallel and equally spaced slices and are sensitive to differences in the gain and contrast of the images within the same dataset. Popular registration methods are based on pixel similarity measures, however too few points are available at the intersections of the 2D slices and that is not suitable to compute reliable similarity measures. A few attempts have been made to combine two or three stages in the same framework, most of them using parametric models. Such models lack flexibility and are restricted to a given object with limited shape variations. They also require prior knowledge and a training phase.

We propose to integrate the three stages of registration, segmentation and interpolation, for handling sparse and misaligned data, in a new level set framework based on the interpolation of the level set implicit function using Radial Basis Functions (RBFs). This new level set scheme allows the level set implicit function to evolve in a 3D or 4D volume, in spite of only partial data support and regardless of the spatial configuration of the data. The volume can be made up of any number of 2D slices having arbitrary positions and orientations, and any segmentation algorithm can be used, both data (e.g. edge or intensity) and prior knowledge-based.

Registration is driven by segmentation results, similar to [3]. Our proposed registration method is more general than [3] since it can register any number of intersecting 2D slices in a 3D volume and it can be used with any segmentation algorithm. Further, it solves a global optimization problem, thus it is more robust to large misalignments and local minima than the local method of [3]. The resulting framework can simultaneously register and segment sparse and misaligned data while interpolating the modelled object's shape in the gaps in the data. It can handle concurrently images that have different gains and contrasts, and images from different modalities, thanks to the interpolation of the level set surface and to the use of segmentation results to drive the registration, rather than image intensity. We validate our new level set framework on artificial data, and MRI and CT scans. The integration of the three stages into a same framework allows them to benefit from each other and improves their robustness and accuracy. In particular, the interpolation contribution of our integrated method reconstructs more accurate shapes than the image intensity interpolation method of [1], especially for very large gaps, and the registration contribution achieves more accurate and robust results than [2].

[1] Cordero-Grande et al. "A Markov random field approach for topology-preserving registration: application to object-based tomographic image interpolation," *IEEE-TIP*, vol. 21, 2012

[2] Lotjonen et al. "Correction of movement artifacts from 4D cardiac short- and long-axis MR data," in *MICCAI 2004*

[3] Yezzi et al. "A variational framework for integrating segmentation and registration through active contours," *MIA*, vol. 7, 2003

## ***Assessment of ocular cell-matrix interactions in three-dimensions***

**Elena Koudouna, School of Optometry and Vision Sciences, Cardiff University**

Three-dimensional (3D) structural information is essential in the field of biomedical sciences in order to gain a deeper understanding of the interactions between cells and extracellular tissue components. Here, we report two examples where structures in the eye were investigated in three dimensions using the new technique of serial block-face scanning electron microscopy. Keratocyte-collagen interactions were studied in the chick cornea during development to determine how cells associate with collagen fibril bundles which they organise into lamellae during the transition of an opaque embryonic matrix into a transparent functional mature tissue. In addition, we examined the 3D arrangement of extracellular matrix in the human trabecular meshwork, where changes in outflow pathways are thought to contribute to elevated intraocular pressure and visual impairment in glaucoma.

Embryonic chick corneas were isolated at embryonic day (E) 12, and biopsies of human trabecular meshwork were carefully dissected from two donor eyes obtained for research purposes from Bristol Eye Bank. Samples were fixed in glutaraldehyde, passed through a series of solutions -- including osmium ferricyanide, tannic acid, osmium tetroxide and uranyl acetate -- to increase backscatter electron contrast and embedded in Araldite resin. Tissue blocks were transferred to a FEI Quanta FEG ESEM equipped with a Gatan 3View system, where automated block-face imaging alternating with serial sectioning at 100-125 nm was performed. Stacks of several hundred serial images were obtained and 3D reconstructions were generated using ImageJ and EM3D software.

Serial block face scanning electron microscopy facilitated the reconstruction of 3D tissue nanostructure, over large tissue volumes, in the embryonic chick cornea and the human trabecular meshwork. At E12, corneal keratocytes displayed lamellipodia and novel filopodia-like structures, we term 'keratopodia', extending many microns from the cell surface. Noticeably, primary cilia were abundant in nearly all cells at this developmental stage. Collagen fibrils appeared within cell involutions that ultimately opened into fibril bundles, detaching from the cell surface into the extracellular matrix. Moreover, small numbers of collagen fibrils were found in membrane-bound intracellular compartments. In trabecular meshwork, the ultrastructure of the Schlemm's canal inner wall and the juxtacanalicular tissue was examined. Schlemm's canal endothelial outpouchings led to the formation of giant vacuoles which were discernable along the inner wall of the canal, often encircled by the cytoplasm of trabecular cells. In the underlying juxtacanalicular tissue, a complex array of elastic fibers was observed. Also, in this region, empty spaces were visible, reminiscent of separation between cell-cell and cell-matrix, and which are likely to serve an outflow pathway for aqueous humour.

Our findings illustrate the potential of serial block face scanning electron microscopy for the acquisition of large image series for 3D reconstruction of cell-matrix interactions at electron microscopy resolution. In developing cornea the extent of cellular processes, *keratopodia*, which associate with collagen bundles during lamellogenesis has become evident. These structures appear important for long-range cellular control over the assembling matrix. In the trabecular meshwork, the complexity of the outflow pathways and the elastic matrix component of the juxtacanalicular tissue has become evident for the first time in 3D. These observations provide a useful baseline against which to compare changes accompanying glaucoma in future studies.

### ***Concealment constrained by culture: the evolution of human camouflage***

**Laszlo Talas, School of Biological Sciences, University of Bristol**

The concealing colouration of animals is often presented as a vivid example of how the forces of natural and sexual selection collide and reach a trade-off. The animal must be camouflaged enough to evade the attention of enemies, yet detectable by its mates. Contrarily, human camouflage is generally considered to have an exclusive function: concealment. However, beginning from the mid-20<sup>th</sup> century, nations have come up with hundreds of designs, which cannot be explained solely by geographical variation.

The talk will present a research project aimed to discover the underlying factors driving camouflage pattern design. Examples from military history will be presented in order to show that – paradoxically – signalling is equally an important factor and the diversity of human patterns are similarly constrained like animal camouflage. Furthermore, a prospective, computer vision-based framework for constructing a ‘camouflage space’ will be outlined. By placing each pattern into a high-dimensional feature space supported by temporal information, one would be able to draw inferences about pattern ‘evolution’ and predict what novel combinations of textures and colours could comply with both concealing and signalling functions.

### ***Determinants of the conscious perception of afterimages***

**Georgina Powell, School of Psychology, Cardiff University**

The presence of adaptation on the retina that is sufficient to generate an afterimage signal does not guarantee the afterimage will enter conscious perception. We suggest that the reason for this is that afterimage signals are inherently ambiguous and thus are highly influenced by cues that increase or decrease likelihood that they represent a real object. In a series of experiments, we explored two cues that influence afterimage perception in opposite ways: contextual luminance edges and saccadic eye movements. We hypothesised that contextual edges would increase afterimage duration because they support the perceptual interpretation that the afterimage signal represents a real object. Conversely, saccadic eye movements would decrease afterimage duration because they cause an afterimage to move in ways unlike any real object. Further, this effect would be specific to saccades and not to other eye movements and blinking which do not cause an afterimage to move unnaturally. Results supported our hypotheses: contextual edges increased afterimage duration while saccadic eye movements decreased duration relative to fixation, pursuit and blinking. Exploration of the interaction between the two cues revealed that contextual edges dominate whether to perceive the afterimage in the first instance, after which, the effect is additive.

### ***Investigating avian magnetoreception using head movements in Homing pigeons***

**John Barnes, School of Optometry and Vision Sciences, Cardiff University**

A wide range of animal species are known to possess the ability to detect features of the Earth’s geomagnetic field and to use this information to aid navigation. Despite over 70 years of research, the one or more physiological mechanisms by which they achieve this remain highly elusive, with the leading theories still lacking conclusive empirical evidence. Previous research has largely involved migratory behaviour (orienting) experiments, using a range of species, or field release experiments with homing pigeons. In both paradigms, precise conditions can be difficult or impossible to reproduce by

different research groups, resulting in an inability to replicate findings and frequently producing contradictory results. To date, a primary challenge has been to identify a reliable behavioural response that demonstrates magnetoreception irrespective of the motivational state of the animal. Novel, and highly reproducible, lab-based methods for assessing pigeons' head movements in response to Earth-strength magnetic stimuli will be described, and preliminary experimental results, including a characterisation of common responses will be presented.

### ***Single image plane detection for robot navigation***

**Osian Haines, Merchant Venturers' School of Engineering, University of Bristol**

When using computer vision for robot navigation -- where we want to localise a moving camera while mapping its surroundings -- it is possible to exploit the presence of higher-level structures such as planes, in order to simplify the 3D representation and thus make mapping more efficient. While previous work has achieved this by detecting planar structure via geometric means, over multiple images, we argue that the ability to immediately perceive planes from one image would be a big advantage. To investigate this we use our single image plane detection algorithm, which can find planes and estimate their orientation from one image -- this method is inspired by human vision, in that it learns the relationship between image appearance and structure from examples. We show that by allowing the mapping system to detect planes in one image, we can rapidly build large maps with significant planar structure, while running faster and maintaining good trajectory estimation.

### ***Exploring reference frames using motion after-effects***

**Brice Dassy, School of Psychology, Cardiff University**

Our perception of the environment supposes the existence of a representation of space in the brain. To account for this, two types of representation were proposed: a map of the world based solely on retinal coordinates, called the retinotopic map and a map of the world as we perceived it, based on spatial coordinates, called the spatiotopic map. Motion after-effects have been used to probe for the presence of a spatiotopic map and evidence has been presented that suggests that it is possible to produce a spatiotopic motion after-effect. Here we examine whether it is possible to simultaneously adapt two different spatiotopic locations.

## **Abstracts for poster presentation (alphabetical by first name)**

### ***1. Drunken gamma oscillations: A study of the neurophysiological effects of alcohol on visual gamma using magnetoencephalography***

**Annie Campbell, School of Psychology, Cardiff University**

Alcohol, more specifically ethanol, is a potent drug affecting many neurotransmitter systems in the brain including glutamate,  $\gamma$ -amino butyric acid (GABA), dopamine and acetyl choline. Evidence from substitution and elimination studies in animals suggests that it is ethanol's enhancement of GABAergic activity at the GABAA receptor in particular that is most associated with the psychotropic and subjective effects of ethanol. Recently a number of sources, including both modelling and pharmacological manipulation, have indicated a link between GABAergic activity and oscillations measured in the gamma frequency (30-80Hz).

In this single-blinded, placebo-controlled crossover study, 12 participants (6 male 6 female) completed two study days, one in which they consumed a dose of 0.8g/kg alcohol, and the other a placebo. Magnetoencephalography (MEG) recordings of brain activity were taken before and after beverage consumption. During scanning participants were required to view a visual grating stimulus known to induce gamma activity in the visual cortex. Using time-frequency analysis of beamformer source reconstructions in the visual cortex, a trend towards an alcohol-induced slowing of peak gamma frequency was observed. This trend is not significant as it is suspected that the study was underpowered. No differences in evoked responses were observed. These data indicate potential support for the notion that gamma oscillations are generated in part from activity of GABAergic interneurons. It also provides further insight into the neuropharmacological action of ethanol as there are no previous reports of ethanol's modulation of gamma band activity as measured by MEG.

### ***2. Perception-based Video Quality Metrics***

**Aaron Zhang, Merchant Venturers' School of Engineering, University of Bristol**

In this work, a novel perception-based hybrid model (PVM) is presented for video quality assessment. This simulates the HVS perception process by adaptively combining measures of noticeable distortion and blurring using an enhanced non-linear model.

The proposed method is evaluated on the VQEG FRTV Phase I database, showing competitive performance compared with existing video metrics using various validation measures. This method is suitable for in loop RQO integration in perceptual video compression algorithms

### ***3. Analysis of the inner retinal layers in glaucomatous and healthy subjects using 1050nm OCT datasets***

**Bethany E Flynn, School of Optometry and Vision Sciences, Cardiff University**

Purpose: To assess regional changes in volume and thickness in the retinal nerve fibre layer (RNFL), ganglion cell layer (GCL) and inner plexiform layer (IPL) in retinas of glaucoma and age-matched normal control eyes.

A laboratory 1050nm spectral domain optical coherence tomography (OCT) device was used to acquire images from 10 glaucomatous (MD +0.16 to -10.00dB) and 10 healthy subjects. 3D-OCT tomograms centred on the macula were acquired and post-processed using ImageJ, then averaged and the three innermost layers of the retina were delineated using a manual segmentation technique using custom written software. Colour-coded thickness maps were generated in Matlab for each of the layers and the images were divided into 13 regions. The volume of each region was calculated and compared for both healthy and control data.

The RNFL was found to have significantly lower volume in each of the 13 regions in the glaucomatous group when compared to the healthy control group ( $p < 0.05$ ). The IPL was not found to differ in volume between the two groups in any region ( $p > 0.05$ ). The GCL showed distinct volume differences; particularly in the inferior regions with closer proximity to the fovea. When the three retinal layers were combined to form the ganglion cell complex (GCC) there was a significantly lower volume in the glaucomatous eyes in each region than in the corresponding regions of control retinas ( $p < 0.05$ ). Regions of lower GCC volume corresponded to visual field loss in retinas with more advanced glaucoma.

Variations in volume in both the RNFL and GCC were identified in glaucoma retinas. 1050nm OCT and the techniques described may be used to detect and monitor these losses as a means to measure the progression of glaucomatous disease. These indices, together with measurements of optic nerve head changes, will allow us to quantitatively profile the changes that occur at the back of the eye as a result of glaucoma and allow us to detect those eyes most susceptible.

### ***4. The extended phenotype of C57 Bl/6 Opa<sup>Q285</sup> mouse model of ADOA***

**Caroline Waters, School of Optometry and Vision Sciences, Cardiff University**

Autosomal dominant optic atrophy (ADOA) is an inherited retinal disease which results in progressive loss of vision. The cause of ADOA is a mutation in the mitochondrial fusion gene Opa1. In ADOA, 20% of affected humans also have an extended phenotype – ADOA ‘plus’ which can result in a wide range of extra ocular symptoms which involve neurological and neuromuscular disorders.

The C57 Bl/6 mouse model of ADOA is a truncated heterozygous mutation which results in a 50% reduction in the expression of Opa1 protein. This mouse exhibits the symptoms of ADOA from 10 months of age and is considered a late onset form of the disease.

In order to examine whether the mouse model exhibited any of the ADOA plus symptoms, various phenotypic investigations were performed on 12 month old animals. The methods employed were rotarod, narrow beam, SHIRPA, novel object recognition and T maze.

The results demonstrated that the Opa1 mouse model has a significant motor deficit (rotarod latency to fall  $p < 0.05$ ), and exhibits reduced initiation to explore (narrow beam initiation  $p < 0.05$ ). Cognitive function is also impaired with an impaired discrimination



for novel over original (T maze  $p < 0.05$ , novel object recognition  $p < 0.05$ ). SHIRPA observational analysis reveals the Opa1 mouse model also exhibit behavioural traits which indicate involvement in autonomic and neuropsychiatric function. These findings confirm that the Opa1Q285 mouse model represents the first ADOA 'plus' model of the disease. Further analysis will investigate the bioenergetics of this animal.

### ***5. The role of peripheral vision in flow parsing during rolling self-motion*** **Cassandra Rogers, School of Psychology, Cardiff University**

Rushton and Warren (2005, *Curr Biol*, 15, R542-R543) suggested that in order to assess scene-relative object movement the brain identifies and globally subtracts (parses) patterns of visual flow consistent with self-movement. Although this flow-parsing process has been studied in central vision (Warren & Rushton, 2009, *Curr Biol*, 19, 1555-1560), our recent results suggest that peripheral flow, a strong cue to self-motion, also permits the extraction of object motion during self-movement (Rogers et al, 2012, *Perception*, 41, 1524). Previously we simulated lateral translations of an observer to investigate the effects of peripheral flow on perceived object trajectory in central vision. Here we considered rotational movements of an observer. Using monitors placed to the side of the head, or a large ring of limited lifetime dots (50 degrees diameter), we introduced patterns of rotational flow into peripheral vision to simulate clockwise or anticlockwise roll of the observer about the line of sight (z-axis). Simultaneously a vertically moving probe was placed 2 degrees above or below a central fixation point. Observers orientated a line to indicate the perceived trajectory of the probe. We predicted that due to a global subtraction process, peripheral flow would bias perceived trajectory in the opposite direction to the presented motion; clockwise flow would produce an anticlockwise trajectory bias, and anticlockwise flow would bias responses clockwise. The results were in line with the flow-parsing hypothesis for the near and far peripheral self-motion stimuli. These findings suggest that peripheral vision also contributes to the flow-parsing process for rotational observer movements.

### ***6. Retinal feedback: The avian centrifugal visual system.***

**Chris Dillingham, School of Optometry and Vision Sciences, Cardiff University,**

Feedback to the retina from 'higher' brain centres is a feature common to all vertebrate groups. So called centrifugal visual projections exist in mammals, including humans, but are far more prominent in sauropsid species, with the majority of functional and anatomical studies focusing on birds. In pigeons, for example, ~12,000 neurons project from a paired midbrain structures, the isthmo-optic nucleus and ectopic cells of the surrounding tegmentum, to amacrine-like target cells (isthmo-optic target cells), distributed exclusively within the ventral retina. Isthmo-optic target cells, in-turn modulate the activity of a large percentage of retinal ganglion cells through intrinsic retinal connectivity, first described by Ramon y Cajal in the late nineteenth century. The 'closed-loop' that comprises the centrifugal visual system is completed via retinal ganglion cell projections to the optic tectum (analogous to the mammalian superior colliculus) which in turn input upon the isthmo-optic nucleus.

We report recent work from our lab which has demonstrated that lesion induced disruption of midbrain centrifugal efferents to the retina transiently unhinges eye growth in the chick, a common model for studies into the mechanisms that control

emmetropization, i.e. early refractive development. In addition, using pathway tracing and histological techniques, experiments in the pigeon have explored local midbrain connectivity, while investigations into brain-retina connectivity in the tree shrew have provided a comparative facet to the ultimate goal of elucidating the function(s) of the centrifugal visual system.

### ***7. Three-dimensional quantitative analysis of collagen fibre architecture in human peripapillary sclera***

**Craig Boote, School of Optometry and Vision Sciences, Cardiff University**

The collagen fibre architecture of the peripapillary sclera has a significant influence on the optic nerve head (ONH) biomechanics and may therefore be important in glaucoma. Our purpose was to obtain the first quantitative, 3D maps of collagen fibre architecture in the human peripapillary sclera.

6mm left peripapillary scleral buttons were removed post-mortem from three normal Caucasian human donors aged 74-79 years and with no glaucoma history. Six 150  $\mu\text{m}$  thick serial sections were obtained for each specimen using a cryo-microtome. Wide-angle x-ray scattering was used to quantify the orientation, mass distribution and degree of anisotropy of preferentially aligned collagen fibres at 0.5mm intervals across each section. Second harmonic generation multiphoton microscopy provided visual confirmation of the collagen fibre alignment.

Consistent with previous findings by our lab and others, a ring of fibres was noted circumscribing the ONH, in which the degree of fibre alignment varied with circumferential position. New quantitative depth-profiling of the fibre anisotropy revealed that the circumferential fibre ring structure was concentrated in the mid stromal depth. Meridional fibre bands were also noted anchoring superiorly and inferiorly into the peripapillary fibre ring and radiating obliquely into the mid-posterior sclera. This feature was also largely restricted to the mid-stromal depth.

The anisotropic collagen fibre architecture of the human peripapillary sclera exhibits marked depth-dependency. This may represent a mechanical adaptation designed to protect the ONH from pressure elevations by more effectively reinforcing the peripapillary tissue at its insertion point with the lamina cribrosa.

### ***8. When bigger is not better: Modelling distractor disruption in a neural field model of the superior colliculus***

**Geoffrey Megardon, School of Psychology, Cardiff University**

Saccade end-points are attracted toward distractor stimuli that are spatially and temporally close to the saccade target. The magnitude of this effect shows a reversal pattern with distractor size (Tandonnet et al. 2012): for relatively small distractors attraction increases with size, but after a critical point attraction decreases with size. To explain this, it was suggested that lateral connections in the superior colliculus lead to auto-inhibition of large distractors. Here we modelled the superior colliculus with a 2D map of spiking neurons with a 'Mexican-hat' lateral connection profile. First, we show that auto-inhibition occurs for intermediate stimulus sizes, while larger stimuli maintain strong activation at their extremities. Second, we simulate the experiment of Tandonnet et al. and successfully reproduce the reversal pattern in the behavioural

data, but only if the Mexican-hat is elliptical, not circular as normally assumed (whereas a Gaussian connection profile provides a less strong reversal pattern). Importantly, however, the reversal pattern has two origins in the model: auto-inhibition, as suggested, and a repulsion effect stemming from the active extremities of the distractor. Testing the existence of this repulsion effect behaviourally provides a novel avenue for testing the Mexican-hat hypothesis in humans.

### **9. Towards 2D+3D Modelling of Conversational Expressions**

**Jason Vandevanter, School of Computer Sciences and Informatics, Cardiff University**

In terms of facial expression research, the majority of work is based on the so-called universal expressions (i.e., happiness, sadness, anger, disgust, fear, and surprise), as defined by Ekman [3]. With the exception of happiness, however, these expressions do not occur with high frequency in everyday conversations. In recent years, there has been an effort to examine other expressions that occur in conversations with a higher frequency (such as thinking, agreeing, being confused, being bored, etc.). Conversational expressions are not limited to movements of facial muscles; they also include global head motion and orientation (e.g., to indicate agreement or disagreement); and gaze (e.g. to indicate the addressee of a question).

In human conversations, it is commonly accepted that facial expressions of the speaker, known as *frontchannel expressions*, contain a vast amount of information that has an effect, both consciously and subconsciously, on the listener. Recent research indicates that the facial expressions of the listener may also impact the state of the speaker; these expressions have been termed *backchannel expressions*. Backchannel expressions can indicate comprehension (e.g., a look of confusion), provide an assessment (e.g., saying "correct"), control conversational flow, or even add new content (e.g., sentence completion).

The exchange of these dynamic facial expressions creates a catalogue of *conversational expressions*, many of which have been studied by psychologists in experiments regarding the perception of human facial expressions. One of the main challenges for researchers in recent times is the availability of natural (i.e. "free-rein"), dyadic conversations. In order to detect backchannel expressions, let alone fully model them, it is necessary to have real-world test data. Whilst some conversational databases exist, there are issues with the "natural" interaction between participants. For example, pre-defined speaker/listener roles, poor visibility of subjects, and one side of the conversation containing an operator-controlled synthesized face make these databases unsuitable for our research.

The Cardiff Conversation Database (CCDb) is a unique 2D/3D multimodal database of natural conversations designed specifically to allow modeling of front- and backchannel elements of dialogues, between pairs of people. It currently consists of 30 conversations, eight of which are fully annotated for speaker activity, facial expressions, head motion, and non-verbal utterances. Baseline experiments were performed for the 2D data, in which an SVM classifier was used to differentiate frontchannel from backchannel expressions. Using this database, it is possible to develop 3D models of conversational expressions.

CCDb can be used to create dynamic, 2D/3D models of conversational expressions. After registering the facial data, statistical models of shape and appearance (i.e. Active Shape

Models (ASMs) and Active Appearance Models (AAMs) are developed. These models can be used in perceptual experiments regarding human facial expressions. This work will describe the CCDB, 2D results, and the current work on building dynamic, 3D models of conversational expressions.

### ***10. Distance-dependent defensive colouration***

**James Barnett, School of Biological Sciences, University of Bristol**

The study of animal defensive patterns has largely focused on single strategies; how to maximise the efficiency of camouflage or aposematism. However, animals may well be doing both simultaneously, managing to be both aposematic and camouflaged depending on where they are viewed from. In nature camouflage is often compromised by other life history traits, such as movement; and aposematism is undermined by naïve, specialised or nutritionally stressed predators. This suggests that a secondary back-up defence could be an advantage. One potential mechanism is the through the perception of spatial frequency - an image made up by combining two patterns of different spatial frequency is perceived differently based on observer distance. To investigate whether distance dependent signalling can reduce predation risk, we presented artificial 'moth-like' targets to wild avian predators in an English woodland. From this we show that by combining high spatial frequency aposematism with low spatial frequency camouflage, so as to be inconspicuous from a distance and aposematic close up, survival can indeed be increased.

### ***11. Using diffused Maxima Region to improve Photometric Stereo***

**Jahanzeb Ahmad, Centre of Machine Vision, University West of England**

Photometric Stereo is good at recovering the local surface orientation, but provides no absolute depth information about the observed scene. The subsequent reconstruction procedures used to obtain 3D shape of the scene are prone to low frequency geometric distortion and systematic error (bias) build-up due to imperfections of the illumination in practical application and error in the calibrated direction of light sources. The general assumption of a collimated light source is not always true for real world applications, especially where the setup space must be constrained. To overcome these problems we propose a novel calibration process to dynamically calculate light vectors for each pixel with very little additional computation cost. The Lambertian diffused maxima region is used to calculate object distance from the camera, from which the corrected light vector per-pixel is derived and the absolute dimensions of the object can subsequently be estimated. Experiments performed on synthetic as well as real data show the proposed approach offers improved performance, achieving a reduction in the estimated surface normal error of almost 2 degrees.

### ***12. The effect of obstacle baseline displacement on traversal behaviour in humans during locomotion***

**Katherine Daniels, Merchant Venturers' School of Engineering, University of Bristol**

Raised obstacles in the path of locomotion can cause loss of balance and injury if not anticipated. Information about the horizontal location and height of an obstacle must be obtained using vision in advance of reaching the obstacle for successful traversal.

Although the height of the obstacle can only be determined from its highest point, it is not clear whether the location of the obstacle is determined from the intersection of the base of the obstacle with the ground (the baseline) or from some other part of the obstacle. Here we investigated whether the presence and location of the baseline was used by human subjects to traverse a raised obstacle. Subjects ran along a straight 15 m track and leaped over an obstacle consisting only of an elevated horizontal rod. An identical rod, the baseline, was placed on the ground and its position varied in the direction of travel to alter the geometry of the obstacle without changing the mechanical requirements for traversal. We show that there were no significant differences between traversal foot trajectories when no obstacle baseline was present compared to when a baseline was present vertically beneath the obstacle. However, modifying the position of the baseline affected the horizontal but not the vertical trajectory of the feet when leaping over the obstacle. This suggests that a baseline, when present, contributes to the visual judgement of obstacle location.

### ***13. Semi-automated Sholl analysis: a systematic comparison of methods***

**Kate E Binley, School of Optometry and Vision Sciences, Cardiff University**

Sholl analysis is a tool commonly used in neurobiology to quantitatively measure the branching pattern of neurons. It is widely used as a benchmark for neuronal degeneration and a number of software packages have been developed to work with image analysis programs such as ImageJ to semi-automate the derivation of Sholl scores. We observed discrepancies between these packages and therefore undertook a systematic comparison of 4 packages using a defined population of retinal ganglion cells (RGCs).

62 mouse RGCs were labelled with DiI and DiO and z-stacked images were imported into ImageJ. The cells were traced in 3D using Simple Neurite Tracer. Simple Neurite Tracer Sholl analysis was carried out on 3D tracings and 8-bit tracings were used for the other methods. For the conventional method concentric circles were digitally drawn onto the 8-bit cell tracing. For all analyses intersections were measured in 10  $\mu\text{m}$  steps up to a maximum radius of 500  $\mu\text{m}$ . Bland-Altman plots were constructed to compare agreement between methods.

The Sholl profiles for Simple Neurite Tracer, Fast Sholl, and conventional method overlap well, and Bland-Altman plots suggest good agreement. Bitmap Sholl Analysis and Ghosh lab Sholl analysis Sholl profiles have reduced peak amplitudes, relative to the conventional method profile, and second peaks. Bland-Altman plots indicate poor agreement for these 2 methods with the conventional method.

The ImageJ plug-in Simple Neurite Tracer and the MATLAB script Fast Sholl demonstrate very good agreement with the conventional method for Sholl analysis. We highlight errors of undercounting and a second peak, as well as presence of systematic errors, in Bitmap Sholl Analysis and Ghosh lab Sholl analysis. We therefore suggest amendments to these algorithms.

This work was funded by the Medical Research Council.

#### ***14. Automatic vanishing points detection applied to visual surveillance environments*** Katy Tarrity, Centre for Machine Vision, University West of England

In visual surveillance, scene analysis is a complex task. It gives better understanding of the scene by extracting relevant information such as geometry, colour, texture, 2D or 3D data, size of objects, their distance from the camera, etc. Vanishing point detection is a well known problem and one of the most classical techniques which can assist this task by detecting line is the Hough Transform. In this work, we deal with the problem of automatic vanishing points detection to improve other visual surveillance tasks such as image segmentation, image understanding, 3D reconstruction, camera calibration etc. We present a novel algorithm based on linear geometries within railway station scenes. We make use of a priori information on the scene to constraint our line and vanishing point detection. The method uses the Hough Transform to automatically highlight linear features, such as railway tracks and shelters, which are then extrapolated to form one to three vanishing points from a sequence of video images. Finally, our technique does not require any user intervention or known measurements unlike most existing methods.

#### ***15. Individual variability in orientation discrimination thresholds as a function of stimulus duration and orientation***

Laura Whitlow, School of Psychology, Cardiff University

Previous research investigating individual variability of the oblique effect could have been confounded by the stimulus used at vertical axes being too easy causing participants to perform 'at ceiling'. The purpose of this experiment was to investigate this possible ceiling effect at vertical axes by progressively shortening the stimulus duration from a maximum of 250ms to a minimum of 10ms, increasing the difficulty of the task. Individual variation across these different stimulus durations and orientations will also be investigated. This experiment will additionally be used as preliminary work for future experiments with patients with a diagnosis of schizophrenia.

The task consisted of two sequentially presented gabor patches, width  $4^\circ$ , with participants ( $n=48$ ) instructed to respond which of the two patches was orientated more to the right by mouse button presses, left = first circle and right = second circle.

With a starting angle of  $0^\circ$  across 5 different stimulus durations; 10ms, 36ms, 60ms, 100ms, 250ms, orientation discrimination thresholds were calculated using two randomly interleaved 1up-2down adaptive staircases. A further oblique condition with a starting angle of  $45^\circ$  and stimulus duration of 250ms was also administered.

Average thresholds within the vertical conditions reduced as the stimulus duration increased. The mean threshold for the oblique condition, however, was significantly higher than all the vertical conditions at the  $p<0.01$  level (see Figure 1). Furthermore, after all results 2SD above the mean were excluded, thresholds from each condition significantly correlated within participants except the 60ms and 250ms-oblique conditions (see Table 1).

Results suggest the shorter the stimulus duration using vertical axes the harder the task becomes as shown by the increase in mean thresholds as stimulus duration decreased. The oblique condition proved harder still for participants as thresholds in this condition were significantly higher than any of the vertical conditions. These results also suggest that there was no ceiling effect present as shown by the high correlation between the 250ms and 10ms vertical conditions.



### ***16. 3D Facial Expression Recognition using Photometric Stereo***

**Laurence Broadbent, Centre for Machine Vision, University West of England**

In this work we argue that the high frequency spatial variations in the topological information of the face are important for Facial Expression Recognition. Stereo and laser scanner based datasets currently used are inherently regularised, resulting in the loss of high frequency information.

We test our hypothesis on the dense gradient field from photometric stereo which preserves this high frequency information. To overcome the geometric artefacts introduced through the integration of the gradient field we take a local approach and, assuming piecewise smoothness, we directly extract the second order differential geometry. We combine the local normal distribution, curvature information and the dynamic change in these distributions to represent the static and dynamic morphology of the face.

We carry out analysis on the Binghamton BU4DFE, the Bosphorus dataset as well as a novel photometric stereo dataset and show that the high frequency information preserved by photometric stereo may be highly useful for automatic facial expression recognition.

### ***17. Smooth pursuit mechanisms in normals and infantile nystagmus***

**Lee McIlreavy, School of Optometry and Vision Sciences, Cardiff University**

Smooth pursuit (i.e. tracking) is a fundamental class of eye movement that is used to align the eyes with a moving target, for example when following a bouncing ball. For successful tracking, the smooth pursuit system must modulate eye velocity accurately to match target velocity; too slow and the eye lags behind the target, too fast and the eye leads in front of the target. We have investigated how the smooth pursuit performance (i.e. accuracy and precision) of young and older observers, with normal vision and with infantile nystagmus, varies as a function of eye position. Dot stimuli, moving back and forth over  $10^\circ$ , were presented at positions directly ahead and up to  $\pm 20^\circ$  either side at  $10^\circ$  intervals. Although previous smooth pursuit experiments in normals have assumed that performance does not change with eye position, this has never been formally investigated, while in infantile nystagmus, where performance does change with eye position, it has never been formally quantified. We discuss the perceptual implications of our data and the consequences for models of oculomotor control.

### ***18. Human Visual Search Performance for Targets in a Natural Scene***

**Olivia Matthews, School of Experimental Psychology, University of Bristol**

The mechanisms of camouflage have been subject to renewed interest at the interface between Biology and Psychology. The need to assess camouflage performance remains pressing for the military, particularly when field trials are expensive and constrained in what they can achieve. This investigation sought to establish human visual search performance for targets in a natural scene, with the ultimate objective of assessing the performance of a computer vision system designed for object classification. Nine participants were recruited to complete a visual search task involving images of three possible targets of varied and arbitrary form (a model rat, a taxidermy crow and a green rucksack) hidden within a forest scene. A 3-by-2-by-2, within-subjects design, blocked by these 12 combinations, was used, with target (rat, crow or rucksack), location

prompt (fixation cross at screen centre or target centre) and presentation time (user terminated or 500msec) being the within-subject factors. Response time and percentage of correct responses were measured as the dependent variables. Initial statistical analysis of results indicates participants found targets quickly and consistently, broadly in line with the performance of the computer system. Future research will investigate the influence of distance, colour and orientation of the target, cross-validating the computer model, thus providing a rapid method for the assessment of camouflage efficacy.

### ***19. Can High Pressure Freezing Preserve Native Structure of Cells and Developing Collagen Lamellae in Hydrated Embryonic Cornea?***

**Philip N Lewis, School of Optometry and Vision Sciences, Cardiff University.**

In embryonic cornea, keratocytes (fibroblasts) deposit collagen fibrils with remarkably regular diameter and spacing into an ordered array of superimposed lamellae, essential for transparency of mature tissue. Mechanisms involved remain unknown. Observation of native structure is important to understand how cells orientate collagen fibrils for cornea-specific function within highly-hydrated embryonic tissue.

Corneas from developing chicks at embryonic day 14 - when loose collagen bundles begin condensing into lamellae - were either fixed for 1h in 2.5% glutaraldehyde/2% paraformaldehyde in 100mM cacodylate buffer, or processed immediately unfixed. Corneas, +/- fixation, were trimmed to 1 mm<sup>2</sup> x full thickness (approximately 200µm), transferred to 1.5mm dia Leica flat specimen carriers (+/-sapphire discs), or membrane carriers, with 10% PVP/ 7% methanol cryoprotectant, and rapidly frozen in a Leica EMPACT2 high pressure freezer. Frozen specimens were freeze substituted at -80°C in 2% Osmium/Acetone for 24hrs in a Leica AFS2, and embedded in Araldite resin at 20°C. 100nm sections cut on a Leica UC6 ultramicrotome were examined in a Jeol 1010 TEM, and images recorded with a Gatan Orius SC1000 CCD camera.

The freezing quality, judged from ultrastructural preservation was relatively good in both fixed and unfixed samples. However, freezing quality varied markedly with location within single specimens, peripheral, and outer sites showing better structural integrity, with gross distortion of structure at the centre. In regions of better freezing, keratocyte organelles, cell membranes and surrounding collagenous matrix all showed adequate structural preservation. This enabled identification of putative cell membrane channels, first recognised in developing tendon and termed, fibripositors, considered crucial for extracellular deposition of orientated collagen fibrils

We have achieved satisfactory cell and matrix preservation by high pressure freezing of embryonic cornea, although full thickness freezing of the tissue was not attained. Cellular structures potentially crucial for orientated collagen secretion were identified for the first time in cornea.

### ***20. Target location frequency and saccadic reaction time: Evidence for long term effects***

**Rosie Clark, School of Experimental Psychology, University of Bristol**

Saccadic reaction times are faster to locations that occur more frequently (Carpenter and Williams, 1995). Within models of saccade latency (such as LATER) this change is accounted for by a modulation in the starting point of the accumulation process.

Previous work has shown that such changes in saccadic reaction times could be the result of a temporally local mechanism. Saccadic reaction time to the current target is dependent on the repetition of target location on consecutive trials (Walthew and Gilchrist, 2006).

Here we show that the saccadic reaction time to more frequently occurring locations also changes across testing sessions within a single day and even in some cases across consecutive days of testing. This suggests that there is an additional longer term mechanism driving this effect.

We conclude that this apparently simple phenomenon is a product of a number of separate processes acting over very different timescales.

*Carpenter, R. H. S., and Williams, M. L. L. (1995). Neural computation of log likelihood in the control of saccadic eye movements. Nature 377, 59-62.*

*Walthew, C., & Gilchrist, I. D. (2006). Target location probability effects in visual search: An effect of sequential dependencies. Journal of Experimental Psychology: Human Perception and Performance, 32(5), 1294-1301.*

## ***21. Anatomical implications of trephination and graft/host tissue misalignment in corneal transplant surgery***

**Sally Hayes, School of Optometry and Vision Sciences, Cardiff University**

Although the success rate of corneal transplantation is high, post-operative astigmatism is a common problem. This study examines the structural consequences of trephination and graft/host tissue misalignment and their potential impact on the biomechanical stability of the cornea.

Wide-angle X-ray scattering was used to determine the predominant direction of corneal collagen (the major load-bearing component of the tissue) in four *in vitro* human donor corneas before and after the trephination and replacement of a 4mm, 6mm, 7.5mm and 9mm corneal button in either the correct anatomical orientation or at a 45 degree angle.

The extent of disruption to the natural organisation of corneal collagen was strongly influenced by the size of the trephine used and the orientation of the graft with respect to the host tissue. The use of trephines  $\leq 7.5$ mm and the subsequent replacement of the corneal button in the correct anatomical orientation resulted in the least disruption to collagen arrangement.

Disturbances to the organisation of corneal collagen following trephination and/or the misalignment of graft/host tissue may affect the biomechanical stability of the cornea and potentially increase the risk of post-operative astigmatism.

## ***22. Fibrinogen, riboflavin, and UVA to immobilize a corneal flap—conditions for tissue adhesion and molecular mechanisms***

**Stacy Littlechild, School of Optometry and Vision Sciences, Cardiff University**

Laser in situ keratomileus (LASIK) is an eye surgery aimed at correcting common vision conditions such as nearsightedness, farsightedness, and astigmatism. A caveat to this procedure is that it creates a permanent flap that remains non-attached to the underlying laser-modified corneal stroma. This lack of permanent adhesion is a liability. To immobilize a corneal flap, a protocol using fibrinogen (FIB), riboflavin (RF), and

ultraviolet (UVA) light (FIB+RF+UVA) was devised to re-adhere the flap to the stroma. In addition, several covalent and noncovalent interactions between these classes of macromolecules are studied.

A model flap was created using rabbit (*Oryctolagus cuniculus*) and shark (*Squalus acanthias*) corneas. Solutions containing FIB and RF were applied between corneal strips as glue. Experimental corneas were irradiated with long wavelength (365 nm) UVA. To quantify adhesive strength between corneal strips, the glue-tissue interface was subjected to a constant force while a digital force gauge recorded peak tension. SDS-PAGE and Western blot techniques were used to identify covalent interactions between tissue glue molecules and corneal ECM molecules in either the presence or absence of RF and UVA, *in vitro* and *ex vivo*. Surface plasmon resonance (SPR) was used to characterize noncovalent interactions, and obtain  $k(a)$ ,  $k(d)$ , and  $K(D)$  binding affinity values.

In the presence of FIB, substantive non-covalent interactions occurred between rabbit corneal strips. Adhesiveness was augmented if RF and UVA also were applied, suggesting formation of covalent bonds. Additionally, exposing both sides of rabbit corneas to UVA generated more adhesion than exposure from one side, suggesting that RF in the FIB solution catalyzes formation of covalent bonds at only the interface between stromal molecules and FIB closest to the UVA. In contrast, in the presence of FIB, shark corneal strips interacted non-covalently more substantively than those of rabbits, and adhesion was not augmented by applying RF+UVA, from either or both sides. Residual RF could be rinsed away within 1 hour. SDS-PAGE and Western blot analyses indicated that covalent interactions occurred between neighboring FIB molecules, as well as between FIB and collagen type I (Coll-I) proteins (*in vitro* and *ex vivo*). These interactions occurred only in the presence of RF and UVA. SPR data demonstrated the ability of FIB to bind noncovalently to corneal stroma molecules, Coll-I, decorin, dermatan sulfate, and corneal basement membrane molecules, laminin and heparan sulfate--only in the presence of  $Zn(2+)$ .

Glue solution containing FIB and RF, together with UVA treatment, may aid immobilization of a corneal flap, potentially reducing risk of flap dislodgement. Covalent and (zinc-mediated) noncovalent mechanisms involving FIB and stromal ECM molecules contribute to the adhesion created by FIB + RF + UVA.

### ***23. Getting Down with the Kids - Cornea in Trisomy 21,***

**Stephanie Campbell, School of Optometry and Vision Sciences, Cardiff University**

How would you tell someone that your vision was blurry if you couldn't use any words?

Keratoconus is a condition whereby the cornea becomes thinner, and protrudes, creating much imbalance in the refractive abilities in the eye; resulting in a marked loss of vision. While this also affects the general population to a lesser degree, the disease is much more common in Down's syndrome. Unfortunately this group is rarely able to communicate a problem with their vision until the latter stages of the condition, when the only treatment option available is corneal transplant.

A new treatment called collagen cross-linking is soon to be available on the NHS, and this has shown to be highly effective if initiated early. It is therefore vital to establish a method of early diagnosis of keratoconus for our Down's syndrome patients.

From a clinical viewpoint, this presentation reviews the necessity of early screening, the practicalities of obtaining data and the current difficulties in making a diagnosis.

Modelling the light scattering in the cornea caused by stromal cell activation, S.J.Gardner  
Cardiff University

Recent studies have suggested the development of post-operative corneal haze could be due to an increase in light scattering from activated corneal stromal cells. Quiescent keratocytes are thought to produce crystallins which match the refractive index of their cytoplasm to the surrounding extra-cellular material, reducing the amount of light scattering. In a previous study stromal cells were measured to have a change in refractive index of  $0.013 \pm 0.005$  on activation. This study presents the results of attempts to model the scattering that an increase in refractive index mismatch would cause. We model the stromal cells as cuboidal slabs of constant thickness and utilise the anomalous diffraction approximation to Mie scattering. We show that scattering is increased throughout all areas of the cornea on cell activation, and that while transmission through the stroma remains above 90% in most cases for populations of quiescent cells at normal volume fractions, this drops to a maximum of 60% upon cell activation.

#### ***24. Dark adaptation as a biomarker of hypoxia in age-related macular degeneration*** Tamsin Callaghan, School of Optometry and Vision Sciences, Cardiff University

Background: Age related macular degeneration (AMD) is currently one of the leading causes of blindness in the western world, with this figure set to increase with the ageing population.

The retina is one of the most metabolically active areas in the body, and there is evidence that in the dark the healthy retina is on a hypoxic knife edge, with cells only just having enough oxygen for their requirements. We hypothesise that the reduction in choroidal blood supply and the thickening of Bruch's membrane associated with early AMD are likely to lead to retinal hypoxia. This is supported by the finding that early AMD has an effect on scotopic visual thresholds and the rate of dark adaptation which is similar to the effect of induced hypoxia in healthy subjects.

This study aimed to investigate the effect of mild transient hypoxia and hyperoxia on scotopic thresholds at three retinal locations in healthy subjects. Scotopic thresholds were measured using annular targets at 2, 7 and 12 degrees from fixation, with the participant breathing either 14% oxygen, medical air or 60% oxygen for a period of 5 minutes. This process was repeated for each gas at each location. Location and gas order were randomised. Peripheral blood oxygen saturation ( $SpO_2$ ) was monitored throughout using a pulse oximeter.

There was a steady decrease in mean  $SpO_2$  with time when participants were breathing 14% oxygen, but no plateau was reached within 5 minutes. There was no statistically significant difference in mean scotopic thresholds between the three gases at any location.

The lack of a significant difference in thresholds between gas conditions could be due to the participants not being sufficiently hypoxic. A follow up study, also presented, measuring  $SpO_2$  in older and younger subject groups concluded that 14% oxygen needs

to be breathed for 13 minutes for SpO<sub>2</sub> to equilibrate. A further study is planned assessing scotopic thresholds when 10% oxygen breathed for 15 mins.

## ***25. High dynamic range video compression by intensity dependant spatial quantisation with the HEVC standard***

**Yang Zhang, Merchant Venturers' School of Engineering, University of Bristol**

The Human Visual System (HVS) shows nonlinear sensitivity to the distortion introduced by lossy image and video coding. This nonlinear sensitivity is due to luminance masking, contrast masking and the spatial and temporal frequency masking phenomena of the HVS. This paper presents the application of a quantisation tool that exploits luminance masking in the HVS in order to enhance the performance of the High Efficiency Video Coding (HEVC) standard for the case of High Dynamic Range (HDR) video content encoding.

Results from HDR luminance masking psychovisual experiments indicate that the HVS is less sensitive to coding distortions introduced in HDR image areas where the average pixel intensity is either low or high. To exploit this varying distortion sensitivity, a luminance masking profile is used to map the average luminance intensity and the quantisation step for each coded block. Usually, one profile is used for the whole sequence, although this prevents to adapt the luminance masking with respect to the variations of the luminance dynamic range along the video frames. To adapt the luminance masking profile for each frame, this paper proposes a profile scaling based on the tone mapping curve computed for each frame. With the obtained profile, the quantisation step is perceptually tuned on a Transform Unit (TU) basis. The proposed HDR Intensity Dependant Spatial Quantisation (HDR-IDSQ) tool is designed to make the inverse quantisation step at the decoder independent on the availability of average luminance of each block, therefore no further latency and pipeline refactoring is introduced at the decoder.

The proposed HDR-IDSQ method has been implemented in the HM-10-REXT and its performance was assessed by measuring the bitrate reduction with respect to the HM-10-REXT codec. The HDR-VDP-II video quality metric was employed to measure the compressed picture quality. For the same quality level, significant bit rate reductions are achieved across all tested HDR sequence.