Measuring image distortions in age-related macular degeneration (AMD)

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Metamorphopsia, a condition often associated with macular disorders such as AMD, manifests itself as the perceived distortion of straight contours. Currently, the most commonly used clinical tool to assess metamorphopsia is the Amsler chart which is a printed grid of equally spaced horizontal and vertical lines. The degree to which patients report this grid as deformed and irregular is taken as indicator of the severity of the condition. To obtain a reproducible map of visual deformations, we developed a new diagnostic tool which we call ‘Iterative Amsler Procedure’, or IAG. In this procedure, curved horizontal and vertical lines segments (perceived or physical distortions) are displayed on a computer monitor to probe different regions of the visual field, to be manipulated by the observer via mouse-control such that they appear straight. Control participants were able to reliably correct deformations that simulate metamorphopsia. They reduce an aggregate error measure in this iterative process, with the total number of iterations depending on the extent of deformation. Pilot experiments involving AMD patients suggest that they are comfortable using the IAG method and generate sensible deformation maps, but also indicate that stabilising gaze can be difficult for them.

Using psychophysical reverse correlation to measure the extent of spatial pooling of luminance contrast

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Area summation experiments measure the improvement in detectability of contrast as stimuli get larger. But what are the limits of this improvement, and what strategy does an observer use to integrate contrast across space? We employed a reverse correlation technique to directly estimate the size of the pooling region, and to compare two different strategies: signal selection (MAXing) and signal combination (summing). Stimuli were regular arrays of (27x27) grating patches, the contrasts of which were determined individually from a normal distribution (mean 32%, SD 10%) on each trial interval. Observers detected a contrast increment applied to a square subset of the patches (1 to 27 elements wide). Each observer completed 2000 2IFC trials per target size using a blocked method of constant stimuli design. We correlated the observer’s trial-by-trial responses with the contrast difference of each patch across trial intervals. This produced a map, akin to a classification image, that revealed the patches contributing to the observer’s decisions. But this standard approach cannot distinguish between summing and MAXing strategies. We therefore directly compared (again using correlation) trial-by-trial model predictions of observer responses for both strategies across a range of pooling windows. Summing target contrasts over space produced the strongest correlation with human behaviour, and provided an estimated pooling region of 9-13 grating cycles. This supports earlier work that had reached similar conclusions using more traditional techniques. Furthermore, individual differences in maximum pooling region correctly predicted the rank ordering across observers of the magnitude of area summation at detection threshold.
Pooling strategies for the integration of orientation signals depend on their spatial configuration

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The visual system combines samples from the retinal image into representations of spatially extensive textures. Local orientation signals can be pooled over a texture to estimate global orientation, with psychophysical performance improving as a function of signal area. We used a novel stimulus to investigate how orientation signals are combined over space (whether observers could ignore signals from irrelevant locations), and the effect of spatial configuration on this pooling. Stimuli were 24×24 element arrays of 4 c/deg log-Gabors, spaced 1 degree apart. A proportion of these elements had a coherent orientation (horizontal/vertical), with the remainder assigned random orientations. The observer’s task was to identify the global orientation. The spatial configuration of the signal was modulated by a checkerboard-like pattern of square checks containing either potential signal elements or only irrelevant noise. The distribution of signal elements within the array was manipulated by varying the size and location of these checks within a fixed-diameter stimulus. A blocked staircase procedure found the threshold coherence for identification. An ideal detector would pool over just the relevant locations (vector-averaging and filter-maxing models make identical predictions for these signal combination effects), however humans only did this for medium (5×5 to 9×9) check sizes, and for large (15×15) check sizes when the signal was placed at the fovea. For small (1×1 to 3×3) check sizes and large (15×15) peripheral checks the pooling occurred indiscriminately over relevant and irrelevant locations. These findings suggest orientation signals are combined mandatorily over short ranges and in the periphery, but flexibly otherwise.

Responses to symmetry measured with a series of implicit association tests

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In previous work, we studied preference for symmetrical abstract patterns with the Implicit Association Test (IAT). On some trials, participants saw positive or negative words and classified them as quickly as possible. On interleaved trials, they saw reflection or random patterns and again had to classify them quickly using the same buttons. As expected, participants were faster in congruent trials (symmetry and positive, random and negative) than in incongruent trials (symmetry and negative, random and positive). In this study we included different dimensions (multidimensional IAT: Gattol, Sääksjärvi, & Carbon, 2011, PLoS One, 6, e15849), in addition to valence we looked at the relation between symmetry/random and arousal, complexity, and numerosity. Results showed a strong association between symmetry and positive valence (positive D scores based on t test), but also an association between symmetry and words higher in arousal. There was also a significant but weaker association between symmetry and simplicity. Finally, we found no association between preference for symmetry and the score on the Personal Need for Structure (PNS) questionnaire. Valence and arousal are believed to be independent dimensions of emotion, but we found that symmetry is associated with both, as well as with simplicity, possibly because of its perceptual fluency.
Distortion and Comfort in Stereoscopic Angle Estimation

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3D content producers use low amounts of screen disparity to minimize viewer discomfort. Low screen disparity can result in a flattened 3D image. Participants made 250 2AFC judgments of whether a hinge stimulus (Banks et al., 2009, Information Display, 25, 15) had an angle of greater than or less than 90°. Two factors were manipulated. First, virtual camera separation which linked interaxial separation to HIT (horizontal image translation) (20, 40, 60, 80, 100mm). This kept the point of zero parallax at the hinge apex. Second, the rendered angle of the hinge (50-130°) was changed in 10° steps. Overall disparities presented were in the range (30-165 arcmin). Screen width (50cm), viewer distance (60cm), target width (20cm) and virtual target distance (60cm) were calibrated to display an orthoscopic image with a matched 45° horizontal field of view to the angle of view. Angle responses were predicted using a ray-tracing disparity model. The angle PSE only matched prediction with a 60mm virtual camera separation which approximately matched observer interpupillary distance. Changing virtual camera separations produced less perceived angular distortion than predicted but was still significant between camera separations. Viewer comfort was rated after each trial on a 5 point Likert scale (Shibata et al., 2011, Journal of Vision, 11:8(11), 9). A strong negative correlation was found between disparity (arcmin) and comfort. No correlation was found between angular distortion and comfort ratings. Changing camera separation by linking interaxial and HIT is a distortive process thus making a comfortable undistorted stereoscopic image difficult to achieve.

Increasing velocity reduces the perceived duration of a visual interval.

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Identical intervals containing visual objects that drift or flicker at different rates do not appear to have the same duration. Higher rates lead to duration overestimation (Kanai et al., 2006, Journal of Vision, 6, 1421-1430; Kaneko & Murakami, 2009, Journal of Vision 9, 14). A mechanism that determines perceived duration by reflecting the number of temporal changes occurring within an interval was proposed to explain this effect. According to this view, two intervals that contain the same number of changes should appear to have the same duration. In this study, we asked subjects to compare the relative duration of an interval that contained accelerating or decelerating drifting motion (average speed: 10 °/s, different velocity ranges in different sessions) with that of an identical stimulus that drifted at a constant speed (also 10 °/s). Note that accelerating and decelerating stimuli have the same number of cycles. We observed a clear asymmetry between the two conditions. Increasing the velocity progressively reduced perceived duration, as observed by Binetti et al. (2012, Journal of Vision, 12, 7). However, the reduction was proportional to both range (rather than acceleration) and to the standard length indicating a constant effect through the interval. Decreasing velocity only induced a mild dilation. The effect on duration was dissociable from changes in perceived onset/offset or differences in perceived average speed between acceleration and deceleration. Our results show that the relationship between speed and apparent duration is not well captured by simply detecting and accumulating the temporal features within an interval.
Cortical processing of form, motion and biological motion in patients with congenital achromatopsia

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Congenital achromatopsia is a condition characterised by an absence of functional cones within the retina, resulting in poor visual acuity, absence of colour vision and photophobia. Research with patients has previously focused on low level visual perception (e.g. Hess & Nordby, 1986, J Physiol, 371, 365-385).

To study the impact achromatopsia may have on extra-striate visual processing, we measured coherence thresholds for global form, global motion and biological motion (discrimination between scrambled and intact point-light walkers degraded by noise) in four patients and six controls. The tests were completed under five light conditions ranging from photopic to scotopic.

Patients showed higher coherence thresholds than controls for both global form and motion. This effect persisted even in the scotopic condition in which all participants have to rely on rods, and for three of the four patients could not be explained by insufficient contrast sensitivity for detecting the stimuli. Biological motion did not show the same impairments, with patients showing comparable thresholds to controls. This suggests that biological motion perception can function independently of global form and motion perception. These psychophysical measures will next be compared with vERP responses in order to determine how cortical processing of these stimuli may differ in patients compared with controls.

With the development of treatments for retinal disease such as gene therapy, understanding the impact of photoreceptor deficits on higher level visual functions can inform us about neural plasticity and its implications for restoration of sight.

Simultaneous sketching aids the haptic recognition of raised line drawings of objects

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Recognising raised line drawings by haptic exploration is extremely difficult for reasons which are still not clear. We investigated whether much of this difficulty lies in integrating sequentially acquired information about global shape. This hypothesis is consistent with Wijntjes et al's (2008, Acta Psychologia, 128, 255-263) finding that items which participants had failed to recognise whilst they were touching them could sometimes be identified if people subsequently sketched what they had felt. This suggests that people can sometimes use touch to acquire the information necessary to recognise raised line drawings but they can only use this information when it was all available to them simultaneously. We extended this task and found that sketching at the same time as touching a raised line drawing improved recognition compared to sketching only after touching for 45s and also compared to sketching whilst touching but with the sketch hidden from view. Thus reducing the working memory load further improved haptic recognition. Note that participants used their whole hand to explore stimuli so haptic inputs were not restricted to a small spatial area. Our results suggest that the serial nature of information acquisition (rather than problems in accessing stored pictorial representations) is a major reason why raised line drawings are hard to identify. This conclusion is consistent with the well-established finding that 3D objects are recognised much more efficiently than 2D drawings since the simultaneous acquisition of global shape information is much easier for 3D than 2D objects (Lawson & Bracken, 2011, Perception, 40, 576-597).
Global motion coherence level modulates transient VERP amplitude

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Steady-state visual event-related potentials (VERPs) show differential responses to zero versus 100% coherent rotational motion in random dot patterns (RDPs) (Wattam-Bell et al., 2010, Current Biology, 20(5), 411-415). The current study examined the relationship between transient VERP amplitude and intermediate levels of coherence between 0-100%. Transient VERPs were recorded while adult participants viewed one-second trials of translational or radial motion RDPs and performed a 2AFC direction discrimination task. One hundred trials at each of six coherence levels (0.00%; 6.25%; 12.50%; 25.00%; 50.00%; 100.00%) were presented in random order, with separate runs for each motion type. Consistent with VERPs to rotational motion, the main response to both radial and translational motion was a posterior midline negative component starting at about 200 milliseconds post stimulus onset. Random effects analyses of this response revealed significant quadratic relationships between coherence and amplitude across the group for each motion type, demonstrating that the cortical response is modified by coherence level.

Observers voluntarily average with zero and invisible external noise

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Equivalent noise (EN) analysis has been used to quantify local and global limits on observers’ voluntary averaging of texture attributes like size and orientation. However Allard & Cavanagh (2012, Journal of Vision 12(11)(6): 1-12) have recently presented evidence that observers do not average across multiple elements in the absence of external noise, questioning a key assumption of EN. Specifically, these authors measured mean-orientation discrimination thresholds with one and with multiple elements, and used the ratio of these measures to quantify sampling efficiency. Ratios estimated under conditions of low noise were lower than those measured under high noise. Here we show that this arises not from a lack of averaging at low noise but from the ratio-method failing to deal with known elevation in internal noise that occurs as the number of elements increases. Contrary to Allard & Cavanagh’s explanation – that observers might only average elements that appear different to one another (i.e. at higher noise levels) – we show that observers voluntarily average orientation in the presence of zero, and demonstrably invisible noise in a manner that is closely consistent with the predictions of the EN model. We conclude that while it is true that observers could choose not to average under conditions of low noise this would lead to poor performance inconsistent with results reported here, Allard & Cavanagh’s own data, and a sizable body of prior psychophysical work.
Enhanced simultaneous contrast and reduced White’s Illusion in a remote population

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A remote population (the Himba of northern Namibia) with a pronounced local bias (Davidoff et al., 2008, Cognition, 108, 702-709; Caparos et al., Cognition, 2012, 122, 80-85) show a remarkable ability to ignore the non-target context of displays (de Fockert et al., PLoSOne, 2011, 6(10) e28337; Caparos et al., Psychological Science, in press; Linnell et al., JEP:HPP, in press). The Himba are also minimally susceptible to the Ebbinghaus (Titchener’s circles) Illusion, again apparently ignoring non-target context (de Fockert et al., 2007, JEP:HPP, 33, 738-742). So, given that White’s illusion leads Westerners to perceive exaggerated brightness changes via a comparison to the spatial context (Barton, 2003, Perception, 32, 269-284), we hypothesised that the Himba would also be less susceptible to that illusion.

Stimuli were presented to the Himba and British observers on the same CRT supplied by Cambridge Research Systems. The Himba were less susceptible to White’s illusion. However, a control condition investigating simultaneous contrast produced a quite different outcome. Observers were presented with two grey circles that were surrounded by backgrounds of different brightness. Now, the Himba were more susceptible to that illusory brightness change than were Westerners. We are looking for mechanism(s) which can explain these effects.

Lighting for pedestrians: Is facial recognition an important task for pedestrian at night?

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Within the street lighting community it has been argued that whilst people need light to detect obstacles along their route and orientate themselves, it is facial recognition that is a key task for pedestrians that requires the most light (Caminada and van Bommel, CIBSE National Lighting Conference 1982). However, this argument was based on assumed visual tasks and the amount of light each one required rather than any objective assessment. An eye tracking method was adopted to explore the importance of different visual tasks for the pedestrians at night. Eye tracking is a technique that has been used by many studies (e.g. Land MF, Lee D. 1994 Nature 369(6483) 742–744 and Patla AE, Vickers JN. 1997 Neuroreport 8 3661-3665) to try to understand what people are looking at a given time. Wearing an eye tracker, two groups of subjects were asked to walk three different residential routes (5 subjects in day time and 15 subjects at night). In order to obtain further information about the experience of the subjects during the walk, a short interview was performed after completion of the task. The results show that looking at other people appears to be important to pedestrians however, during this study, subjects’ fixation time on other people was limited. Also it shows that whilst pedestrians may spend between 40% and 50% of their time looking at the footpath, not all of that time is spent on critical visual tasks. Amongst the non critical visual tasks, looking at objects of personal interest was observed.

The apparent importance of the visual tasks away from the footpath raises questions about the priorities in lighting of different areas for pedestrians, in particular are vertical surfaces more important than horizontal surfaces.
Cascaded effects of spatial adaptation in the early visual system

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Visual adaptation is a phenomenon whereby neuronal responses are sensitive to the recent image statistics. It has been typically measured in one visual area at a time (Kohn, 2005, J Neurophysiology, 97, 3155-3164). How does adaptation in a visual area affect responses in downstream areas? We engaged spatially-selective adaptation subcortically, and asked whether primary visual cortex (V1) would simply inherit the effects, or whether it would add to them.

We recorded in visual thalamus (dLGN) and area V1 of adult mouse and mapped receptive fields with two types of one-dimensional sparse noise sequences. The first type was balanced, so that the probability of presenting a bar at any position was equal. The second type was biased, with the bar 2-3 times more likely to appear at a given “adaptor” position.

Neurons in dLGN underwent a gain change which depended on the proximity between neuronal receptive fields and the adaptor position: neurons with nearby receptive fields decreased their gain while the others increased their gain. The receptive fields did not change position. Effects on cortical neurons were markedly different – receptive field positions were repelled by the adaptor with no systematic effect on gain. We can reconcile these distinctive changes in the two areas by implementing a simple model where V1 cells summate geniculate inputs under a Gaussian weighting profile, fixed to be identical in the two adaptation conditions.

We conclude that the summation rules from one neural stage to the next are unaffected by changes in the image statistics.

Measuring BOLD response in human MT/MST as a function of visual motion density

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In humans the brain areas MT and MST are associated with the processing of motion information. Neurophysiological studies have shown that in macaque MT and MST neurons saturate very rapidly in their response to the density of visual motion (Duffy and Wurtz, 1991, Journal of Neurophysiology, 65, 1329–1345; Snowden et al. 1991, Journal of Neuroscience, 11, 3215–3230). We measured BOLD signal as a function of the number of randomly positioned moving (left or right at 2.5°s⁻¹) and static dots. The dots were restricted in their location by being overlaid with a gray mask containing randomly positioned 0.5° diameter transparent apertures, through which the stimuli could be seen (on average 3 dots each aperture), enabling a close match between the area covered by the static and moving stimuli. The stimuli gradually ramped on/off to minimize onset/offset responses and participants performed a central attention demanding task. We presented 1, 2, 3, 6, 12 and 64 apertures in order to measure response threshold. In contrast to early retinotopic areas, MT/MST responded to very small amounts of motion. We were able to describe in detail the response in these areas as a function of increasing motion signal density.
Individual differences in self-face recognition

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As we see our faces only indirectly, self-face recognition (SFR) requires efficient multisensory integration. Little is known about the mental representation of one's face, even though SFR is a hallmark of reflexive self-consciousness. A new paradigm was used to explore SFR and investigate how well we know our own facial features: participants (N = 35; 25 females) chose which of two self-face images was their veridical one (veridical image vs. image with eye, mouth and nose size digitally manipulated) and then which of those two images they liked most. The study provides evidence that recognition was better when veridical self-faces were paired with self-face ‘clones’ with larger rather than smaller facial features. Accuracy improved further when the features were enlarged concurrently as opposed to separately. Smaller noses and larger eyes were preferred and participants manipulate their self-images accordingly. Large individual differences and an asymmetrical self-face representation were common. The results indicated a certain tolerance for error in self-face recognition, which might be required to maintain a consistent facial identity during one’s life span. Surprisingly, the preference for neotenous self-facial features points to the internalisation of notions of attractiveness often desired in possible partners.

Individual differences in timing of audiovisual integration

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The sight and sound of a person speaking or a ball bouncing seem simultaneous, but their neural signals converge on different multimodal brain sites with different asynchronies. Brains come in different shapes and sizes, which further entails individual variations in this temporal distribution. How do people, and their brains, differ in how they integrate and synchronise hearing with vision? We measured temporal order judgements (TOJ) concurrently with the McGurk illusion (lip movements influence hearing), as functions of audiovisual asynchrony. There was no correlation between McGurk susceptibility, the width of the window of integration, or the Just Noticeable Difference for temporal order discrimination (TOJ), suggesting distinct mechanisms. However each measure did correlate with the volume of distinct brain regions quantified from MR structural images (lIPS/rMTG, rMFG, and rMTG, respectively). Different measures also correlated with reading aloud versus listening comprehension. Counterintuitively, individual differences in the asynchrony for maximal McGurk and also Stream-Bounce illusions (sounds influence perceived visual motion) correlated negatively with Point of Subjective Simultaneity for TOJ: individuals who needed auditory lag for optimal integration, needed an auditory lead to perceive the same stimuli as simultaneous, and vice-versa. We propose that asynchronies within individual brain mechanisms are perceived relative to the average asynchrony across mechanisms.

These observations allow us to (1) fractionate 'multisensory perception' functionally and structurally into distinct mechanisms, (2) relate a profile of simple perceptual abilities to more complex cognitive abilities, and (3) explain how we can perceive the multisensory world accurately on average, despite evident disunity of audiovisual timing.
Local Pooling Processes Limit Cyclopean Form Perception

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The perception of cyclopean form in random dot stereograms (RDSs) depends upon the linkage of multiple disparity measurements across space. This paper examines how local disparity measurement processes affect multi-local linkages in the perception of cyclopean orientation. Participants were presented with RDSs showing a sinusoidal modulation in depth, with an orientation of ±20 degrees. In a series of experiments, the number of dots depicting the cyclopean surface was manipulated. The placement of stimulus dots was also manipulated through grouping into elongated contours of 1, 2, 3 or 5 dots in length. The orientation of the depth sinusoid was reported in a 2AFC, clockwise versus counter-clockwise, discrimination task. Orientation discrimination performance depended on the number of dots used to define the depth sinusoid, and on their proximity to one another. Increasing the number of stimulus dots improved discrimination performance. However, this effect was reduced when dots were grouped into contours. Increasing the gap between contour dots led to improved discrimination performance. 75% correct thresholds for RDSs comprised of five-dot contours, with each dot separated by 5.5arcmin, were around 2.5 times those of RDSs comprised of two-dot contours, where dots were separated by 22arcmin, indicating that intervening dots in the five-dot contour contributed little to cyclopean form processing. A comparison of human performance to a cross-correlation model of cyclopean orientation discrimination suggests that local pooling processes in disparity measurement may limit the perception of global cyclopean structure when dots are grouped into contours.

Visual discomfort and the photoparoxysmal response - are they related?

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Certain grating patterns are capable of provoking epileptiform EEG activity in patients with photosensitive epilepsy. Healthy individuals generally find these patterns uncomfortable to look at, and the patterns usually induce a large haemodynamic response. Drifting patterns are an exception. These patterns are uncomfortable and induce a large haemodynamic response but they do not provoke epileptiform activity. We suggest that the discomfort is the result of a large neural response and consequent metabolic demand, and provides for homeostasis. Epileptogenesis requires not only a large neural response but in addition requires that the evoked neural activity be synchronous. Drifting patterns do not synchronise the evoked neural activity because the contours pass into and out of overlapping receptive fields. Patterns that repeatedly reverse their direction of drift are highly epileptogenic. We propose that this is because they alternately stimulate populations of neurons sensitive to the two directions of drift.
Modelling the Modulation Transfer Function to Account for Visual Discomfort Judgements

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The spatial frequency content of images affects visual discomfort judgements. In particular, relatively low amplitudes at high spatial frequencies compared to natural images can increase discomfort (e.g. Juricevic et al, 2010, Perception, 39(7), 884-99). We investigate the possibility that this occurs because these images create difficulties with the accommodative (focussing) response. Poor control of accommodation had been proposed as a potential cause of discomfort from visual stimuli (Tosha et al, 2009, Ophthalmic Physiol Opt, 29(6), 625-33). It is thought that the goal of the accommodative response is to maximise retinal image contrast (MacKenzie et al, 2010, Journal of Vision, 10(8), 22). We assessed the effects of changes in accommodation on retinal image contrast by modelling the modulation transfer function of the human eye. A monochromatic model of the MTF was created using wavefront aberrations from data of large sample studies (Salmon and van de Pol, 2006, J. Cataract., Refract., Surg., 32(12), 2064-2074). The model MTF was applied to visual stimuli previously identified as uncomfortable, to assess the effectiveness of these stimuli for driving the accommodative response. The effects of defocus on both the amplitude spectrum of the retinal image, and the maximum contrast gradients that it contained, were assessed. The results of the model suggest that there is little change in maximum contrast gradient with the addition of defocus for the more uncomfortable stimuli. Additionally, more uncomfortable stimuli are those lacking amplitude at spatial frequencies relevant to the accommodation response.

A near distractor effect for stimulus offsets

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When participants are asked to make a goal-directed saccadic eye movement to a visual target, irrelevant simultaneously presented distractor onsets in the other hemifield are found to slow down the initiation of these saccades. In contrast, distractor onsets that occur near the target influence the amplitude of the saccade, but do not have an effect on the saccadic latency (Walker et al, 1997, J. Neurophys, 78, 1108-1119). We here show that distractor stimulus offsets have an opposite effect. When presented in the other hemifield, distractor offsets have no influence on latencies or amplitudes. When presented near the saccade target, offsets slow down saccade initiation, but have no effect on saccade amplitude. Interestingly, distractors that remain present, increase in luminance, or decrease in luminance, have the same effect on saccadic latencies. Distractors that increase in luminance (from half luminance to full luminance), however, modulate saccade amplitudes, similar to onsets, but all other transients leave saccade amplitudes intact. The results will be discussed in the context of existing models of saccade target selection.
Motion detection in a noisy environment: Unexpected effects of background orientation on motion streak masking

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Geisler (Nature, 1999, 400, 65-69) demonstrated that fast moving visual features activate local orientation-selective neurons aligned along the axis of motion, resulting in cortical 'motion streaks'. These streaks have been found to augment motion detection, such that 1-D spatial noise masks aligned parallel to the direction of motion increase detection thresholds, whereas orthogonal masks have less of an impact upon perception. In this study we sought to systematically quantify the orientation tuning of streak interaction with motion detection. 4 observers undertook a 2IFC motion detection task, during which a single Gaussian dot (sd 0.067°) traversed a 1-D dynamic noise mask (duration 250ms). Dot speed was tested at 5.35 and 10.6°/s, mask orientation was varied from 0, 5, 10, 20, 30, 45 and 90° from motion direction. Most observers showed higher sensitivity to the motion target when the noise mask was orientated perpendicular, rather than parallel to the motion direction, in agreement with previous studies. However the orientation tuning function was found to be non-monotonic, with peak masking occurring approximately 5-10° away from the axis of motion. Testing with various motion directions and speeds found that this phenomenon was not an oblique effect and that tuning was slightly broader for slower motion speeds. The traditional interpretation of the Geisler motion streak model does not predict these findings, suggesting a more complicated interplay of cross channel interactions between orientation detectors and motion processing.

Encoding of direction during occluded target motion

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In natural scenes, moving objects are often occluded during their trajectory, and it has been shown that people are able to track this invisible motion. We have previously shown that observers are able to make relative speed judgements about occluded Gabor stimuli, but these judgements are affected by pattern motion within the Gabor patch in a systematic manner (Hughes et al, 2012, Perception ECVP Supplement, vol. 41, p. 118). We have conducted further experiments investigating the accuracy of position or direction estimation during invisible tracking. Observers viewed a Gabor target moving with a linear trajectory randomly chosen within 17 degrees of the horizontal. This target then became occluded, and observers were asked to judge where it would later have crossed a vertical line, using a numerical scale bar. Results showed that observers were able to make accurate position judgements for a range of target speeds and trajectory angles. We found that the addition of pattern motion within the Gabor patch affected the observers’ direction judgements. When the pattern appeared to be moving upwards relative to the overall direction of motion, observers tended to predict that the Gabor would cross the line above the veridical crossing place. Conversely, when the pattern appeared to be moving downwards relative to the overall direction of motion, observers perceived the Gabor to cross below the veridical crossing place. These results suggest that direction is normally encoded accurately during short occlusions, but can be biased by certain stimulus properties.
Efficient coding of binocular image statistics produces joint phase and position disparity tuned components

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Physiological studies of the mammalian visual cortex have identified binocular cells that are tuned to different phases and positions in each eye (Prince et al, 2002; *J. Neurophysiol.*, 87, 191-208). These measurements have found that individual neurons are selective to phase disparity, to position disparity and to both. The standard binocular energy model does not as yet predict or explain these results. The sparse coding theory of vision (Olshausen & Field, 2001, *Network – Comp. Neural*, 7, 333-339) hypothesises that early stages of processing in the visual cortex attempt to form an energy efficient sparse coding of visual input. We used Independent Components Analysis (Hoyer & Hyvärinen, 2000, *Network – Comp. Neural*, 11, 191-210) to form a sparse decomposition of 100,000 25 by 25 pixel binocular image patches taken from 139 image pairs. By fitting Gabor functions to these components, we have performed a detailed statistical analysis of binocular natural images in order to determine which distributions of phase and position disparity are best suited to encoding visual inputs. We have found a strongly bimodal distribution of phase disparities, suggesting a two-channel coding of correlated and anti-correlated inputs. We have also found that the distribution of positional disparities obeys an inverse power law with 94% of components having displacements less than ½ of the component’s wavelength. We found little evidence of phase or position only components, most components exhibited a mixture of both types of disparity.

Collinear facilitation and contour integration in adults with high functioning autism

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Autism Spectrum Disorder (ASD) is a neuro-developmental disorder, emerging in the first few years of life. Although diagnosed primarily by social criteria, it is usually accompanied by sensory abnormalities, including enhanced performance in such as the Wechsler block design task and visual search. Two competing explanations for these findings are Weak Central Coherence (WCC) (Frith, 2003, Blackwell) and Enhanced Perceptual Functioning (EPF) (Mottron et al, 2006, *J Aut Dev Dis*, 36, 27-43). WCC suggests an impairment of top down (global) processing leading to a bias towards low level (local) processing. EPF explains superior perceptual discrimination by way of enhanced low level (local) processing. In the current study, we use collinear facilitation and contour integration to investigate these theories. Our tasks probe low and intermediate level visual processing with increasingly ‘global’ stimuli. Using temporal 2AFC designs, we examined collinear facilitation (Polat et al, 1993, *Vis Res*, 33, 993-999) at a range of flanker orientations, and contour integration (Field et al, 1993, *Vis Res*, 33, 173-193) for both open contour (linear) and closed contour (rectangular) stimuli. Contrary to previous results (Keita et al, 2011, *Bio Psych*, 70, 806-811; Blake et al, 2003, *Psych Sci*, 14, 151-157), the initial findings of our study are that (i) collinear facilitation performance in ASD is similar to neurotypicals, and (ii) contour integration in ASD is enhanced with simple, open stimuli and impaired with the closed, more complex stimuli. These findings suggest an explanation for autistic perception that incorporates elements of both WCC and EPF.
Face adaptation improves trustworthiness discrimination

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Adaptation to facial characteristics, such as gender and viewpoint, has been shown to both bias our perception of faces and improve discrimination. In this study, we examined whether adapting to two levels of face trustworthiness improved sensitivity around the adapted level. Facial trustworthiness was manipulated by morphing between trustworthy and untrustworthy female prototypes, each generated by morphing eight trustworthy and eight untrustworthy faces respectively. In the first experiment, just noticeable differences (JNDs) were calculated for an untrustworthy face after participants adapted to an untrustworthy face, a trustworthy face, or did not adapt. In the second experiment, the three conditions were identical, except that JNDs were calculated for a relatively trustworthy face. In both experiments, the same participants completed a two-interval forced-choice adaptive staircase procedure, in which they judged which face was more untrustworthy. JNDs were derived from a psychometric function fitted to the data. To avoid local (feature) adaptation, the adapting stimulus was 75% the size of the test stimulus. When adapting to and discriminating around the same level of face trustworthiness (e.g. adapt trustworthy, discriminate trustworthy), improved sensitivity was observed compared to no adaptation. When adapting to and discriminating around a different level of face trustworthiness (e.g. adapt trustworthy, discriminate untrustworthy), there was no improvement in sensitivity and JNDs were equivalent to those in the no adaptation condition. These findings suggest that distinct neuronal populations encode the level of facial trustworthiness, and that adaptation can alter the tuning of these neuronal populations to improve sensitivity to facial trustworthiness.

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Human Bodies Capture Attention in Both Natural and uniform Grey Scenes

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Human bodies are socially and biologically significant stimuli. Several behavioural studies have demonstrated that bodies may have an attentional advantage over other objects (e.g. Ro et al, 2007, Vis Cog, 15, 322–348; Downing et al, 2004, Cognition, 93, B27–B38). We used a variant of the additional singleton paradigm to investigate whether human bodies engage attention. Within the experiment, we used ladybirds as the non-body targets and human bodies (without the head) as the irrelevant distractors. In a within-subjects design, participants (n=42) made speeded target present/absent judgments in two types of background scene (natural and uniform grey) for 4 target/distractor arrangements: (1) target present/distractor present (2) target absent/distractor absent, (3) target present/distractor absent, and (4) target absent/distractor present. The results showed no effect of background scene (p>0.05). There was an effect of target/distractor arrangement whereby responses in target present/distractor absent scenes was significantly faster than responses in target present/distractor present scenes (p<0.05), irrespective of background scene. The slowest responses were in the target absent/distractor present and target absent/distractor absent scenes. However, within the natural scenes there was no difference in performance between the target present/distractor present scenes and target absent/distractor absent (p>0.05). Conversely, within the grey scenes performance was significantly faster in the target present/distractor present scenes than the target absent/distractor absent scenes (p<0.05). Consistent with Ro et al. (2007) & Downing et al. (2004), we offer evidence in favour of an attention capture by human bodies, within both natural and uniform grey background scenes.
Probing visual choice in the mouse in virtual reality

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We developed a 2-alternative forced choice task for visual contrast detection in mice in virtual reality. The mouse is running on an air-suspended styrofoam ball while its head is fixed to facilitate recording of neural signals (Harvey et al, 2009, *Nature*, 461, 941-946). It is trained to navigate through a virtual corridor where a grating is displayed on the left or the right wall, and to report the grating location by turning left or right at the end of the corridor.

We show that the mice are able to control the ball well and to learn the task within 4-6 weeks, performing on average 150-250 trials per session. The high-quality psychometric curves indicate that the mice can distinguish visual contrasts as low as 5-10%, even when masked with 20% contrast noise. This performance is superior to the one we measured in freely moving mice in the absence of noise (Busse et al, 2011, *J Neurosci*, 31, 11351-11361).

Detailed analysis of the navigation trajectories reveals that the reaction length (RL, analogous to reaction time) depends on the stimulus strength. For lower contrasts the animal integrates over longer distance before making a decision. The psychometric and RL curves can be fitted by classical parametric families (Gold and Shadlen, 2002, *Neuron*, 36, 299-308).

We conclude that virtual reality poses no obstacle to the careful measurement of contrast sensitivity in mice. Together with simultaneous neural recordings it allows to study the neural responses of the visual system during perceptual choice, navigation, and reward-driven behavior.

Efficient Codes for 2D shape with minimal blur via the Local Scale Transform

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Cohen (IEEE Trans. Signal Processing, 41, 3275-3292, 1993) suggested that a signal’s scale can be regarded as a ‘physical attribute’ that decouples the size of a phenomenon from its shape. His idea, in combination with invariant signal representations, has clear ramifications for the phenomenon of size constancy in vision science. In the visual system, it is hoped that size constancy might be derived from the collected responses of a distribution of isotropic spatial filters whose underlying spatial extent are systematically varied from coarse to fine scales according to a diffusion model of image blur: the so-called scale-space representation (e.g. Koenderink, *Biol. Cyb.*, 50, 363-370, 1984). We demonstrate that this ‘blurring’ approach is flawed. The reason is because scaling and blurring are fundamentally different image operations – application of linear filters whose degrees of blur are different before attempting to extract scale information can seriously impair one’s ability to extract the physical attribute of scale. We show that local scale (and position) invariant signal representations can be derived by finding unknown coefficients that allow one to predict the image intensity signal from a power series expansion. We further show that the inverse of this power series is a Taylor expansion of discrete local image derivatives whose coefficients are invariant of position and scale. The expansion retains the benefit of efficiency when representing 2-D shape. Finally, we show how our ideas link scaling, fractional orders of differentiation and pyramid sampling as a means for determining the scale of a 2D shape. We suggest that similar computations underpin position and scale invariant computations in the visual system.
Extracting Monet’s cataract: Simulating a specific visual defect from impressionist paintings

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A number of painters of the Impressionist movement were known to suffer from eye diseases, and this is considered to be apparent in the development of their style of painting. In particular, Claude Monet was known to suffer from cataract late in life – a period during which he continued to produce several series of paintings of the same scenes in the gardens of Giverny, through progressively advancing cataracts.

Using MATLAB, images from the ‘Japanese Bridge’ and ‘Nymphéas / Water Lillies’ series were analysed. Previous investigations have shown that images distorted by a lens with cataract could be restored by a holographic correction (Reynolds et al., 1973, Optical Engineering, 12, 23-34; Pierscionek et al., 2002, JOSA-A, 19, 1491-1500); this suggests that individual cataracts produce a specific and unique pattern of attenuation in the frequency spectrum of images. We attempt to extract the particular pattern corresponding to Monet’s cataract. We apply a simple model of primary visual cortex processing to the resulting data, showing that this pattern is consistent with clinical observations of vision through cataract, i.e. mid-frequency contrast channels are selectively attenuated in the ‘cataract’ paintings, while there is a similar amount of low spatial frequency content compared to the ‘pre-­­cataract’ paintings. There is less reduction in the high-­­frequency cut-­­off.

Unlike previous work based on Monet’s oeuvre (e.g. Marmor, 2006, Arch. Opthalmol., 124(12),1764-1769), we use filters directly calculated from selected paintings that could replicate the effects of Monet’s cataracts on the frequency content of images of natural scenes – we conclude by presenting a series of images of natural scenes as they may have appeared through Monet’s cataract.

Does the left hemiface bias cause a greater reduction in the perceived attractiveness/cuteness of infant faces when the abnormality is located on the left side of the face?

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When judging the attractiveness, age or gender of Chimeric faces participants show a bias towards using cues from the left hand side of a face (Burt et al, 1997, Neuropsychologia, 35, 685-693) They also demonstrate a 'left gaze bias' when processing facial cues (Guo et al, 2012, Psychological Research, 3, 263-269). This attentional bias might cause facial abnormalities located within the left hemiface (the left hand side of a face) to impact the perceived attractiveness of the face more than those located within the right hemiface. This might be particularly salient in the case of infant faces, for which ‘cuteness’ ratings correlate highly with adults’ ratings of care-­­giving motivation.

To test this hypothesis, participants were presented with 48 neutral infant faces that either had no abnormality, an abnormality located in the left hemiface or an abnormality located in the right hemiface. Participants rated both how attractive, or how cute, they thought each face was on a 7-­­point scale.

The presence of an abnormality significantly reduced both cuteness and attractiveness ratings, however, the location of the abnormality made no difference to ratings. This indicates that the left hemi-­­face bias does not result in a greater reduction in aesthetic ratings when abnormalities are located within the left hemi-­­face. In addition, despite a moderate correlation between cuteness and attractiveness ratings, images with an abnormality received significantly lower attractiveness than cuteness ratings. This suggests that the presence of an abnormality may disrupt the perception of attractiveness more than the perception of cuteness.
Achromatic adjustment outdoors using MEMS reflective display

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Achromatic or neutral point adjustment (APA) in psychophysics refers to a procedure in which a participant is asked to adjust the colour of a certain surface so that it appears neutral (achromatic, grey), typically used to measure colour constancy, or the degree to which object colours are perceived as stable under varying illumination conditions. To date, most such experiments have been confined to the lab environment. The emergence of new display technologies now offers the possibility to perform such experiments outdoors under natural illumination. Here, we report an experiment utilising the recent Qualcomm Mirasol display which uses interferometric modulation (IMOD) technology. Unlike other common display technologies (CRT, LCD), the IMOD display is purely reflective, i.e. it does not have its own light source, and therefore the reflected light depends not only on the RGB setting but also on the illumination spectrum. This feature allows for using the display outdoors as its screen radiance varies with the amount of incident light and thus tracks changes in brightness adaptation of the human visual system. APA was performed using a multiple staircase paradigm in 2D opponent colour space, similar to (Xiao et al, 2012, JoV, 12(4):6, 1-15). The experimental setup poses certain challenges including the changeable illumination conditions between and during each experimental session, controlled for by spectrometric measurements on each trial, including of the observer’s achromatic setting. Despite the challenges, the observers’ staircase adjustments consistently converge toward the correct physical neutral point.

Auditory clicks selectively alter extra-retinal velocity representations

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During ocular fixation, object motion produces retinal velocity signals, while smooth pursuit eye movements give rise to extra-retinal velocity signals from an efference copy of the oculomotor pursuit command. Makin et al. (2012, Acta Psychologica 129, 534-521) found that prior presentation of repetitive auditory click trains increase subjective velocity. However clicks may alter retinal and extra-retinal velocity signals in different ways. We explored this in the current work. In our first experiment, participants listened to either a 4Hz auditory click trains or a silence of the same duration, then viewed single horizontally moving dot-target that travelled at 7.5 to 17.5 deg/s. Pursuit or fixation trials were compared, and compliance with instructions was monitored with an eye tracker. Velocity estimates were entered with the keyboard after each trial. We found that auditory clicks only increased velocity estimates during pursuit. In a second experiment we found that the same results for vertical motion. In a third experiment, the click effect was eliminated altogether when a textured background was presented behind the pursuit target, possibly because it encouraged participants to base their velocity estimates on retinal velocity signals that result from the opponent background motion. These findings provide convergent evidence that auditory clicks selectively alter extra-retinal velocity signals. This work clarifies the nature of the links between visual and auditory networks.
Difficulties processing dynamic information have previously been reported in individuals with autism spectrum conditions, although no research has systematically compared motion processing abilities for slow and fast speeds. Here, we measured speed discrimination thresholds and motion coherence thresholds in slow (1.5 deg/sec) and fast (6 deg/sec) speed conditions in children with an autism spectrum condition aged 7 to 14 years, and age- and ability-matched typically developing children. Children with autism were as sensitive as typically developing children to differences in speed at both slow and fast reference speeds. Elevated motion coherence thresholds were, however, found in children with autism, but only in the slow stimulus speed condition. Rather than children with autism having pervasive difficulties in motion processing, these results suggest that they have a selective difficulty in extracting coherent motion information specifically at slow speeds. Potential explanations for these findings will be discussed, along with implications for refining theoretical models of altered perception in autism.

Weibull $\beta$ for contrast detection is the Naka-Rushton exponent

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One of the goals of neuroscience is to understand the relationship between physiology and behaviour. Here we report a previously unknown connection between the neural contrast-response function and the psychometric function for 2-alternative forced choice (2AFC) contrast detection. The contrast-response function describes mean neural spike rate, $r$, as a function of stimulus contrast, $c$. It is often fitted with a 4-parameter Naka-Rushton function, given by $r = r_{\text{max}} c^q / (c^{50} + c^q) + r_0$. The psychometric function for 2AFC contrast detection describes the proportion correct, $P$, as a function of target contrast, $c$. It is often fitted with a 3-parameter Weibull function, given by $P = (1-\lambda) - (0.5-\lambda) \exp[-(c/\alpha)^\beta]$. We show that optimal decoding of a population of neurons with Naka-Rushton contrast-response functions, and spike distributions generated by a family of Poisson-based random processes, results in a psychometric function that closely approximates a Weibull function with $\beta$ equal to the Naka-Rushton exponent, $q$. We proved this result analytically under restrictive assumptions, and used Monte Carlo simulations to show that it still holds to a close approximation when these assumptions are relaxed. Our finding provides a remarkably straightforward interpretation of Weibull $\beta$ for 2AFC detection, and explains the close match between $\beta$ and $q$ obtained from fits to empirical data (both are about 3 on average). Unlike previous researchers who have mostly used the Weibull function for mathematical convenience without strong theoretical justification, we argue that the Weibull function is theoretically the most appropriate mathematical form for the psychometric function for 2AFC contrast detection.
Bias-Free (almost) techniques for measuring context effects

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The measurement of context effects, including adaptation and illusions, presents difficulties since these effects are hard to separate from response and/or decision biases. In particular, the often-used Method of Single Stimuli (MSS) measures biases by shifts in the P50 point of the psychometric function, but such shifts are easy for an observer to introduce, or to nullify, by a simple change in decision criterion. Here I suggest ways in which this problem can be overcome, by using 2AFC rather than MSS, and by interleaving different conditions in which the strength of the putative perceptual bias is varied in a manner that is difficult for even a sophisticated observer to guess. For example, velocity adaptation was measured by spatial 2AFC in which the two moving grating patches moved in random directions and were presented in retinal locations adapted either to leftwards or rightwards movement. Applications of the method will be described for two cases: (1) the effects of perceptual load upon motion adaptation (2) the retinotopy vs. spatiotopy of the tilt after-effect.

Localising cortical responses to faces in frequency, time and space using MEG

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There is now an abundance of evidence from intra-cranial recordings that faces elicit a complex pattern of evoked potentials and induced oscillatory responses in occipito-temporal cortex. Here we sought to characterise these responses non-invasively using MEG. Eighteen participants viewed images of neutral faces and phase-scrambled control stimuli while MEG was recorded using a 275-channel CTF system. Time-frequency windows of interest were identified from sensor-level responses and localised to the cortex using the Synthetic Aperture Magnetometry beamformer (a commonly used technique for MEG source localisation). We found that face stimuli produced an enhancement of both gamma-band (55-100Hz) power and the M170 evoked response in a region of the right ventral temporal cortex close to the fusiform gyrus. In contrast, two lower frequency responses (0-10Hz & 10-32Hz) did not significantly differ between faces and scrambled stimuli anywhere in the cortex, and hence did not appear to be diagnostic for the presence of a face. Finally, we found that the M220 - the evoked field immediately following the M170 – was enhanced for faces versus scrambled stimuli in the right superior temporal gyrus, but reduced in the left ventral occipital cortex. In conclusion, our evidence suggests that it is possible to measure a rich pattern of cortical responses to faces in frequency, time and space using MEG.
The role of peripheral vision in flow-parsing

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We have suggested that in order to assess scene-relative object movement the brain identifies and parses out (globally subtracts) patterns of visual flow consistent with self-movement (Rushton & Warren, 2005, *Curr Biol*, 15, R542-R543). Previous research has explored the role of central vision in this flow parsing process (Warren & Rushton, 2009, *Curr Biol*, 19, 1555-1560). Here we explored whether peripheral visual motion, a strong cue to self-motion, also permits the extraction of object motion during self-movement. Using monitors placed to the side of the head, or a large ring of limited lifetime dots (54 degrees from fixation), we introduced patterns of expanding and contracting flow into peripheral vision to simulate forwards or backwards movement of the observer. Simultaneously a vertically moving probe was placed 4 degrees above or below a central fixation point. Observers set a line to indicate the perceived trajectory of the probe. We predicted that due to a global subtraction process, contracting peripheral flow would bias perceived trajectory towards fixation and expanding flow would bias responses away from fixation. The results were in line with the FPH when self-motion was indicated by a ring of peripheral flow, but not when segments of the same ring, or the peripheral monitors alone, provided self-motion information. We suggest that the presence of clear visual edges in these stimuli may have acted as a reference and impeded a scene-relative percept of object trajectory. These data suggest that peripheral vision also contributes to the flow parsing process.

The effect of temporal frequency induced duration compression and speed adaptation on the flash-lag illusion.

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Temporal frequency (TF) adaptation compresses perceived event duration, independently of the effect on perceived TF, suggesting a distinct duration perception mechanism from TF detection (Johnston, Arnold & Nishida, 2006, *Current Biology*, 16,472-479). We investigate if duration compression affects flash-lag (Nijhawan, 1994, *Nature*, 370, 256-257), where an observer perceives a moving object displaced further along its trajectory compared to a spatially localised flash. Flash-lag scales with object speed; thus has a time component that may change with TF adaptation, possibly implicating the duration mechanism in perceived motion and/or position. We measured the effect of TF adaptation (5Hz & 20Hz) on flash-lag at two speeds (18.2 & 27.3 °sec⁻¹) with a 2-AFC paradigm by varying displacement between flash and bar where participants judge bar position relative to flash. The point of subjective equality (PSE) is taken as the 50% point on the resulting psychometric function and is compared to a no adaptation control. We measured TF adaptation’s effect on perceived speed whereby participants indicated the faster of two bars. One appeared in a TF adapted area with one of two speeds as in the flash-lag condition. We varied the second bar’s speed to construct a psychometric function with PSE taken as before. We observed a consistent reduction in flash-lag and perceived speed with 20Hz adaptation and no effect at 5Hz. Assuming proportional change in flash-lag magnitude with perceived speed, the reduction in perceived speed accounts for less than 50% of reduction in flash-lag. This finding implies that duration perception may have a functional role in motion/position perception.
Integration of visual motion and locomotion in mouse visual cortex

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Successful navigation through the world requires accurate estimates of one’s own speed. Neural correlates of animal speed have been found in high-level brain structures such as entorhinal cortex and hippocampus (Geisler et al., 2007, PNAS, 104, 8149-54; Sargolini et al., 2006, Science, 312, 758-62). To estimate animal speed, the inputs to these structures must integrate visual speed gauged from optic flow and run speed gauged from the proprioceptive and locomotor systems (Jeffery, 2007, Curr Opin Neurobiol, 17, 684-91). Multimodal integration can occur within the visual system, e.g. in primate extrastriate cortex (Angelaki et al., 2009, Curr Opin Neurobiol, 19, 452-4). Measurements in rodents show that locomotion modulates responses even in primary visual cortex (V1) (Niell & Stryker, 2010, Neuron, 65, 472-9). However, the role of V1 during navigation is unknown, because experiments measuring its responses have not typically been performed during navigation.

Here we show that, in mice, the integration of visual motion and locomotion signals occurs as early as V1. We recorded from mice that traversed a virtual reality corridor, by running on an air-suspended styrofoam ball, and found that V1 neurons are driven by linear combinations of virtual reality speed and run speed, with weights that varied between neurons. Most neurons gave equal weight to run speed and virtual reality speed, and the population together encoded “combined speed” – an equally weighted average – better than virtual reality or run speeds alone. These data suggest that V1 is the first stage in the multimodal processing circuit that supports self-localization and navigation.

Saccade adaptation induced by a perceptual task

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Saccade adaptation allows for the gradual compensation of systematic position errors, e.g. due to muscle weakness or growth. Saccade adaptation is commonly induced by a bottom-up visual position error after the saccade, which is created by shifting the target mid-flight during the saccade. In this contribution, we asked whether adaptation can be similarly driven by a mismatch between the requirements of a post-saccadic perceptual task and the saccade landing position.

Observers were asked to saccade towards a peripherally displayed array of 7 letters, and perform a letter-discrimination task at one particular location. During the pre-adaptation and post-adaptation phase, discriminated letters were always presented at the center location. In the adaptation phase, the discriminated letters were presented at fixed eccentric locations, which required shorter or longer saccade amplitudes.

Saccades were directed towards the discriminated letter from the first trials on, indicating a strategic effect, but there were also gradual changes in amplitude during the adaptation and post-adaptation phases. Gradual changes of amplitude over about 100 trials are indicative of sensorimotor adaptation. If saccade amplitudes reflected the strategic use of knowledge about target location, they should change by letter-wide steps, and reach the discriminated letter within a few trials. Further, we found no adaptation with the same stimulus when the observers did not perform the discrimination task, confirming that the requirements of the perceptual task were actually driving the adaptation.

We suggest that a perceptual task can modify oculomotor commands by generating a top-down error signal in saccade maps just like a bottom-up visual position error would do.

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Action perception at extreme distances

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We know a great deal about the information that can be obtained from watching other people move, much of this knowledge gathered from studies employing point-light techniques. The goal of the current study was to establish how action perception varied as a function of the distance between actor and observer. Although the military have long used human size/distance variation in stadiametric range finding applications, such as sniper sights, there has been little basic research into this issue. Here, we created a matching task in which two flanking point-light figures were kept at a constant apparent distance of 15 meters, subtending approximately 6.7° in height. The apparent distance of a central target figure was varied between 15 and 500 meters by systematically scaling its size. On each trial, the two flankers performed different actions, and were randomly rotated in depth. The target figure always copied the action of one flanker, but was out of phase and had an independent depth orientation. The task was simply to indicate whether the target action matched the left or right flanker. To our surprise, matching accuracy remained above 75% even at the most extreme distances when the entire figure subtended only 0.2° in height. This finding will be discussed in relation to current models of biological motion. In particular, the pattern of accuracy and reaction time data suggest increasing distance leads to a transition from fast, efficient processing, to a slower, more effortful decision-making mode, an idea that is absent from existing models.

Visual surround suppression in schizophrenia

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Compared to unaffected observers patients with schizophrenia show characteristic differences in visual perception, including a reduced susceptibility to the influence of context on judgements of contrast, a manifestation of weaker surround suppression. To examine the generality of this phenomenon we measured the ability of 24 individuals with schizophrenia to judge the luminance, contrast, orientation and size of targets embedded in surrounds that would typically influence the target’s appearance. The data show that individuals with schizophrenia experience weaker surround suppression compared to age- and IQ-matched controls for stimuli defined by contrast or size, but not those defined by luminance or orientation. As perceived luminance is thought to be regulated at the earliest stages of visual processing we propose that the data are consistent with a suppression deficit that is predominantly cortical in origin. Further, we speculate that the finding of robust orientation surround suppression in schizophrenia may reflect the sparing of broadly tuned mechanisms of suppression, and attempt to reconcile these data with findings from previous studies.
A Simpler Structure for Local Spatial Channels

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It is generally accepted that there are continuous arrays of spatial-frequency tuned channels at any local retinal region available for processing virtually any stimulus structure visible within the optical limits. However, a new evaluation of the local structure of spatial channels with local stimuli in peripheral retina shows that that local channels have a markedly restricted range of tunings, consistent with the ranges of physiological receptive fields. The study employed the masking sensitivity approach in order to minimize analytic assumptions, with stimuli designed to assess the range of channel tunings of the predominantly sustained response system in the near periphery from 2 – 8 deg eccentricity. Under these conditions, the range of identifiable channels spans a narrow range of only about two octaves of spatial frequency, scaling with eccentricity, with no evidence of channels outside that range and no channels tuned below 1 cy/deg. The data are consistent with the possibility that the two-octave range of spatial frequencies is covered by just three channels, but a higher sampling density within that range could not be excluded.

For local sustained stimuli, human peripheral spatial processing therefore appears to be based on a simpler channel structure than is often supposed. We propose that stimuli below 1 cy/deg (and below as high as 4 cy/deg in the fovea) are encoded by levels of activation across the multiple local receptive fields forming the lowest tuned channel at each eccentricity, rather than by specialized channels tuned to those lower spatial frequencies per se.

Making magic: applying artificial intelligence methods to design a psychophysically compelling illusion

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Conjuring tricks can be used to provide insight into the nature of human perceptual and cognitive processes. The geometric Principle of Concealed Distribution (Gardner, Mathematics Magic and Mystery, 1956, Dover Publications) describes a type of trick that relies on dissections and rearrangements of shapes to elicit a magical vanish of one of the shapes where the remaining shapes are imperceptibly larger. To automate the generation of such vanishes we exploit the vertical-horizontal illusion (Robinson, The Psychology of Visual Illusion, 1998, Courier Dover Publications), that shows a viewer perceives vertical lengths as longer than identically sized horizontal lengths. A psychophysical measure can be used to determine the degree of shape change possible before an observer can detect it. Here we present a novel conjuring trick, in the form of a jigsaw puzzle with two solutions, one showing eight rectangles, the other seven. We algorithmically optimise the jigsaw pieces and images using a psychophysically defined fitness function to ensure that size changes on reassembly are below a viewer’s threshold for detection. Using these methods we were able to find versions of the trick that would be difficult to obtain for a human designer. Our method demonstrates that Artificial Intelligence techniques, when configured to incorporate human perceptual observations, can be used as designers of conjuring tricks.
A reversal of part-whole Gestalts in a patient with visual form agnosia

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For many visual phenomena the ‘whole’ is not just different from the sum of its ‘parts’, but these parts seem to become lost or inaccessible. Neuroimaging (Kubilius, Wagemans, Op de Beeck, 2011) suggests that this increased behavioral sensitivity to ‘wholes’ over ‘parts’ reflects the way in which visual input is integrated as it progresses from V1 to LOC. More specifically while early visual areas may contain more information about parts (edges), higher areas contain more information about wholes (shapes). Typical behavior is consistent with a ‘read-out’ of information from these higher areas. But how is information read-out from the visual hierarchy when these higher stages of visual processing are damaged? Here we report results from one such well-documented case, patient DF, who, in contrast to the normal controls, demonstrated better access to parts than to wholes in the configural superiority effect used by Kubilius et al. We further show that such behavior is consistent with simulations of the early layers of HMAX, a popular model of the ventral visual stream. Our results highlights that compelling Gestalts can break down with selective lesions to the ventral stream, particularly to the area LO. Moreover, the combination of neuroimaging, modeling, and patient neuropsychology potentially provides a useful tool for investigating not only how visual input is processed, but also to test how information is read-out from the hierarchy of visual areas.

How invariant is neutral grey: effect of task, luminance and illumination

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Despite the theoretical importance of unique (or neutral) grey, there is little agreement on its precise chromaticity. Often an equal-energy white (CIE x=0.33; y=0.33) is assumed (Werner & Shiffrin, 1993, JOSA, 10(7), p.1509-1516) which is close to ecologically relevant illuminations, such as the sun’s disk (x= 0.331; y = 0.344) and daylight (D65: x = 0.313; y = 0.329). Here we test the invariance of these neutral grey settings under changes in illumination, task and luminance (5, 20 or 50 cd/m²).

Stimuli were displayed on a CRT on a black background and ambient illumination was controlled by a luminaire. Neutral grey settings were obtained (n=30) under dark viewing conditions, under D65 (x= 0.312 y=0.334), and under CWF (x=0.394 y=0.387), using two different tasks: adjustment along the axes in LAB space or along the unique hue lines.

We report three main results: (1) the average neutral grey point (under dark viewing conditions) is located at CIE x=0.292, y=0.303, which is at a significantly higher colour temperature than daylight. (2) Observers are more accurate when asked to navigate along the unique hue lines (3) Changing the illumination from dark to D65 (CWF) shifted the neutral grey point towards D65 (CWF).

We conclude that observers are able to provide accurate but illumination-dependent settings. Simple cone adaptation models (ignoring possible rod intrusion) do not predict the observed shifts from D65 to CWF.
How stimulus image features of Kanji characters influence the absence of attention

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A Rapid Serial Visual Perception (RSVP) dual-target task using rapidly presented Kanji characters was used to investigate the absence of attention. During the task, subjects reported the detection of two target Kanji characters (Targets 1 and 2) out of a set of 14 -16 characters. When the time interval between the two targets was about 200 msec, the phenomenon known as “absence of attention” was observed. The phenomenon was influenced by the level of difficulty of Kanji character shapes, but the effect could not be explained by this factor (Yago and Nakayama, 2011, ECVP Abstract, p.188). Therefore, two types of feature sets of the stimulus images were then analyzed using a Discrete Cosine Transform (DCT) for Kanji stimulus images. The first is the change of luminance between two Kanji images, using a target and distracters. The luminance level can be extracted as a DC component of the DCT coefficients. The second is the degree of similarity between two Kanji characters which can be defined using a metric of DCT sign-only correlation (Ito & Kiya, 2008, IEICE Tech. Rep. ITS2007-52). The occurrence of absence of attention is supposed in some conditions in the above metrics. The results of our analysis show that absence of attention is prevented when the luminance varies between the target 2 and the previous distracter, and when the degree of similarity between the two targets and the previous distracter changes sufficiently.

These provide evidence that features of Kanji image stimuli significantly affect absence of attention performance.

Testing Illusions in Perception and Imagery

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Neuroimaging data have overwhelmingly demonstrated the similarity between visual mental imagery and visual perception. Results are not nearly as convincing in behavioral studies. Here we used visual illusions to establish the relationship between perception and imagery and resolved a number of methodological inconsistencies reported in previous behavioral studies.

Participants were asked to estimate the size of lines in the vertical-horizontal illusion. In the perception task both the stimuli and a measuring scale were presented on the screen. In the imagery task the stimuli were presented on the screen for three seconds, then removed. Only then, the participants were informed which of the two lines they were estimating and the scale was offered. They would use imagery to inspect the illusion. In this methodology, we controlled for a number of factors including consistent instructions and measurement scales, we avoided hybrids between perception and imagery, and included appropriate control stimuli.

Results showed no difference between perception and imagery. Not only that there was no difference in the illusion size in both tasks, there was no difference in the absolute size of estimated stimuli or in the variability of results.

A second experiment was designed to test the two additional factors: stimuli size and gender differences. Results revealed one characteristic of imagery unmatched in visual perception. While male participants performed equally in the two tasks, female participants tended to underestimate size in the imagery task. This tendency intensified as the size of stimuli increased.

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