Abstracts from CIP 2007

Segundo Congreso Ibérico de Percepción

KEY SESSION 1

Human Visual Motion Perception, why do we Make so many Errors?

A. M. Derrington (University of Kent, United Kingdom).

It is by charting the limits of perceptual performance that we are able to characterise the mechanisms that support different modalities of perception. In the case of motion perception, it has been possible to design experiments in which consistent patterns of errors reveal systematic shifts, distortions, or even reversals of motion perception that can be used to infer distinctive principles of operation. A long-standing example of this is the motion after-effect, which was first reported in the scientific literature in the early 19th century and which is still being used today to probe the mechanisms of motion perception. This talk will concentrate on two more recent examples: second-order motion and the reversals in motion perception that occur when coarse and fine features are combined in a briefly presented moving stimulus.

The first indication that humans respond to second-order motion came from experiments that showed that when observers were required to discriminate the motion of a complex high spatial frequency moving pattern, their responses were consistent with second-order but not first-order sensitivity (Badcock & Derrington, 1985). Subsequent experiments showed that second-order features contribute to motion judgements in many situations, but measurements of the limits of second-order motion perception suggest that any purely second-order effects are exerted at a high level—there is no such thing as a dedicated second-order motion mechanism.

Human ability to distinguish the direction of motion of a small, brief visual stimulus that contains only fine, detailed features is systematically impaired if coarser features are added to it. The impairment is most dramatic if the coarser features do not move; under these circumstances, the perceived direction of motion reverses completely. These impairments are not explained by current theories of motion perception, which predict that the motion signals from coarse and fine features should not interact because they are extracted by independent mechanisms. We show here in a preliminary model that a low-level process can explain our main findings if we include a subtraction stage between the mechanisms that extract motion signals from fine and coarse scales.

Keywords: computational modelling, motion-energy detectors, differential motion processing, second-order motion

Address correspondence to A. M. Derrington. E-mail:a.m.derrington@kent.ac.uk

KEY SESSION 2

The Origin and Nature of Categorical Colour Perception.

I. R L. Davies (University of Surrey, United Kingdom).

The wavelength continuum appears as a number of qualitatively different bands, or 'perceptual categories,' and discriminability varies across categories, making cross-category discrimination easier than within-category discrimination—the signature, and operational definition, of categorical colour perception (CP). Languages also segment the colour continuum into linguistic categories, but the number of categories and the location of category boundaries vary across languages. The relationship between perceptual and linguistic categories is controversial. For Relativists, perceptual categories are created by language 'warping' the metric of perceptual colour space, and colour CP should co-vary with the location of linguistic boundaries. For Universalists, perceptual categories arise from hardwired and universal properties of our visual systems, and colour CP should not co-vary with language. There is evidence consistent with both positions. Consistent with Universalism, infants show CP long before they learn language (Franklin & Davies, 2004; Franklin et al,, 2005), and toddlers from very different cultures show the same pattern of CP up to four-years-of age (Franklin, Clifford et al., 2005). Consistent with Relativism, adults only show CP for category boundaries marked in the speaker's language (e.g., Roberson et al., 2004), and CP can be learned through intensive training (Özgen & Davies, 2002), suggesting that there is sufficient plasticity for language or culture to shape CP. However, where CP is shown, it can be eliminated by a concurrent verbal task (Witloff et al., 2007), suggesting that it may be due to the online use of language, rather than warping of colour space during language learning. Recent findings that CP is stronger for stimuli in the right visual field than in the left visual field (Gilbert et al., 2006; Drivonikou et al., 2007) may also imply online language involvement, given the RVF connects to the left hemisphere, which contains the language centres. Moreover, lateralisation is only shown if the speaker's language marks the boundary (Drivonikou et al., 2007b), and it is eliminated by concurrent verbal interference (Drivonikou et al., 2007c). The converging evidence for the online influence of language

on CP appears to be inconsistent with the infancy data mentioned above, but recent studies at Surrey (Franklin et al., 2007) have found that CP in infants is lateralised to the right hemisphere, and that this persists at least up until four years of age, even though children of this age know their colour terms. The emerging picture is one of subtle interplay between the influences of nurture and nature in the development of colour perception and categorisation.
Keywords: categorical colour perception, Relativism, Universalism, development, lateralisation

Address correspondence to I. R L. Davies. E-mail: i.davies@surrey.ac.uk

KEY SESSION 3

Phonetics, Phonology, and 'Categorical Perception'.
Burton S. Rosner (University of Oxford, United Kingdom).

Fifty years ago, Liberman and his colleagues unexpectedly discovered a peak in the discrimination function for a synthetic speech continuum. To explain this startling phenomenon, models of 'categorical perception' were offered. The essential property of the models is the reduction of perceived speech to underlying phonological forms before any decisions are taken about discrimination or identification. Fifty years of research has demonstrated that the models consistently underpredict observed discrimination functions. This failure shows that phonetic information stubbornly remains in short-term (working) memory and influences discrimination (and identification). Further evidence for phonetic information in short-term memory is offered from a study on iterative mimicry of intonation contours. Moreover, fine phonetic detail is currently proposed to affect even meaning. One might then characterize speech as a 'rich auditory' event. This is a truism that evades the phenomenon of auditory streaming and, above all, the fact that speech carries meaning. Research on speech perception must now take words as its principal units of concern and abandon its traditional entanglement with 'phonemes' (a dubious concept amongst linguists) and syllables. Three questions then arise for future research: First, exemplar models of the lexicon propose that words are stored in long-term memory in some auditory form. What are the properties of that form? Second, what auditory information is extracted from fluent speech for storage in short-term memory? Third, how do these two forms of representation communicate, in order to segment the speech stream into words and endow those words with meaning?
Keywords: identification, discrimination, phonetic detail, lexicon

Address correspondence to Burton S. Rosner. E-mail: burton.rosner@phon.ox.ac.uk

SYMPOSIUM 1: MOTION PERCEPTION AND ACTION CONTROL
Conveners: Joan López-Moliner and Jorge Santos

A Motion Model to Explain Reversals of Human Motion Perception Caused by Interactions between Spatial Frequencies.
I. Serrano-Pedraza and A. M. Derrington. (University of Kent, United Kingdom).

Human ability to distinguish the direction of motion of a small, brief visual stimulus that contains only fine, detailed features is systematically impaired if coarser features are added to it. The impairment is most dramatic if the coarser features do not move; under these circumstances the perceived direction of motion reverses completely. These impairments are not explained by current theories of motion perception, which predict that the motion signals from coarse and fine features should not interact because they are extracted by independent mechanisms. We show here in a preliminary model that a low-level process can explain our main findings if we include a subtraction stage between the mechanisms that extract motion signals from fine and coarse scales. The basic motion analyzer is a hybrid of two well established models (Adelson & Bergen, 1985; Watson & Ahumada, 1985). It uses the computational approach of Adelson & Bergen's motion energy detector and uses some of the filter parameters from Watson and Ahumada's linear motion sensor. To compute the model responses, the basic sensor is replicated at 6 orientations and 2 spatial frequencies (1 and 3 c/deg) at 16 locations covering a 4° x 4° patch. Sensor responses to movies used in experiments are calculated (by multiplying the sensors by the stimulus across time) within each orientation band and summed across locations. The high frequency response is subtracted from the low frequency response (and vice versa) for the same direction of motion (right or left) and orientation. Responses are half-wave rectified and pooled across different orientations using cosine weighting and the final response is taken from the spatial frequency channel that has the highest difference between right and left. The

highest difference is converted to a direction index and then converted into a performance score using a sigmoidal response function in order to obtain the probability of correct response. This processing of the sensor signals is too simple to be completely realistic but it serves to demonstrate that subtraction of sensor responses will reproduce the basic failures and reversals of motion perception.
Keywords: computational modelling, motion-energy detectors, differential motion processing

Address correspondence to I. Serrano-Pedraza. E-mail: i.s.pedraza@ncl.ac.uk

Perception and Action: Working Together towards the same Ends.
M. P. Aivar (Universidad Autónoma de Madrid).

One of the main roles of vision is to provide the information needed for the control of our actions. This requires a close interrelationship between the neural processes involved in perception and those involved in action. However, much is still unknown about how perception and action relate to each other. Some psychological theories, like the theory of the two visual pathways suggested by Goodale and Milner (Milner & Goodale, 1995), even suggest that perception and action are independent processes that imply the activation of different cortical paths. In this talk we will review different experimental results that show a close interrelationship between perception and action, and will therefore question Goodale & Milner's assumption of a strict separation. First, we will focus on some experiments that analyze eye-hand coordination in complex tasks to show how closely linked the movements of the eye, the head and the hand are and how they depend on the demands of the task at hand. Then, we will review different studies dealing with the processes of planning and the on-line control of hand movements which show very fast hand responses to changes in the position of the hand's target or the position of other objects in the environment. Finally, we will suggest that a tight link between perception and action is needed to explain the fast corrective reactions obtained in these tasks.
Keywords: perception-action coupling, arm movements

Address correspondence to M. P. Aivar. E-mail: mariapilar.aivar@uam.es

Computational Methods in Visual Perception.
Miguel V. Correia (University of Porto, Portugal), and Jorge A. Santos (University of Minho, Portugal).

The computational paradigm of vision works both ways. On one hand, it allows the formulation of computational models of vision that can be used to build machines with visual abilities of growing complexity, while on the other, it allows devising perceptual experiments to test hypothesis of increasing realism in quantifiable and objective approaches. In this presentation, we will demonstrate the use of computational methods in studies of the visual perception involving natural textures and biological movement analysis. We will also show that the computational methods are based in models built from psychophysical and neurological evidence, and that they can be further refined and validated as our knowledge grows in these fields. In contrast to random dot kinetograms and point light walkers, the quantification of visual motion in images with natural textures and unconstrained biological movement demands for a dense description of velocity vectors, that can be obtained by methods that compute optical flow as reliably as possible. This computation, by itself, already builds upon models of visual perception. However, it can be refined to include surround inhibition effects known to exist in biological visual systems and already explored in the context of spatial contour detection.
Keywords: computational modelling, biological motion processing

Address correspondence to Miguel V. Correia. E-mail: mcorreia@fe.up.pt

Biological Motion Perception and Action.
Jorge A. Santos (University of Minho, Portugal).

Since the seminal studies of Johansson in 1973 the biological motion perception has been regarded as a particular case. The recognition of the human pattern and other attributes (e.g. type of action, gender, emotions) seems to be a sort of pop-out phenomena. However very little is known on issues such as speed perception, temporal integration and multimodal integration or perception and action interactions. Our preliminary studies pointed to a surprising lower performance in

speed perception tasks with biological stimuli when matched against similar rigid objects. The rules of biological pattern recognition seem to be quite different from those of the motion perception by itself. On this paper we will present data from our ongoing research on perception of complex biological motion patterns, visual and auditory integration on directional discrimination tasks, and on the influence of the movements of the observer on the perceptual performance.
Keywords: biological motion, perception-action coupling

Address correspondence to Jorge A. Santos. E-mail: Jorge.a.santos@iep.uminho.pt

Dynamic Switching between Visual Cues in Intercepting Timing.
Joan López-Moliner (Universitat de Barcelona).

Perception of motion-in-depth needs integration time, as do the mechanisms for estimating the time that an object will take to contact an observer. It is very unlikely that such estimation relies on a single mechanism along the motion trajectory. Different sources of information that feed these mechanisms might have different integration times (e.g., optical size [θ] is available before higher-motion areas can obtain a reliable estimate of its rate of expansion [dθ/dt]). If so, one would expect systematic bias in the observer's responses for different times of stimulus exposure. In several experiments, it is shown that observers can switch from using one cue to another (e.g., from relying on binocular information to relying on motion; or from change in visual angle to motion). The switching is consistent with the use of the cue that would usually have a more reliable signal. Although different sources can be used, the whole pattern of results across time is well accounted for by a single nonlinear combination of θ and dθ/dt: dθ/dt *exp(–$\alpha\theta$), where θ determines how θ and dθ/dt are weighted. Unlike in previous studies, however, the best account is achieved by modulating θ with time so that θ is taken more into account at the beginning of the trajectory (larger θ) whereas dα/dt is largely considered (smaller α) after a critical integration time.
Keywords: computational modelling, intercepting timing

Address correspondence to Joan López-Moliner. E-mail: j.lopezmoliner@ub.edu

SYMPOSIUM 2: COLOUR PERCEPTION: BASIC RESEARCH AND APPLICATIONS
Conveners: Julio Lillo and Sérgio Nascimento

Contrast is the new Black: Hue and Saturation Shifts from Spatially Induced Blackness.
G. V. Paramei (Darmstadt University of Technology, Germany), D. L. Bimler (Massey University, New Zealand), and C. A. Izmailov (Moscow Lomonosov State University, Russia).

Colour stimuli that occupy adjacent regions of the visual field undergo various forms of interaction, including spatial contrast. In particular, brighter or dimmer surrounds can modify the appearance of a chromatic test field. The present study investigates these changes of the chromatic test and creates a geometrical model to quantify them. A broadband white annulus induced various levels of blackness or whiteness into 25 monochromatic test fields as it ranged in luminance in six steps, across three orders of magnitude. Three normal trichromats provided colour-naming descriptions of each test, using the terms Red, Yellow, Green, Blue, Black or White, or their combinations. The colour-naming responses were quantified following Boynton and Gordon (1965) and then transformed into dissimilarity matrices for analysis with non-metric multidimensional scaling (cf. Shepard & Carroll, 1966). The resulting model, a colour space, requires four psychophysical parameters to describe changes in colour appearance. Two dimensions are interpreted as the traditional perceptual opponent systems, Red-Green and Blue-Yellow. The other two dimensions correspond to independent achromatic parameters of the stimuli. One, labelled Induced Darkness, is a function of the ratio between the luminance of the white surround and the brightness of the chromatic field. Induced Darkness influences the perceived hue of a wavelength, in a nonlinear way similar to the Bezold-Brücke hue shift observed when objective luminance of a colour changes (Bimler & Paramei, 2005). The other dimension, labelled Desaturation, is inter-related with the first achromatic dimension, showing a V-shaped dependence on Induced Darkness for a given wavelength. The surround luminance required to minimise test Desaturation is not constant across the spectrum, but varies in accord with the test brightness. These results have strong implications for any model of colour processing: The computations of spatial contrast (a) are subsequent to the generation of the brightness signal from a nonlinear combination of cone signals, but (b) occur at a stage of processing prior to the nonlinear transformation of chromatic signals, responsible for the hue shift. The suggested

geometrical representation can accommodate these nonlinearities in a parsimonious way, while each dimension is conceived as corresponding to a specific neural channel.
Keywords: colour appearance, luminance contrast, blackness induction, modelling hue and saturation shift

Address correspondence to G. V. Paramei. E-mail: paramei@lichttechnik.tu-darmstadt.de

An Analysis of Colour Perceptual Space: Evaluation of a new Multistage Physiological Colour Vision Model.
E. Chorro (Universidad de Alicante), F. M. Martínez-Verdú (Universidad de Alicante), D. de Fez (Universidad de Alicante), P. Capilla (Universidad de Valencia), and M. J. Luque (Universidad de Valencia).

In this work, the metric of a new multistage colour vision model ("ATTD: A new colour vision model based on the physiology of the visual system," Capilla et al. AIC05; "Testing the perfomance of ATTD colour vision model," Capilla et al. AIC05) is assessed and a uniform space is developed to evaluate colour differences. This research involves three stages. First, the uniformity of this perceptual space is compared with the uniformity of the CIECAM02 space for some Munsell samples. Second, following Luo and co-workers, ("Uniform Colour Spaces Based on CIECAM02 Colour Appearance Model," Luo et al., 2006), we have developed a new space, based on the perceptual descriptors of model (Q, H, M, s). To calculate the free parameters of the space that better fit to a uniform space, we use the PF/3 parameter. Third, we compare colour differences calculated for both ATTD05 models with this new perceptual new space and CIECAM02. The *F* statistical parameter is used to decide which model best predicts the perceptual differences and is therefore the most uniform.
Keywords: colour vision, colour appearance models, colour differences.

Address correspondence to E. Chorro. E-mail: elisabet.chorro@ua.es

Color Perception of Artistic Paintings.
S. M. C. Nascimento, P. D. Pinto, and J. M. M Linhares (University of Minho, Portugal).

Museums use a variety of light sources to illuminate artistic paintings: natural daylight, tungsten halogen lamps, or light sources that approximate natural daylight, such as SoLux. Each type of light source has a specific spectral distribution and therefore produces a specific chromatic distribution for each painting. When choosing the illumination for their museums, curators have to consider, among other factors, the visual impression it produces when applied to paintings. The aim of this work was to use spectral data of artistic paintings obtained by hyperspectral imaging to determine psychophysically the correlated color temperature of the illuminant preferred by observers when looking at the paintings. We intended also to investigate how observers' preferences correlate with the chromatic diversity of the paintings. Hyperspectral images of artistic oil paintings were taken over 400-720 nm at 10 nm intervals. The spectral digitalizations were carried at the Museu Nogueira da Silva, Braga, Portugal. The spectral reflectances of each pixel of the paintings were estimated from a grey reference surface present in the scene. The radiance from each painting under daylight illuminants of correlated color temperatures in the range 25000 K-3500 K was estimated and the corresponding luminance and chromaticity distributions computed. In each case, the number of discernible colors was estimated by computing the painting representation in CIELAB space and by counting the number of non-empty unit cubes in that space. In a psychophysical experiment using precise CRT reproductions of the paintings rendered with the set of daylight illuminants, the observers had to choose in each case the color temperature producing the best visual impression. The psychophysical experiment was carried out at the museum and the observers were selected from the museum visitors. It was found that the average color temperature selected by observers was about 6750 K, significantly larger than the one normally used in museums. Also, some correlation was found between the preferred colour temperature of the illuminant and the chromatic diversity it produced on the paintings.
Keywords: color vision, museum lighting, chromatic diversity, color and art

Address correspondence to S. M. C. Nascimento. E-mail: smcn@fisica.uminho.pt

Colour Basic Categories Use in Aged Tritanomalous: What Can Optics Account For?
J. Lillo (Universidad Complutense de Madrid), H. Moreira (Universidad Cardenal Cisneros. Madrid), L. Álvaro (Universidad Complutense de Madrid), L. Ramos (Universidad Complutense de Madrid), E. Dorado (Universidad Complutense de Madrid) and L. Del Tio (Iubilate).

Colour basic categories (hereafter CBCs) allow consistent stimuli naming in normal observers. Such consistence works for stimuli sets that define specific volumes in CIE colour spaces. Previous research obtained colourimetric delimitation of CBCs for normal Spanish observers and, more importantly, for three types of colour-blind people (protanopes, deuteranopes, and aged tritanomalous). For the three types of anomalous observers, it was also possible to delimitate which CBCs pairs tend to be confused. Also, for each pair, the colourimetric characteristics of the stimuli that produce naming confusions (naming different from controls) were obtained. We evaluated the accuracy of an optical Von Kries type model to predict the naming of a 104 stimuli set performed by a group of 15 tritanomalous. Model predictions were obtained after multiplying two functions. Those were the stimulus reflectance and the transmittance for an aged eye (determined according to Pokorny, Smith and Luce two factors model). Predicted CBCs for the naming task were deduced after finding the stimulus of the NCS atlas closest (in the CIE L*U*V* space) to the prediction provided by the convolution. (The predicted response was the CBC used by normal observers to name such stimulus)
As expected, the optical model predicted many more naming errors than were observed. than observed. On the other hand, the adjustment to empirical results improved when calculus of the transmittance function was based in an age inferior to the mean of the tritanomalous group. This result suggest some kind of perceptual compensation to optic ocular ageing.
Keywords: colour vision, colour blind people, ageing

Address correspondence to Julio Lillo. E-mail: julillo@psi.ucm.es

SYMPOSIUM 3: SPATIAL VISION

Conveners: Vicente Sierra-Vázquez and J. Antonio Aznar Casanova

Gradient Representations and the Perception of Luminosity.

Matthias S. Keil (Universidad de Barcelona).

The neuronal mechanisms which serve to distinguish between light-emitting and light-reflecting objects are largely unknown. It has been suggested that luminosity perception implements a separate pathway in the visual system, such that luminosity constitutes an independent perceptual feature. A recent psychophysical study was conducted to address this issue, that is, whether or not luminosity has feature status. Surprisingly, the results support the hypothesis that luminance gradients, rather than luminosity, are a perceptual feature. Here, I show the conditions that lead to the perception of luminosity within a previously proposed neuronal architecture for generating representations of luminance gradients. This so-called gradient system has been developed to overcome shortcomings of various neural architectures for generating surface representations. Gradient representations are thought to parallel surface representations. Furthermore, the perception of luminosity in terms of luminance gradients has important implications for lightness and brightness computations. These implications will be discussed.
Keywords: visual representations, luminosity perception, Mach bands, nonlinear diffusion, luminance gradients, object recognition

Address correspondence to Matthias S. Keil. E-mail: mats@cvc.uab.es

Spatial-Frequency Selectivity of Visual Filters Estimated by White and Non-White Noise Masking.

I. Serrano-Pedraza (University of Kent, United Kingdom) and V. Sierra-Vázquez (Universidad Complutense de Madrid).

Simultaneous spatial masking has previously been used to measure the spatial-frequency tuning of spatial visual filters, yielding contradictory results for different types of noise masks. To solve the discrepancies, we have carried out an intensive measurement of spatial-frequency selectivity of filters by masking a sinusoidal grating with six classes of one-dimensional, static filtered white noise masks: all-pass, low-pass, high-pass, band-reject (notched), band-pass, and double band-pass noise. We used Bayesian staircases in a 2IFC paradigm to measure contrast detection thresholds (CDTs) of horizontal sinusoidal gratings of test frequencies of 1 and 3 c/deg within the same Gaussian window for two observers. Theoretical threshold curves from the critical-band masking (CBM) model were fitted simultaneously to the data in all six experiments, using visual filters with symmetric (Gaussian) or asymmetric (log-Gaussian) spatial-frequency shapes and two detection models: detection mediated by the channel tuned to the frequency of the stimulus (fixed-channel model) or mediated by the channel that maximizes the signal-to-noise ratio (best-channel model). The following results were obtained: (1) Squared CDT increases linearly with the level of white noise masks, revealing that visual filter shape is not level-dependent; (2) data of masking with low-pass and high-pass filtered noise as a function of their cut-off

spatial frequency appear to be asymmetric on log-log scale and the log-Gaussian function provided the best fit; (3) the fit was adequate with the fixed-channel model for the naive observer and with the best-channel model for the experienced observer; (4) taking the off-frequency looking into account, the relative bandwidth (in octaves) of the assumed visual filters is not constant but instead it shrinks with increased peak frequency of filter.
Keywords: spatial vision, visual filter shape, critical-band masking model, noise masks

Address correspondence to I. Serrano-Pedraza, E-mail: i.s.pedraza@ncl.ac.uk and V. Sierra-Vázquez, E-mail: vicente@psi.ucm.es

How does Orientation and Background Influence Visual Acuity? Differences between Frontoparallel Plane and Depth Vision.
Aurora Torrents Gómez (Universitat Politécnica de Catalunya) and J. Antonio Aznar Casanova (Universitat de Barcelona).

It is well known that human perception is strongly influenced by the surrounding context in many visual tasks (e.g., Vernier acuity tasks, tilt illusion, crowding, etc.). The majority of previous studies have investigated visual acuity (VA) in the two-dimensional visual space (2D) but little is known about the effect of context and cue integration during depth perception in 3D. In a series of experiments, we asked volunteer observers to carry out a Vernier acuity task (i.e., to align two lines either in the 2D or 3D visual space). We used a virtual reality set-up, inducing inter-ocular disparity to simulate the 3D visual space. Experiment 1 compared Vernier visual acuity in the 2D and 3D visual space. In addition, we also investigated acuity as a function of stimulus orientation. The results revealed some impairment in stereo acuity (both lines in the depth plane) in comparison to classic 2D acuity (both lines in the frontal plane). Both conditions revealed the well-known “oblique effect.” Experiment 2 investigated the effect of space curvature while participants carried out the Vernier acuity task either in the 2D and 3D visual space. To simulate space curvature, we use a concave or convex background grid (Bézier surfaces) behind the Vernier lines. We also added a plane grid and a black background as control conditions. The results revealed differences between VA in 2D and 3D related to the background shape.
Keywords: binocular vision, depth perception, steroacuity, Vernier acuity

Address correspondence to Aurora Torrents Gómez. E-mail: torrents@oo.upc.edu

A Role of Optical Declination in Shape Constancy.
J. Antonio Aznar-Casanova (Universitat de Barcelona), Manuel Moreno-Sánchez (Universitat de Barcelona), and Hans Supèr (Universitat de Barcelona - Institució Catalana de Recerca i Estudis Avançats [ICREA], Barcelona).

The visual system processes sensory information in such a way that the perceived size and shape of an object remain constant despite distortions of the retinal image. During the last five decades, numerous studies have investigated these constancies of size and shape. However, as yet, no satisfying explanation for these phenomena has been provided. To understand the mechanisms underlying shape and size constancy, we analysed the role of optical declination. Therefore, we conducted three experiments. In Experiment 1, observers were requested to draw dots on a circular shape on the ground at a distance of 6.5 meters. Two dots were shown, indicating the centre of the circle and the radius. On every trial, the centre dot was placed at the same location and the second dot changed position, but keeping the radius constant. The results showed that the distortion of the shape (an ellipse with particular aspect-ratio) depended mainly on the optical declination. The orientation of the first two dots had an equally strong, albeit different, effect on the shape of the circle. Thus, for all the different conditions, subjects perceived a circle (because they drew a circle) whereas the physical shape—and thus, the retinal image—changed as a function of the optical declination and initial setting of the stimulus configuration. In the second experiment, we asked observers to fit the aspect-ratio of a set of ellipses so that they perceived the ellipse as a circle. We used a textured background in a virtual 3D setting. These results revealed a psychometric function between the aspect-ratio of the ellipse and the inclination of the background. This function corresponded very well to the optical (physical) function. Finally, in Experiment 3, we asked observers to judge the sizes of perceived circles, which were, in fact, ellipses with identical depths but different widths. These results showed that the subtended visual angle determined the perceived size. Taken together, these results explain both shape and size constancy.
Keywords: binocular vision, depth perception, shape constancy, size constancy, spatial vision, visual psychophysics and visual space

Address correspondence to J. Antonio Aznar-Casanova. E-mail: jaznar2@ub.edu

SYMPOSIUM 4: NEURAL BASES OF VISUAL PERCEPTION

Coordinators: Susana Martinez-Conde and Fernando Valle-Inclan

Contrast Gain and the Shape of Thalamic Receptive Fields.

Luis M. Martinez (CSIC-Universidad Miguel Hernández, Spain), Qingbo Wang (University of Southern California, Los Angeles, USA), Fritz T. Sommer (University of California, Berkeley, USA), and Judith A. Hirsch (University of Southern California, Los Angeles, USA).

Thalamic (LGN) neurons transform visual information before directing it to the cortex. Here, we intracellularly mapped the distribution of excitation (push) and inhibition (pull) to the receptive field (RF) of LGN neurons and analyzed their interaction in response to simple visual patterns.
Responses evoked from the RF center had a push-pull profile. Stimuli of the reverse polarity (bright/dark) evoked responses of the opposite sign (excitation/inhibition). However, push and pull were affected differently by eccentricity and stimulus contrast. First, the spatial extent of the push increased with eccentricity. The size of the pull, however, was usually larger and remained nearly constant at all positions in visual space. Second, the excitatory RF center focuses as contrast increases, reducing its latency, duration, and spatial extent; whereas the inhibitory RF center defocuses, reducing its latency but increasing its duration and area. Responses from the RF surround were highly variable, often patchy, and clearly asymmetric and had a higher latency and threshold for contrast. This asymmetric distribution of synaptic inputs to the thalamic RF contrasts with its usual description as the difference of two Gaussian functions and provides a mechanistic explanation of how thalamic neurons adapt to different light levels.
Keywords: contrast, excitation, intracellular, inhibition, geniculate, LGN, receptive field, push-pull, thalamus

Address correspondence to Luis M. Martinez. Email: l.martinez@umh.es

How Fixational Eye Movements Drive Perception.

Susana Martinez-Conde (Barrow Neurological Institute, Phoenix, USA).

Most of our visual experience is driven by the eye movements we produce while we fixate our gaze. In a sense, our visual system thus has a built-in contradiction: when we direct our gaze at an object of interest, our eyes are never still. Therefore the perception and physiology of fixational eye movements are critical to our understanding of vision in general, and also to the understanding of the neural computations that work to overcome neural adaptation in normal subjects as well as in clinical patients. Moreover, because we are not aware of our fixational eye movements, they can also help us understand the underpinnings of visual awareness. The last decade has brought significant advances to our understanding of the neuronal and perceptual effects of fixational eye movements, with crucial implications for neural coding, visual awareness, and visual perception. I will present findings on the type of neural activity generated by fixational eye movements at different levels in the visual system, as well as the importance of fixational eye movements for visual perception. Special attention will be given to microsaccades, the fastest and largest type of fixational eye movement.
Keywords: adaptation, awareness, fixation, fixational eye movements, microsaccades, visual fading

Address correspondence to Susana Martinez-Conde. Email: smart@neuralcorrelate.com

Visual Masking Approaches to Visual Awareness.

Stephen L. Macknik (Barrow Neurological Institute, Phoenix, USA).

In visual masking, visible targets are rendered invisible by modifying the context in which they are presented, but not by modifying the targets themselves. Here, I summarize a decade of experimentation using visual masking illusions in which my colleagues and I have begun to establish the minimal set of conditions necessary to maintain the awareness of the visibility of simple unattended stimuli. We have established that spatiotemporal edges must be present for targets to be visible. These spatiotemporal edges must be encoded by transient bursts of spikes in the early visual system. If these bursts are inhibited, visibility fails. Target-correlated activity must rise within the visual hierarchy at least to the level of V3, and be processed within the occipital lobe, to achieve visibility. The specific circuits that maintain visibility are not yet known, but we have deduced that lateral inhibition plays a critical role in sculpting our perception of visibility, both by causing interactions between stimuli positioned across space, and also by shaping the responses to stimuli across

time. Further, the studies have served to narrow the number of possible theories to explain visibility and visual masking. Finally, we have discovered that lateral inhibition builds iteratively in strength throughout the visual hierarchy, for both monoptic and dichoptic stimuli. Since binocular information is not integrated until inputs from the two eyes reach the primary visual cortex, it follows that the early visual areas contain differential levels of monoptic and dichoptic lateral inhibition. We exploited this fact to discover that excitatory integration of binocular inputs occurs at an earlier level than interocular suppression. These findings are potentially fundamental to our understanding of all forms of binocular vision and to determining the role of binocular rivalry in visual awareness.
Keywords: binocular rivalry, dichoptic, feedback, lateral inhibition, visibility, visual awareness, visual masking

Address correspondence to Stephen L. Macknik. E-mail: macknik@neuralcorrelate.com

Elements for Guiding Action: Working Memory and Decision Making.
Carlos Acuña, José Luís Pardo-Vázquez, and Víctor Leborán (Universidad de Santiago de Compostela).

Working memory and decision-making are essential to goal-directed behaviour. Working memory depends on two sources of information: transient representations of recently experienced information and transient representation of information retrieved from long-term memory. Decision-making involves evaluation of past, current, and future events and their consequences. We are studying the neural substrates of these processes. We trained monkeys to perform in two visual discrimination tasks. The monkeys have to decide whether the orientation of a line is to the right or to the left of another previously perceived line and report their decision by a motor action. During the *continuous discrimination* task, the animals pay attention to the orientation of the first line, store some trace of it during the delay between the two stimuli, and compare the stored trace to the orientation of the second line. In the *fixed discrimination with implicit reference* task, only the second stimuli varied from trial to trial, and trials were presented in blocks corresponding to the same first stimulus, which was not shown. To solve this variant of the task, the subjects have to recall the first stimulus from long-term memory. After training, we recorded the extracellular activity in the inferior convexity of the prefrontal cortex and the ventral premotor cortex while the monkeys performed the tasks. In these areas, the memory trace, either short-term or long-term, interacts in time with successive events to guide action.
Keywords: discrimination, decision, long-term memory, prefrontal, premotor, short-term memory, working memory

Address correspondence to Carlos Acuña, E-mail. carlos.acuna@usc.es; José Luís Pardo-Vázquez, E-mail: josepar@usc.es; and Víctor Leborán; E-mail: nelbla@usc.es

A Role of V1 in Perceptual Decisions.
Hans Supèr (Universidad de Barcelona).

When and where are decisions made? In the visual system, a saccade, which is a fast shift of gaze towards a target in the visual scene, is the behavioral outcome of a decision. Current neurophysiological data and reaction-time models show that saccadic reaction times are determined by build-up activity in motor-related structures, such as the frontal eye fields. I will present observations showing that neural activity in the sensory cortex (primary visual cortex or V1) also predicts the reaction time and location of an upcoming saccadic eye movement. Thus, neural correlates of the decision *when* and *where* to look are found across sensory and motor areas. I will propose the idea that the process of visuomotor integration is distributed in nature, where each cortical area involved has its own particular contribution.
Keywords: decision, frontal eye fields, saccade, saccadic, primary visual cortex, reaction time, V1, visuomotor

Address correspondence to Hans Supèr. E-mail: hans.super@icrea.es

SYMPOSIUM 5: HAPTIC PERCEPTION
Conveners: Soledad Ballesteros and David Travieso

Tactile Texture Perception: An ERP and Psychophysical Study.
Soledad Ballesteros (Universidad Nacional de Educación a Distancia, Madrid), Rupert Hölzl (University of Mannheim, Germany), José M. Reales (Universidad Nacional de Educación a Distancia, Madrid), Dieter Kleinböhl (University of

Mannheim, Germany), Beatriz García (Universidad Nacional de Educación a Distancia, Madrid), Jörg Trojan (University of Mannheim, Germany), Francisco Muñoz (Universidad Nacional de Educación a Distancia, Madrid), and Manuel Sebastián (Universidad Nacional de Educación a Distancia, Madrid).

Previous research has shown the salience of roughness in the textural perceptual space as well as the importance of temporal cues in the perception of this dimension. However, the neural basis of the tactile perception of roughness is not currently well understood. In this study, brain evoked potentials to stimuli varying in physical roughness were recorded while participants performed different behavioural tasks. The study was designed to investigate: (1) how does perceived roughness correlate with physical roughness, the relationships between ERPs parameters, affective evaluation and increasing levels of roughness; (2) the influence of speed of presentation on stimuli varying in roughness and the ERPs components; (3) and finally, the neural and behavioural changes that occur as a function of ageing. We used a novel stimulus delivery system designed to present tactile stimuli to young and older healthy participants while registering electrophysiological responses. In the study, gratings varying in roughness were scanned across the immobile fingerpad at different movement speeds. Participants were comfortably seated in front of the apparatus while performing a series of classification, psychophysical magnitude estimation and hedonic tasks in a counterbalanced order. The topography and ERP components related to levels of physical roughness will be discussed and compared with the psychophysical and hedonic results.
Keywords: ageing, ERPs, psychophysical judgements, roughness, tactile texture perception

Address correspondence to Soledad Ballesteros. E-mail: mballesteros@psi.uned.es

Perceptual Maps of the Body Surface: A Topological Approach to Body Perception.
Jörg Trojan, Dieter Kleinböhl, and Rupert Hölzl (University of Mannheim, Germany).

Brain imaging methods have been repeatedly used to analyse the topographic properties of central body representations. Yet, how exactly the spatial and temporal characteristics of cerebral activation patterns relate to the domain of subjective perception is largely unknown. The main feature of the presented methodological approach is the acknowledgement of the phenomenal space of the body surface as a genuine ontological level, not to be identified with cortical activation patterns. This perspective fosters the empirical examination of how the topographic characteristics of our self-perception are rooted in neural processes. We developed a method of direct localisation of stimuli delivered to the body surface using a 3D digitiser which allows accurate and straightforward reports of the perceived positions as back-projected onto the anatomical reference on the skin by pointing. This approach has been applied successfully to the mechanoceptive and the nociceptive domain, using stimulation of the body surface with pneumatically driven tactors and CO_2 laser stimuli, respectively. In addition to the baseline conditions, we also assessed localisation data after changing the response characteristics of the skin through topical application of capsaicin and in response to spatiotemporal patterns eliciting the *saltation* phenomenon. Our results show that perceptual maps can deliver dimensional descriptions of the body surface as it is individually perceived, providing several advantages for the future assessment of body perception: (1) Their characteristics and transformations can be expressed in formal mathematical terms, allowing a refinement of hypotheses concerning the experimental investigation of body perception. (2) They provide psychophysical measures which can be directly related to brain activation maps, e.g., in order to predict activation patterns in the primary somatosensory cortex from perceptual characteristics and vice versa. (3) Separate dimensions may be integrated in one multi-dimensional map, which may be used to compare the representations of the various somatosensory modalities, e.g., touch and pain. (4) The inclusion of a *temporal* dimension allows the modelling of the inherent *dynamics* of perception.
Keywords: body perception, CO2 laser stimuli, sensory saltation, somatosensory cortex

Address correspondence to Jörg Trojan. E-mail: joerg.trojan@osi.uni-mannheim.de

Is Haptic Orientation Blind? A Search for Crossmodal Effect on Orientations.
Marion Luyat (University of Lille 2, France) and Janik Naveteur (University of Valenciennes, France).

The ability of visual directional cues to influence haptic perception of orientations has been poorly ascertained, although it is well known that our senses do not process information in strict isolation. For example, it has been found that the

two strategies classically adopted in order to suppress visual information (occulting vision with a mask or only hiding the stimulus) do not provide similar performances in the processing of orientations. In line with a previous experiment that showed a clear intramodal effect of context in haptics, we investigated here the crossmodal influence of vision on touch by trying to answer to the following question: Is haptic perception of orientations influenced by vision? In Experiment 1, participants were asked to orient a rod, with the right hand, to either vertical (0°) or oblique directions of space (respectively right or left 45° orientations). Simultaneously, different visual contexts were presented: without visual directional cues, with congruent stripes (parallel to the orientation to be produced) or incongruent stripes (tilted relative to the orientation to be produced). The analysis of variable errors revealed a classical oblique effect that is a better precision for vertical production than for oblique ones but this effect of orientation was not significant on the constant errors. No effect of the visual background was found on either the variable errors or the constant errors. In Experiment 2, we used a similar methodology but we additionally recorded the subjective difficulty of the task by means of a visual analogue scale and the time of response. Variable errors, constant errors and time of response revealed an oblique effect but unaffected by vision. Concerning the subjective assessment of the task's difficulty, vision was influential: performing the orientation was described as more difficult with incongruent contextual cues than with congruent ones or with no contextual cues. The results were discussed relative to the conditions necessary to evidence crossmodal effect
Keywords: crossmodal and intramodal effectsn, haptic orientation, visual cues

Address correspondence to Marion Luyat. E-mail: marion.luyat@univ-lille3.fr

Deviations in the Haptic Parallelity Test under Restrictions of Movement.
David Travieso, Marcos Fernández, and Pilar Aivar (Universidad Autónoma de Madrid).

Research on haptic space can be defined as the ability to perceive space through the active contact of our body with the environment. Different studies since the 1930s have demonstrated that the space derived from this kind of interactions is highly fluctuant and, at the same time, distant from a Euclidean description. More recently, Kappers and her colleagues used parallelity and other geometrical transformation tasks to show systematic deviations from Euclidean space that were described as fitted to a curved space of constant negative curvature. They explained haptic space as a representational map with two frames of reference, one egocentric, or body-centered, and another alocentric. Two facts, however do question the representational hypothesis. First, similar but smaller deviations have been described for vision and audition despite a medial energy is used for perceiving. Second, former studies showed interactions with auditory cues that can reduce deviations when applied to help performance instead of perception. In fact, despite haptic is considered an active version of touch interactions; none of the studies on haptic space have studied the effects of movement on haptic space tasks like the parallelity test. This study analyses the differential effects of restricting movement at the levels of wrist and elbow, together with variations in the position of the *protactors* in reference to the body midline. Results show that executive factors must be considered for an appropriate description of haptic space.
Keywords: alocentric frames of reference, body-centred frames of reference, haptic parallelity test, haptic space

Address correspondence to David Travieso. E-mail: david.travieso@uam.es

Use of External Frames of Reference in Tactile Spatial Attention: Evidence from the Blind and Sighted.
Alison F. Eardley (University of London, United Kingdom), Jose van Velzen (University of London, United Kingdom), and Martin Eimer (University of London, United Kingdom).

To investigate whether the external frames of reference acquired through touch have a role to play in the control of spatial attention, event-related brain potentials (ERPs) were recorded during a tactile attention task for a group of totally blind participants who were either congenitally totally blind or had lost vision during infancy, and a group of blindfolded age-matched sighted controls. Before carrying out the ERP task, participants explored the experimental booth using touch alone. Following this, participants sat at a table with a soft block on one side and a hard block on the other. Participants had to shift attention to the soft or hard side (as indicated by an auditory cue presented at the start of each trial), in order to detect infrequent tactile targets delivered to the hand on the cued side. Hands were either crossed, or uncrossed (alternating between blocks). Making the spatial frame of reference available through touch does not have the same effect on the sighted as when it is made available through vision. Nevertheless, differences in the frontal lateralised ERP components in the sighted, when their hands were crossed, suggests a conflict between the body-centric

and external spatial frames of reference. Although hands were anchored in the external environment as a result of the different tactile pads, the effects of hand-crossing were attenuated in the early blind group.
Keywords: blindness, event-related brain potentials (ERPS), frames of reference, spatial attention

Address correspondence to Alison F. Eardley. E-mail: a.eardley@psychology.bbk.ac.uk

SYMPOSIUM 6: SOUND AND SPEECH PERCEPTION
Convener: Luis E. López-Bascuas

Psychophysical Estimates of Level-Dependent Best-Frequency Shifts in the Apical Region of the Human Basilar Membrane.
Enrique A. Lopez-Poveda, Luis F. Barrios, and Ana Alves-Pinto (Universidad de Salamanca).

It is now undisputed that the best frequency (BF) of basal basilar-membrane (BM) sites shifts downwards as the stimulus level increases. The direction of the shift for apical sites is, by contrast, less well established. Auditory nerve studies suggest that the BF shifts in opposite directions for apical and basal BM sites with increasing stimulus level. This study attempts to determine whether this is the case in humans. Psychophysical tuning curves (PTCs) were measured using forward masking for probe frequencies of 125, 250, 500, and 6000 Hz. The level of a masker tone required to just mask a fixed low-level probe tone was measured for different masker-probe time intervals. The duration of the intervals was adjusted as necessary to obtain PTCs for the widest possible range of masker levels. The BF was identified from function fits to the measured PTCs and it almost always decreased with increasing level. This result is inconsistent with most auditory-nerve observations obtained from other mammals. Several explanations are discussed, including that it may be erroneous to assume that low-frequency PTCs reflect the tuning of apical BM sites exclusively and that the inherent frequency response of the inner hair cell may account for the discrepancy.
Keywords: cochlear nonlinearity, psychoacoustical tuning curves, apical cochlear tuning, inner hair cell, auditory filter, best-frequency shift

Address correspondence to Enrique A. Lopez-Poveda. E-mail: ealopezpoveda@usal.es

Listening to a Dialect: Dynamics of Phonetic and Lexical Representations.
Núria Sebastián-Gallés (Universitat de Barcelona), Fátima Vera (Universitat de Barcelona), Johan Larsson (Universitat Pompeu Fabra, Spain), Begoña Díaz (Universitat de Barcelona), and Gustavo Deco (Universitat Pompeu Fabra, Spain).

In an auditory lexical decision task experiment, the performances of highly proficient early Spanish-Catalan and Catalan-Spanish bilinguals were contrasted using Catalan materials (Sebastian-Galles et al. 2005, JML). In this task, two types of experimental non-words were specifically constructed by substituting the Catalan phoneme /E/ for a Catalan /e/, or vice versa. As expected from previous research, Spanish-Catalan bilinguals showed great difficulties in discriminating experimental words from non-words. Indeed, these mistakes were manifestations of a perceptual assimilation in the context of lexical decision; both Catalan phonemes being "mapped" to a Spanish /E/. Especially interesting was the asymmetry across both experimental conditions for Catalan-dominant bilinguals. They made more mistakes for /E/→/e/ changes than for /e/→/E/ ones. This pattern was taken as evidence of a developed acceptance for mispronounced Catalan /E/-words; that is, a sort of long-term plasticity, the origin of this phenomenon being exposure to a bilingual environment where such mispronunciations by Spanish-dominant bilinguals abound. These results lend themselves well to biophysically realistic neurodynamical modelling employing descriptions at the level of spiking neurons and the synaptic activity which evokes the spikes in the neuron membrane potential. This model makes specific predictions about the consequences at the phoneme level of different patterns of asymmetries (at the lexical-contextual level). The predictions of the model have been supported by the results of a series of studies (using both behavioral and electrophysiological measures) where phonetic (discrimination) and lexical (lexical decision task) levels have been analyzed.
Keywords: phonological representations, non-native perception, phoneme representation, lexical representation, native speech perception

Address correspondence to Núria Sebastián-Gallés. E-mail: nsebastian@ub.edu

Cross-Language Effects in the Perception of Intonation.

José E. García-Albea (Universitat Rovira i Virgili, Spain), Burton S. Rosner (University of Oxford, United Kingdom), Esther Grabe (University of Oxford, United Kingdom), and Xialin Zhou (University of Peking, China).

Cross-language studies on speech perception have shown that native language affects the perception of segmental phonetic structure and the perception of various prosodic features, such as prominence, stress, and lexical tone. Less work is found, however, on the perception of non-lexical intonation contours across language groups. We therefore undertook an investigation of native language effects on the perception of similarities and differences among intonation contours in a given language (English) by listeners of the same and other language backgrounds (English, Spanish, and Chinese). Our collaborative research includes the two experiments that are reported here. In the first experiment, an English utterance was resynthesized with eleven intonation contours (seven falling contours and four rising contours). Groups of English, Iberian Spanish, and Chinese listeners rated pairs of stimuli for degree of difference. The responses were subjected to multidimensional scaling and a new statistical procedure, the configuration comparison test. The test revealed cross-linguistic similarities and significant differences. All listeners perceptually separated the stimuli into two clusters, one ending in falling pitch and one ending in rising pitch. Within the falling cluster, significant cross-linguistic differences occurred in the arrangement of stimuli. In a second experiment, English, Spanish, and Chinese participants listened to frequency-modulated (FM) sine waves that duplicated the fundamental frequency contours of the speech stimuli used in the first experiment. Listeners again divided the stimuli into falling and rising clusters, but no convincing effect of native language appeared in either cluster. The speech and FM stimuli seemed more closely related perceptually in the Chinese than in the English or Spanish data, which suggests that Chinese listeners essentially treated the English speech contours more like FM stimuli than did participants of the other two languages. Overall, our results show that universal auditory mechanisms that process frequency modulations may underlie the basic perceptual distinction between falling and rising contours of intonation in speech. Experience with a given native language then builds on the outputs of those mechanisms in its own particular way, leading to some degree of cross-language specificity in the perception of similarities and differences of intonation contours used in a given language.

Keywords: auditory perception, speech perception, intonation, cross-language comparisons, frequency modulation, multidimensional scaling

Address correspondence to José E. García-Albea. E-mail: jegarcia.albea@urv.cat

Temporal and Intonational Features of Prosodic Structure in Sentence Perception and Production.

J. M. Igoa, C. Teira, and P. E. García (Universidad Autónoma de Madrid).

The importance of prosody in sentence processing is beyond any doubt. In this paper, we address two fundamental issues about the processing of prosodic structure in sentence comprehension and production in Spanish. The first issue concerns the relative weight or salience of different prosodic features in performing perceptual and grammatical judgments in structurally complex sentences, and in the segmentation and grouping of sentence constituents in speech production. By using a variety of tasks, we purport to show that temporal features (duration of segments, and length and placement of nonterminal breaks) play a more outstanding role than intonational features (variations in f0 contour, placement of tone accents, f0 decline at significant sites in utterances) both in perceptual/grammatical judgments and production tasks. However, whereas variations in f0 per se appear to be minimally relevant in grammatical judgments, they do play a significant, though subtle, role in production. A second issue we examine in this work is the contribution of structural and prosodic factors to decisions involving prosodic phrasing. For this purpose, we chose as the relevant structural factor the syntactic dependencies between constituents in ambiguous sentences and their unambiguous counterparts, while the relevant prosodic factor was the relative length of the target syntactic constituents. Our results suggest that syntactic dependency regulates decisions about prosodic phrasing to a greater extent than constituent length, and this happens both in perception and production. We report a series of experiments of two kinds: (a) a sentence elicitation experiment where speakers engaged in a virtual conversation, in which they had to produce novel sentences by combining parts of previously presented sentences; the sentences so elicited were of two kinds: fully ambiguous sentences with an attachment ambiguity (a relative clause with two potential antecedent nouns), and unambiguous versions of these sentences, disambiguated by means of number agreement between the verb in the relative clause and the host noun in the main clause. (b) Several sentence-processing experiments with perceptual and comprehension tasks, involving ambiguous and unambiguous versions

of the same sentences used in the production experiment. The prosodic measures employed were acoustic/phonetic (calculated by using the Praat software) and auditory/phonological (i.e., categorical judgments based on the ToBI transcription system for prosody).

Keywords: prosodic features, f0 contour, silent pauses, perceptual discrimination, prosody-syntax relations

Address correspondence to J. M. Igoa. E-mail: josemanuel.igoa@uam.es

Signal Detection Analysis of the "Categorical" Perception of Spanish Front Vowels and Stop Consonants.

Luis E. López-Bascuas and Juan J. Rahona (Universidad Complutense de Madrid).

Categorical perception of an acoustic continuum entails that: (a) identification functions have a steep slope, (b) discrimination functions show a peak at the category boundary, and (c) discrimination functions are perfectly predictable from labelling probabilities. Early research at Haskins laboratories indicated that, though not perfectly, consonants accommodated rather well to these criteria. Vowel perception, however, was considered continuous or, at least, much less categorical. Articulatory factors were called for in order to account for the discrepancy. More recent research attempted to offer a unified view of the processing of vowels and consonants, along with nonspeech signals, in terms of the preliminary theory of auditory resolution. As vowels seem to cover a broader perceptual range, the theory predicts that context-coding noise for vowels should be greater than for consonants, leading to a less categorical performance on the vocalic segments. However, new experiments have cast doubt on the assumption of different perceptual ranges for vowels and consonants even though context variance is acknowledged to be greater for the former. Therefore, range is not the only determinant of context variance. A possibility is that context variance actually confounds two things: local context variance (as defined by the range of a particular experiment) and global context variance (as defined by the number of long-term phonemic categories). It is hypothesized that perception of vowels and consonants should be more similar in Spanish than in other languages with phonological systems containing more vowel categories (as English or Dutch). In this paper, a signal detection analysis of identification and discrimination functions (obtained with Spanish speakers) is presented. Such an analysis is compared with data obtained in English and Dutch by other authors. It is concluded that context variance is also influenced by the number of long-term phonemic categories.

Keywords: categorical perception, signal detection theory, vowel perception, context variance, perceptual range

Address correspondence to Luis E. López-Bascuas. E-mail: lelopezb@psi.ucm.es

TALK SESSION 1: VISION: EARLY PROCESSING, SPATIAL VISION AND MOVEMENT PERCEPTION

Convener: Manuel Blanco

Effect of Noise on Retinal Image Contrast and Stochastic Resonance.

A. Guirao and M. Ferri (Universidad de Murcia).

Stochastic resonance (SR) is a phenomenon of optimization by means of noise in nonlinear systems. It consists basically of the fact that a weak signal, undetectable below a certain threshold, becomes detectable in the presence of an optimum amount of noise. SR has raised a great interest in biology because noise may improve information processing in the nervous system, in particular in the visual system. For example, a subject's contrast threshold decreases significantly, reaching a minimum (resonance), when Gaussian noise is added to the view image. The SR phenomenon has also been found in depth perception and in the mechanism of binocular rivalry when different stimuli were presented to each eye. In this work, we studied the effect on spatial perception of both the intensity noise and the optical noise, and looked for SR occurrence. Intensity noise was added to a scene (external noise) or directly to the simulated retinal image (internal noise). Retinal images were computed by convolving the scene with the eye's point-spread function. A model of contrast detection, based on the neural contrast sensitivity function, was considered. We found that, for the low contrasts, intensity noise may enhance the retinal image and increase the contrast sensitivity of a subject, and that SR occurs with different optimum noise amounts for each spatial frequency.

On the other hand, we treated the fluctuations of the eye's optical aberrations as a source of noise. To simulate the retinal image, series of point-spread functions were computed from noisy aberrations and convolved with the object.

We found that optical noise, due in particular to fluctuations of defocus, improves the optical performance in some conditions, which may be interpreted as a process of SR.
This positive role of noise in spatial vision and some potential applications will be discussed in this presentation.
Keywords: spatial vision, retinal image, noise, stochastic resonance

Address correspondence to A. Guirao. E-mail: aguirao@um.es

Monocularly Biased Access to Consciousness.
Fernando Valle-Inclán (Universidad de A Coruña), Manuel Blanco (Universidad de Santiago de Compostela), & Luz Leirós (Universidad de Santiago de Compostela).

Considering that monocular channels are complex neural networks and that their interactions might not be symmetric, subtle interocular differences in information-processing capacities would not be surprising. We have found that two thirds of the observers, when presented with series of dichoptic pairs of alphanumeric characters, one every 100 or 150 ms, do not detect targets presented to one eye, but have perfect detection in the other eye. This method to assess 'eye dominance' has many advantages over previous techniques and yields very reliable eye-dominance estimates.
If this interocular suppression is an inherent characteristic of the visual system, possibly rooted in inhibitory interconnections, it should be independent of the particular stimuli presented (provided that they have the same contrast, size, spatial frequency, and luminosity). Consequently, briefly presented binocular (identical) stimuli will be perceived through one eye. We tested this counterintuitive hypothesis by presenting two identical series of alphanumeric characters (except one target monocularly presented). Observers identified the target when presented to one eye and completely ignored it when presented to the other eye. The monocular suppression increased as a function of the number of previous binocular transients and reached a plateau at about 400 ms after the onset of the dichoptic series. We concluded that relatively small (1 dgv), brief, and foveally presented stimuli are perceived through one monocular channel (see Wolfe, 1986) and that the suppression develops as a function of the number of previously experienced onset/offset transients.
Keywords: binocular vision, monocular suppression, dichoptic stimuli

Address correspondence to Fernando Valle-Inclán. E-mail: fval@udc.es

Spatial Facilitation in Flash-Lag Effect.
A. Maiche (Universitat Autònoma de Barcelona), R. Budelli (Universidad de la República, Uruguay), and L. Gómez-Sena (Universidad de la República, Uruguay, and CNRS, France).

The flash-lag effect (FLE) is the perceptual phenomenon in which a flash adjacent to a continuously moving object is perceived behind it. Horizontal propagation of activity could explain a shorter latency for moving than for flashed objects. Here, we show that two concurrent moving stimuli increase the FLE, presumably due to a latency decrease in movement perception.
In order to measure the FLE in a situation that allows interaction between two moving objects, we use an experimental paradigm in which the primary moving object is a ring that passes horizontally across the screen; the flash is a vertical line that appears over the ring, and the second moving object is a filled circle that moves vertically. For the sake of simplicity, we refer to this second moving object as the "primer." The position at which the line was flashed was varied according to the constant stimuli method.
By means of four experiments, we show that a second moving object (the primer) that would collide with the ring increases the FLE, and that what is really important for this magnification is the direction of motion of the primer. Also, we prove that the effect of the primer is spatially bounded and depends on its contrast: more contrast of the primer produces a higher pre-activation and, consequently, increases the FLE.
Our results support the idea that spatial facilitation along the trajectory of a moving object reduces movement perception delay and therefore, sustains an involvement of latency differences in FLE generation.
Keywords: motion, flash-lag effect, neural processing delays, horizontal propagation

Address correspondence to Alejandro Maiche. E-mail: Alejandro.Maiche@uab.es

Visual Area Hmt/V5 is Involved in Perceptual Decision even when Motion Surface Integration Dissociates from Veridical Stimulus Properties.

M. Castelo-Branco (Universidad de Coimbra, Portugal), L. R. Kozak (Universidad de Coimbra, Portugal), J. Teixeira, & J. Xavier (Hospital de Santo António, Porto, Portugal).

The cluttered nature of the visual world often imposes difficult perceptual decision problems which may even lead to paradoxical interpretations that are incongruent with veridical stimulus properties. Here, we have studied neural mechanisms underlying visual segmentation of moving surfaces under variable conditions of stimulus ambiguity, and noise.
Decision mechanisms were studied using perceptually bi-stable stimuli: during fMRI scanning experiments, subjects were asked to press buttons to indicate their interpretation of two superimposed gratings moving in different directions (plaid stimuli). Plaids may be perceived either as two surfaces, one being transparent and sliding on top of the other (transparent or component motion), or as a single coherent pattern whose direction of motion is intermediate to the component vectors (non-transparent or pattern motion). We constructed textured plaid stimuli because they can be physically disambiguated into pattern and component motion by local dot movement. We provided graded levels of disambiguation by varying the ratio of horizontally and vertically moving dots. This parameterization included 5 conditions where C:P (Component/Pattern) ratios ranged from 4:2 (200%) to 2:4 (50%).
Surprisingly, we found that physically disambiguated component/pattern stimuli could still be perceived as pattern/component stimuli, yielding non-veridical perception.
Using general linear model analysis (GLM), we found that both pattern and component motion elicited significant activation patterns in hMT/V5 ($p < .001$). To verify whether hMT is indeed causally related to perceptual decision, we performed event-related analyses, which confirmed a significant involvement of hMT in the near-perceptual-switch periods. Furthermore, given that pattern and component perceptual responses had distinct button-press assignments, we were able to extract highly significant sensorimotor representations corresponding to the perceptual response. These representations were used as internal temporal markers of decision and as an input for correlation analyses to find directly involved areas. We found that the hMT area was significantly involved in this process even in physically disambiguated conditions that can still lead to non-veridical perception. We conclude that the hMT complex directly encodes and triggers decision processes related to surface segmentation, even when perception is dissociated from veridical stimulus properties.
Keywords: motion perception, perceptual bi-stability, neuroimaging

Address correspondence to M. Castelo-Branco. E-mail: mcbranco@ibili.uc.pt

TALK SESSION 2: ILLUSIONS, SPATIAL ORIENTATION, NON-VISUAL PERCEPTION

Convener: S. Ballesteros

Bisection Disrupts Performances at Line Length Estimation.

P. Charras and J. Lupiáñez (Universidad de Granada).

Human beings report a general tendency to overestimate vertical line length, as in the Horizontal Vertical Illusion (HVI). This figure is composed of two equal-length lines: a horizontal and a vertical line forming an inverted T. When comparing the two lines' length, the vertical line is perceived 5 to 20% longer than the horizontal one (Avery & Day, 1969). However, when the two lines form a cross (they meet at midpoint), the lines are very well estimated. The position of the vertical line along the vertical axis determines the vertical-line overestimation magnitude (Charras & Lupiáñez, submitted).
The current study aims at investigating the role of bisection on the magnitude of the illusory effect by manipulating the relative position of the lines. In the first experiment, the vertical line was always displayed at fixation, whereas the horizontal-line position took on 7 values, and varied from left to right. In the second experiment, the horizontal line remained at fixation, and the vertical line was implemented in a series of positions varying from cutting upwards to downwards (7 values). We replicate our previous findings according to which the cross-shaped drawings allow a very high perceptual discrimination and in whatever series they are implemented (Experiments 1 and 2). An interaction between lines and positions was observed, showing that bisection determines line-length overestimation. These results are interpreted in terms of the Gestalt theory: "The whole is more than the sum of its parts" (Wertheimer, 1924). Indeed, a whole line is perceived as longer than two half lines which add up to the same length.
Keywords: length estimation, line, bisection

Address correspondence to P. Charras. E-mail: pom.charras@univ-montp3.fr

Invoking the Rubber Hand Illusion in Virtual Environments.

D. Pérez-Marcos (Universidad Miguel Hernández-CSIC, Spain), M. Slater (Universitat Politècnica de Catalunya, Spain), and M. V. Sanchez-Vives (Universidad Miguel Hernández-CSIC, Spain).

In the "rubber hand illusion", Botvinick and Cohen (1998) showed that synchronous stimulation of a rubber hand and the subject's hidden real hand could result in a projection of ownership towards the rubber hand. In previous studies, we have demonstrated that the "rubber hand illusion" can be also induced with a virtual 3D-projected arm (Sanchez-Vives and Slater, 5th FENS Forum, 2006). In an attempt to determine the critical factors that influence the occurrence of the evoked illusion, here we compared the virtual illusion evoked using two different paradigms. In both conditions, the participants saw a computer generated stereo image of a virtual right arm as projecting horizontally out from their right shoulder. Their real right arm rested on a mounted shoulder-high wooden shelf, hidden from their view. After 5 minutes stimulation, the virtual arm rotated slowly to the right and returned to the original position (supination-pronation movement). One-channel EMG recording on the forearm was recorded. In the first condition, the experimenter tapped and stroked the subject's real hand with a ball. The subject saw a virtual sphere that tapped and stroked the virtual hand in synchrony and in the same place on the hand as the real hand was touched. In the second condition, two alternating air puffs stimulated two different locations of the hidden real hand at random intervals and randomly between the two locations. The visual input observed by the subject was a virtual spray can that provided air puffs synchronously and on the corresponding two positions of the virtual hand. Subjective, behavioural, and physiological measures showed that the illusion worked in both conditions although the degree of the experienced illusion varied between them. After the experiment, subjects were interviewed to collect their impressions about the experience and then they filled out a 14-item questionnaire for quantifying the presence of the evoked illusion. In both conditions, the mean score of the illusion-related questions was significantly higher than the scores of the control questions (following Botvinick and Cohen, Nature; 391: 756, 1998). A possible reason for such differences between the conditions is that when tapping and stroking with the ball, more extensive areas of the hand are randomly stimulated. It is possible that this stimulus is more realistic and induces less adaptation due to the randomness of the location. Another possible reason is that the air puffs cause a sensation of coldness to the subject that intensifies the perception of their own real hand, as reported by some participants. Summarising, the significance of the illusion-related questions was demonstrated in two different conditions of the virtual hand illusion. However, although the results of EMG data are encouraging and support the results obtained in previous studies, further investigation in this direction is needed. Additional physiological measures will be included in future research. 50.

Keywords: visual illusions, proprioception, visual capture

Address correspondence to Daniel Pérez Marcos, E-mail: perez.marcos@gmail.com

Perceptual Priming and Recognition of Familiar Odours in Young and Older Healthy Adults.

A. Fusari and S. Ballesteros (Universidad Nacional de Educación a Distancia).

A major approach in the study of memory over the last three decades has focused on the distinction between two memory systems, one involuntary or implicit, and the other voluntary or explicit. Although implicit memory has been the focus of intense investigation, most studies have dealt with stimuli presented either visually or auditorily. In contrast, just a few studies have been conducted on the olfactory modality with young adults and none with older participants.

The present study had two goals. First, to assess whether olfactory priming (as a measure of implicit memory) exists and whether implicit memory dissociated from explicit memory in young adults and healthy older adults employing a set of real world edible and non-edible substances. Implicit memory for odours was assessed using a speeded odour identification task and explicit memory with an "old-new" recognition test. The second goal was to see whether implicit memory is resistant to the passage of time. For this purpose, implicit memory was assessed twice: immediately after encoding and 4 weeks after the study episode.

Results from the immediate odour identification task revealed intact odour priming for both groups. Moreover, in the older adult group, the priming effect was still significant after the 4-week interval, whereas for young adults, this effect was enhanced. In contrast, explicit recognition was impaired in older adults compared to young adults. The intact odour priming obtained across the two age groups in two separate time intervals adds validity to the results. Our results suggest that not all memory systems decay with age and that implicit memory for odours is intact in older adults and is long-lasting.

Keywords: olfactory priming, recognition, aging

Address correspondence to A. Fusari. E-mail: ninafusari@googlemail.com

Influence of Validity and IOR Effects on Implicit and Explicit Memory.
Julia Mayas (Universidad Nacional de Educación a Distancia), Soledad Ballesteros (Universidad Nacional de Educación a Distancia), and Luis J. Fuentes (Universidad de Murcia).

Spatial orienting is a powerful mechanism to enhance location and object processing. In this experiment, we study the influence of validity and inhibition of return (IOR) effects in two long-term memory tasks. In the first part of the study, 20 participants performed an orienting attention task in which pictures of familiar objects were presented at a valid or an invalid location at different stimulus onset asynchrony (SOAs) while performing a right-left discrimination task. To assess implicit memory (IM), participants were presented incidentally with half of the studied pictures intermixed with another set of new pictures while performing a speeded picture-naming task. Finally, explicit memory (EM) was assessed with an "old-new" recognition task.
Results from the IM task showed the classical validity and IOR effects. At the short SOA, naming for valid pictures at encoding was faster than for pictures shown at an invalid location (validity effect). At the long SOA, the inverse pattern was found (IOR). Explicit recognition was highly impaired (d´<1). Moreover, results did not show any of these effects (validity or IOR). However, attention influenced explicit memory. Pictures encoded at the short SOA were recognized significantly better than those presented at the long SOA. The present results are in congruence with previous findings from our laboratory (Ballesteros, Reales, García, & Carrasco, 2006; Ballesteros, Reales, & García, in press) and suggest that attention at encoding influences both implicit and explicit memory tasks.
Keywords: inhibition of return, attention, implicit and explicit memory, ageing

Address correspondence to Julia Mayas. E-mail:psycomayas@hotmail.com

TALK SESSION 3: VISUAL PERCEPTION: APPLICATIONS
Convener: Humberto Moreira

Red-Green Dichromats, Surface Colours and Naming Errors.
H. Moreira (Universidad Cardenal Cisneros, Madrid), J. Lillo (Universidad Complutense de Madrid) and L. Del Tio (Iubilate).

Protanopes' and deuteranopes' behaviour is very different when comparing, on the one hand, the adjustments they perform in an anomaloscope and, on the other, the way they name surface colours. In the first case, they do not detect differences among stimuli that normal observers name: reds, oranges, yellows or greens. In the second case, their prototype naming is very similar to that of common observers and, even more important, dichromats' responses do not indicate confusion of some specific category pairs (for example, red and green).
In our current research, a group of normal observers performed three naming tasks (free monolexemic, restricted bilexemic, and lightness evaluation) using a 33-surface stimuli set. Eleven stimuli were the Spanish Basic Colour Category prototypes. Twenty-two were stimuli that, in previous research, were systematically misnamed (11 for the protanopes, 11 for the deuteranopes). For example, brown (100% consistency for normal observers) was frequently (more than 50%) called green by protanopes. Such misnamed stimuli will hereafter be identified as "confusion referents." Confusion referents provide less consistent responses in the monolexemic naming task, more shared responses in the bilexemic task, and significant differences in lightness estimations. Verbal descriptions provided by naming tasks make it possible to specify confusion referents in natural language and, consequently, they can be used to inform no-colour experts about dichromats' real difficulties for using the Spanish Basic Colour Categories (whose categories they tend to confuse and which are the specific stimuli that produce more confusions).
Keywords: colour vision, colour blind people, naming

Address correspondence to Humberto Moreir a. E-mail: humbertomv2002@yahoo.es

Colour Solids, Illuminant Variation and Colours without Correspondence.
E. Perales, F. M. Martínez-Verdú, and V. Viqueira (Universidad de Alicante).

A colour solid includes all colours perceived in response to a physical colour stimuli set by the human visual system. The optimal colours define its external surface. An optimized algorithm allows searching optimal colour stimuli for any lightness, hue angle and illuminant. Unlike the irregularly shaped colour solid obtained in CIELAB, the colour solids

associated with the most recent perceptual colour spaces, DIN99d and CIECAM02, appear more spherical or homogeneous. Colour-solid shape depends on illuminant spectrum, in particular for discontinuous (and/or very peaked) spectrum sources with correlated colour temperature under 5500 K. Likewise, it can be stated that there is a direct relationship between the colour gamut volume and the number of distinguishable colours. Thus, we can apply several methods to estimate the gamut volume (content) for any colour solid associated with any illuminant or light source, taking into account several packing methods (squares, ellipses, tetrahedron, spheres) in uniform colour spaces and other computing techniques such as convex hull. With this preliminary methodology, we propose an absolute colorimetric quality index for any illuminant/light source based on the computation of the number of distinguishable colours within the colour solid.
The most fascinating corollary of our research can be stated as follows: Applying the same colour correspondence (chromatic adaptation transform) among optimal colour data for each illuminant, we found that there are distinguishable colours under one target illuminant without perceptual correspondence under another, even though target colour-solid volume was smaller. This means that the number of colours discernible by the human visual system is unlimited, because it can not be associated with a single illuminant/lamp, An additional conclusion is that colour constancy, based initially on a chromatic adaptation transform, can be considered the product of an adaptive mechanism that reduces the number of distinguishable colours without correspondence between different illuminants.
Keywords: colorimetry, colour vision, colour discrimination

Address correspondence to Esther Perales. E-mail: Esther.perales@ua.es

Visual and Pupil Response Deficits during Optic Neuritis and Multiple Sclerosis.
S. I. Moro (City University, London, United Kingdom and University of Barcelona, Spain), M. L. Rodriguez-Carmona (City University, London, United Kingdom), G. T. Plant (National Hospital for Neurology and Neurosurgery, London, United Kingdom), & J. L. Barbur (City University, London, United Kingdom).

We investigated the recovery of visual performance and pupil responses in patients with demyelinating optic neuritis (ON) and multiple sclerosis (MS). The pupil constriction amplitude and the time delay (latency) of the pupil response were measured in response to either achromatic (luminance) or chromatic (isoluminant) sinusoidal stimulus modulation. We ensured that the modulation of chromatic saturation remained both scotopically and photopically isoluminant with the display background in order to minimize the contribution from rod signals to the pupil colour response. In addition, we measured detection thresholds for achromatic stimuli with standard visual field perimetry and chromatic thresholds using a new Colour Assessment and Diagnosis (CAD) test which isolates colour signals by means of dynamic luminance masking. The results suggest that the comparison of achromatic and chromatic deficits can provide useful information about remitting and relapsing demyelinative phases during MS and ON.
Keywords: colour vision, pupil, optic neuritis, multiple sclerosis

Address correspondence to S. I. Moro. E-mail: s.moro@physics.org

A Set of Dynamic Tasks for the Assessment of Spatial and Visual Perception.
M. J. Contreras (Universidad Nacional de Educación a Distancia), A. Martínez (Universidad Autónoma de Madrid), D. Peña (Centro de Psicología Bertrand Russell), A. Manzanero (Universidad Complutense de Madrid), and J. Santacreu (Universidad Autónoma de Madrid).

A battery of dynamic tests was developed for measuring spatial orientation, spatial visualization, trajectory estimation, and time estimation. The present work shows the tasks designed and some interesting data. In the Spatial Orientation Dynamic Test-Revised (SODT-R; Santacreu, 1999) and the Spatial Visualization Dynamic Test-Revised (SVDT-R; Santacreu, 1999), the participant must simultaneously direct two moving dots towards a given destination. The destination changes from trial to trial and the two moving dots can appear from the North, the East, or the West of the computer screen. In order to direct the two moving dots, participants must use a digital compass linked to each of them in the SVDT-R, but not in the SODT-R. For the latter test, participants must direct the moving dots by means of a box with two arrows linked to each moving dot. One arrow moves the dot in one direction, and the other arrow moves it in the opposite direction. Furthermore, in the SVDT-R, the moving dots simply disappear from the computer screen and participants must imagine their movement. In the Cross-Trajectories Test (CTT; Santacreu, 1999), two moving dots appear on the computer screen coming from different places. Both dots move at a constant speed. They stop at unpredictable

moments. The person's task is to manipulate the path of one of the dots, so it will contact the second dot at a "predicted" given destination. TCT is also a measure of Spatial Relations. Finally, the Estimation of Arrival Time Test (EAT-Test; Santacreu, 2001) is based on the Arrival-Time task of Hunt et al. (1988; Pellegrino & Hunt, 1989), and on the speed-anticipation tasks included in some assessment batteries for drivers (Maruyama & Kitamura, 1961). The test presents an object that simulates a boat advancing on a certain course, at constant speed. Three or four seconds after trial start, the boat disappears at the same time as a yellow circle appears. The participants' task is to determine the moment at which the boat will arrive at the circle, pressing the circle when they think the boat is over the circle. When participants respond, the yellow circle changes to red and disappears. After a few seconds, another trial starts and the next boat appears. Authors report that the study shows the high validity and reliability of the measures, although a broader sample of spatial tests is considered (Colom, Contreras, Shih, & Santacreu, 2003).
Keywords: spatial ability, visual perception, dynamic tests

Address correspondence to M. J. Contreras. E-mail: mjcontreras@psi.uned.es

POSTER SESSION 1

Additive versus Multiplicative Noise: Implications for Psychometric Functions.
R. Alcalá Quintana and M.A. García-Pérez (Universidad Complutense de Madrid).

Signal detection theory states that a stimulus of contrast c elicits an internal response Rc which is a random variable with mean μ(c) and a variance that may be contrast-invariant (in the so-called 'additive noise model') or contrast-dependent (in the 'multiplicative noise model'). An observer presumably uses the difference D = Rc ! Rc' as a decision variable, where c' is either zero (in detection tasks) or the standard contrast (in discrimination tasks). In this framework, μ is the transducer function describing the nonlinear mapping of contrast onto an average internal response. García-Pérez and Alcalá-Quintana (Spatial Vision, 2007, 20, 5–43) adopted this transducer model with additive noise to show that the mathematical form of the threshold-versus-contrast (TvC) function is determined by μ, and that the psychometric functions for detection and discrimination have a common mathematical form (and parameters) that are determined by μ and by the form of the distribution of D. Empirical results supported the validity of these formal relations, although neither of two alternative versions of the transducer model with additive noise provided a perfect account of the data.
This work evaluates a number of alternative versions of the transducer model with multiplicative noise, with an eye towards determining whether these versions account for detection and discrimination data better than models with additive noise. Several families (exponential, linear and potential) of functional relations between the variance of internal responses and contrast were considered. In each case, the mathematical expression for the transducer function that renders logistic psychometric functions was derived, as was the ensuing TvC curve. Our current results show that most of the model versions with multiplicative noise fit data worse than versions with additive noise.
Keywords: transducer model, psychometric function, signal detection theory

Address correspondence to R. Alcalá. E-mail: ralcala@psi.ucm.es

Perceptual Learning Effect with a Visual Identification Task.
R. Angulo and G. Alonso (Universidad del País Vasco).

The goal of these studies was to asses the effect of experience with similar visual stimuli on their ability to be discriminated (perceptual learning) in human subjects. Four experiments are presented where the participant was asked to identify a target stimulus from similar stimuli in a "same / different" judgment task without feedback. In each experiment, a block of trials consisted of the 5-s presentation of the target stimulus followed by sequential 5-s presentations of 20 other stimuli spaced 3-s apart. There were three identical blocks of trials with the same stimuli.
In Experiments 1 and 2, the target stimulus appeared once among the other similar stimuli. The repeated experience across the three blocks resulted in a significant reduction in the percentage of errors, even when difficulty of the task was manipulated by varying the number of common and distinctive elements between the target and similar stimuli (Experiment 2). In Experiment 3, matching the number of times the target appeared among the similar stimuli in alternation led to a drop in "same" judgment errors, but not in "different" errors. This effect was not found when

only one similar stimulus was used repeatedly (Experiment 4). These results suggest that experience with similar visual stimuli may improve recognition without facilitating differentiation, and they indicate conditions where such dissociation may occur.
Keywords: perceptual learning, visual stimuli

Address correspondence to Rocío Angulo. E-mail: nie_zarat@hotmail.com

Juvenile Perception of Advertising: From Audiovisual Processing to Advertising Response.
E. Añaños, T. Mas, S. Estaún, N. Fígols, M. Tajadura, S. Mariné, K. Lang, M. Duarte, D. Espejo, and S. Bolívar (Universitat Autònoma de Barcelona).

In order to turn children into consumers, the audiovisual medium drives their attention by resorting to any number of techniques using colour, sound, images, simple rhymes and brief messages, as well as quick cuts, which are conducive to automatic processing.
The aim of this study is to study what elements boys and girls perceive in the advertising of products, and if there are any differences in the elements perceived by each gender. The study was carried out on 22 boys and 16 girls aged 10 to 11 years old.
Four audiovisual (TV) commercials for products targeted at a young audience, broadcast in time bands devoted to children's television programmes, were chosen: (1) a commercial for a toy commonly consumed by boys, (2) a commercial for a toy commonly consumed by girls, and (3) and (4) commercials for sports shoes used both by boys and girls.
After the commercial was shown, the subjects were asked to answer a questionnaire on the elements perceived. The results show the visual and auditory elements children perceived in each commercial, as well as the differences in audiovisual processing between boys and girls. Thus, whereas boys visually perceived the product itself (*the tangible*), girls perceived the action (*the intangible*), and whereas boys auditorily perceived the voice off, girls more commonly perceived the sounds of music.
Keywords: perception advertising, advertising children

Address correspondence to to E. Añaños. E-mail: nie_zarat@hotmail.com

Judgments of Distance and Size as a Function of Stimulus Orientation.
J. Antonio Aznar-Casanova (Universidad de Barcelona), Laura Pérez Zapata (Universidad de Barcelona), & Nelson T. Alves (Universidad de Sao Paulo [USP]).

Distance to a stimulus, its size, and its orientation with regard to the observer are relevant metric properties of visual space. However, whether and how these metrics are related to each other is not well known. In the past, some studies have shown that estimates of egocentric distances are usually more accurate than judgments of exocentric distances, suggesting that there is a dissociation between 'localization' judgments and 'size' judgments. In addition, other investigations have revealed that orientation of the stimulus influences the accuracy of distance estimates.
With the aim of better understanding the relationships between these metric properties of visual space, we conducted an experiment that allowed us to compare egocentric and exocentric distance judgments as a function of the stimulus orientation. Subjects were instructed to draw two dots on the screen by clicking with the mouse when the screen was positioned either on the fronto-parallel plane or on the ground plane.
The results showed that judgments of distance were more accurate (lower constant error) and more precise (smaller differential threshold) when operating in width than in depth. On the contrary, for size judgments, comparisons were more precise when operating in depth than in width. In conclusion, these findings suggest that different perceptual mechanisms underlie size and distance judgments.
Keywords: visual psychophysics, spatial vision, visual space, depth perception, binocular vision

Address correspondence to J.Antonio Aznar-Casanova. E-mail: jaznar2@ub.edu

Alterations of Perceived Contrast for Stimuli with Different 3D Interpretations
J. Chacón (Universidad Complutense de Madrid) and I. Serrano-Pedraza (Newcastle University, United Kingdom).

Shading is a major source of information for acquiring knowledge about the shape of objects. Previous research has shown that a certain kind of shaded stimuli (with 3D interpretation) is perceived with different contrast, depending on the polarity of their dark and lit areas (Chacón, 2004). Specifically, circles filled out with a luminance ramp top-dark were perceived with greater contrast than other top-lit ones, although both types of stimuli had the same physical contrast. In this work, two experiments were conducted in order to determine whether this effect remains with different contrast levels (Experiment 1) and whether the effect is observed in stimuli with different 3D interpretations (Experiment 2). In both studies, we measured the perceived contrast using an adaptive spatial two-alternative forced-choice (2AFC) procedure in a discrimination paradigm in which subjects had to indicate whether the stimuli on the left or the right half of the display had higher contrast (which renders a psychometric function analogous to those in yes-no tasks). The contrast of the reference stimulus was maintained constant and the contrast of the test stimulus was manipulated with an adaptive staircase in order to obtain the subjective point of equality. In the first experiment, circles filled out with a luminance ramp top-dark and top-lit were used. The results showed that the perceived difference remains for different contrast levels. In the second experiment, a set of different elements was built with different grey levels, but not all with 3D interpretation. The results showed clear differences in perceived contrast for stimuli with a strong 3D shape perception, whereas the differences decay for stimuli with no 3D interpretation.
Keywords: shape from shading, contrast, 3D perception

Address correspondence to José Chacón. E-mail: jchacon@psi.ucm.es

Oculomotor Correlates (Eye Fixation and Pupil Size) in Numerical Stroop-Like Tasks.
A. Crespo (Universidad Nacional de Educación a Distancia), R. Cabestrero (Universidad Nacional de Educación a Distancia), P. Quirós (Universidad Nacional de Educación a Distancia), and P.A. Conde-Guzón (Universidad de León).

Taking into account the narrow relation between cognitive processing and eye movements, one might argue that different cognitive strategies demanded by selective attention tasks could be revealed by some oculomotor parameters. Therefore, longer eye fixations could be linked to a deeper cognitive analysis of information and, in turn, might reflect the effort demanded from the subject to ignore the nonrelevant dimension in a selective attention task. Additionally, there is a great corpus of rigorous studies pointing out how these cognitive demands are also reflected by pupil dilations. From this last perspective, pupil diameter enlarges insofar a cognitive effort is required during the performance of any mental activity, such as a filtering process in a selective attention task.
The main aim of the present study was to investigate both facilitation and interference effects in a numerical Stroop-like task by means of an eye-tracking approach. Eye movements and pupil size were recorded with an ASL 504 eye tracker following the infrared pupil-center/corneal-reflection technique (the data sampling rate was 50 Hz). Twenty-five psychology students with normal or corrected-to-normal vision volunteered for the experiment. Participants were instructed to verbally report the number of characters that composed alphanumerical strings of variable length, regardless of the numeral identity. The instructions were to respond as quickly and accurately as possible. These alphanumerical strings were distributed over three experimental conditions: "congruent" condition (the number of characters and the numeral were matched: e.g., say "four" to 4444), "incongruent" condition (the number of characters and the numeral were mismatched: e.g., say "four" to 2222), and "control" or baseline condition (strings of "X": e.g., say "four" to XXXX). Results showed both facilitation and interference effects. Relative to the control condition (baseline), eye fixation durations were longer in the incongruent condition and shorter in the congruent condition. Moreover, a relation between pupillary dilations and levels of attentional resources demanded by each experimental condition was also found. Overall, such findings seem to support the validity of eye-tracking techniques to analyze selective attention effects.
Keywords: eye movements, pupil dilation, selective attention

Address correspondence to A. Crespo. E-mail: acrespo@psi.uned.es

Haptic and Auditive Perception in the Use of Computers by Blind Children.
E. Gastón (Grupo ACCEDO ONCE [Spanish National Blind People's Organisation]).

Blind adults use computers that provide tactile and auditive information. This is possible thanks to two different kinds of devices: Braille displays and screen readers. These can translate all the text on the screen and the labels associated with different kinds of graphics to a nonvisual format.

In the case of children, it is more difficult to make up for the loss of visual information. Firstly, until now, these children have been shut off from technology. And secondly, screen readers are difficult to use and cannot be used in many of the common educational activities. Our research reports on the first results upon evaluating a new technological tool, the pen tablet, which can facilitate the use of computers for blind children in common educational activities.
For instance, the pen tablet allows one to use embossed sheets in which some tactile stimulus are presented, analogously to those that appear on the standard screen. And, most important: they allow children to carry out actions such as drag and paste or double click, etc. Due to tactile limitations in the use of spatial information, the use of this material requires simplifications of the tactile information (elimination of ornamental aspects, thick and separated outlines, etc.) because touch does not allow one to respond to high tactile frequencies.
Keywords: haptic perception, screen reader, Braille display, blind, pen tablet

Adddress correspondence to E. Gastón. E-mail: egl@once.es

Soundscape Perception: Importance of Non-Acoustical Variables
J.D. Guillén and I. López-Barrio (Consejo Superior de Investigaciones Científicas, Spain).

The study of non-acoustical variables in relation to the sound assessment has received less attention than the physical and objective ones, in spite of their importance. This work analysed the effect of visual characteristics of the context and sound identification on the assessment of urban sound environment. Three-hundred and thirty-three subjects, between the ages of 18 and 34, participated in the study. Nine soundscapes were selected, all representative of the city of Madrid. The visual stimuli were images of the soundscapes selected. The soundscapes and their respective visual contexts were presented separately and combined in a room that was acoustically fitted with suitable visibility. After the presentation, the subjects were asked to identify the different sound environments and make an assessment both of auditory and visual stimuli on a pleasantness scale (7-point Likert type scale, ranging from 1 = *very unpleasant* to 7 = *very pleasant*).
The results showed that the assessment of pleasantness assigned to the sound depended on the sound environment with which it was identified. Thus, the park soundscape (M = 5.80) was assessed significantly higher when identified as a "river in the mountains" (M = 6.30, t = 4.638, p < .001) than as an "industrial/factory setting" (M = 3.09, t = –10.664, p < .001). This result shows that the assessment of a soundscape depends not so much on its physical features as on the image the subject has of it. It can therefore be proved that, apart from having a physical structure, the soundscape also has a symbolic structure.
The analyses also proved that visual context had a significant incidence on the assessment assigned to the sound environment. When the visual context obtained a high degree of pleasantness (> M), the assessment of the soundscape increased and, on the contrary, it diminished when the visual context obtained a low degree of pleasantness (< M). The effect that the image had on auditory judgement was related to the difference in the degree of pleasantness between both stimuli. The bigger the difference, the stronger the influence on the image in the soundscape assessment.
Keywords: soundscape, sound perception

Address correspondence to the authors. E-mails: iacg317@ia.cetef.csic.es and ilopezb@ia.cetef.csic.es

View of a Periodic Achromatic Test, Having Achromatic Gratings with Different Modulation Ratio as a Field of Adaptation
M. Martínez I. Tortajada, I. Castilla, and M. Aguilar (Universidad Politécnica de Valencia).

We analysed the influence of the Bezold effect on the appearance of a periodic achromatic sequence which has an adaptation field of Ronchi grating (black and white stripes) when modifying the modulation ratio of the grating (r_m = 1/4, 2/4, 3/4) and the luminance factor of the sequence (β = 0’7-light grey, 0’5-medium grey, 0’3-dark grey).
The test consists of three achromatic sequences (rectilinear, parallel and vertical) with the same luminance factor, interspersed in a horizontal Ronchi ruling. The central sequence, with interspersed white stripes of the grating, became clearer, whereas the lateral sequences became more unclear due to the influence of the black stripes.
We used a scale ranging from 0 (where the central white sequence is not seen) to 10 (where the colour perceived in the dark lateral sequences matches the colour of the central sequence). With these values, we determined the chromatic contrast between the central and lateral sequences, with which we quantified the Bezold effect:

$$\frac{10-V}{10} = \text{Bezold effect} = Be$$

Summing up, *Be* increases with the grating frequency, independently of the modulation ratio or luminance factors of the studied sequence. For every β value of the sequence, with grating frequencies over 1.3 cycles/second, *Be* decreases as the modulation ratio of the grating increases, and it remains practically constant or it increases slightly with lower frequencies. This dependence of *Be* on the modulation ratio of the grating contrasts with the results obtained in previous studies with red and green sequences. We think this difference is due to the fact that the Bezold effect caused by black and white gratings in achromatic sequences only influences its clarity, whereas with colour sequences, the Bezold effect introduces a new variable: its saturation modification.

Keywords: Bezold effect, chromatic assimilation

Address correspondence to M. Martínez. E-mail: lmartine@crbc.upv.es

Aesthetic Perception Registered by means of Magnetoencephalography.

E. Munar (Universidad de las Islas Baleares), M. Nadal (Universidad de las Islas Baleares), J. Rosselló (Universidad de las Islas Baleares), and F. Maestú (Centro de Magnetoencefalografía Pérez Modrego, Madrid).

STraditionally, aesthetic experience has been conceived as a supra-perceptual mental process. However, some current theories and models of aesthetic experience emphasize perceptual processes (Seeley, 2006). Semir Zeki (1994, 1999) argued that there was a close relation between visual art and the selective stimulation of early visual cortical areas. Jennifer McMahon (2000) noted that the phenomenic content of aesthetic experience involves a sub-linguistic perceptual scheme. Recent neuroimaging studies have afforded a basic picture of the neural correlates of perceptive and cognitive processes related to aesthetic experience. These seem to involve the caudate nucleus, anterior cingulate cortex, occipital cortex (Vartanian & Goel, 2004; Jacobsen, Schubotz, Höfel, & von Cramon, 2005)—probably associated with the enhancement of early visual processes—orbitofrontal cortex (Kawabata & Zeki, 2004), the temporal pole (Jacobsen et al., 2005), and the lateral and frontomedian prefrontal cortices—probably underlying the actual decision (Cela-Conde, Marty, Maestú, Ortiz, Munar, Fernández et al., 2004; Jacobsen et al., 2005).As with any other computational mechanism, we consider that perception involves information processing, which requires a certain amount of time.

Magnetoencephalography (MEG) is a high-resolution technique that allows following the trail of activity elicited by a stimulus, whether or not it is considered aesthetic. For this reason, we asked 20 participants to categorize illustrations as aesthetic or nonaesthetic while their brain activity was registered with MEG. In order to identify the "first temporal moment" at which both conditions differed significantly, as well as the region showing different activities in each condition, we thereafter compared the trials in which participants reported aesthetic perception with those in which they informed of nonaesthetic perception.

Results showed there was no difference in brain activity between the conditions prior to 300 milliseconds after stimulus onset. Between 300 and 400 milliseconds, clear differences in activity appeared in two regions: (a) a larger one in the left superior parietal cortex (Brodmann's area 7) and (b) a smaller one in the left inferior parietal cortex, in the supramarginal gyrus. In the present study, we use current literature to offer an interpretation of these activations based on presumed perceptual/cognitive functions of each region. Additionally, we discuss the possible causes for the disparity between these results and those offered by previous research.

Keywords: aesthetic perception, neuroaesthetics, magnetoencephalography

Address correspondence to Enric Munar. E-mail:enric.munar@uib.es

POSTER SESSION 2

Linking Perception and Action: The Role of the Premotor Ventral Cortex

J. L. Pardo-Vázquez, V. Leborán, and C. Acuña (Universidad de Santiago de Compostela).

Working memory and decision-making are essential to goal-directed behaviour. Working memory depends on two sources of information: transient representations of information recently experienced and transient representation of information retrieved from long-term memory. Decision-making involves evaluation of past, current, and future events and their

consequences. We are studying the neural substrates of these processes. We trained monkeys to perform in two visual discrimination tasks. Monkeys had to decide whether the orientation of a line was to the right or to the left of another previously perceived line and report their decision by a motor action. During the continuous discrimination task, the animals paid attention to the orientation of the first line, stored some trace of it during the delay between the two stimuli, and compared the stored trace to the orientation of the second line. In the fixed discrimination with implicit reference task, only the second stimuli varied from trial to trial, and trials were presented in blocks corresponding to the same first stimulus, which was not shown. To solve this variant of the task, subjects had to recall the first stimulus from long-term memory. After training, we recorded the extracellular activity in the ventral premotor cortex while the monkeys performed the tasks. In this area, neurons reflect the prediction and contextual relevance of stimuli, their maintenance in working memory, the comparison/decision process, and the association between stimuli and task performance.
Keywords: ventral premotor cortex, discrimination task, working memory, decision-making

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Correspondence should be addressed to Carlos Acuña. E-mail: carlos.acuna@usc.es

Perceived Depth as a Guide of Visual Attention

D. Ponte, M. J. Sampedro, M. Blanco, and L. Leiros (Universidad de Santiago de Compostela).

The present work explores how subjects use information about perceived depth to guide the deployment of their visual attention. In our experiments, subjects had to detect the presence of a pair of forms appearing partially overlapped (targets) when they were presented with other pairs of partially overlapped forms (distracters). We manipulated perceived depth of the forms of each pair by varying occlusion, including a control condition with no occlusion (in which both forms were perceived in the same spatial plane). The displays consisted of 2, 6, 10, 14, 18, and 22 items randomly placed in a regular 5×5 array in a 14×14 deg field. Target was present on 50 % of trials. Ten naïve subjects with normal or corrected-to-normal acuity were tested on four blocks of 288 trials each. We measured the RT $\times$ set size slopes for present and absent target trials. The results showed that perceived depth facilitated detection of target forms: Slopes were lesser when the target forms were perceived in depth than when they were perceived in the same spatial plane. These results suggest that information about depth can be used to guide visual search. Our data support the hypothesis that three-dimension can function as an emergent feature (Enns & Rensink, 1990a, 1993), and they are a demonstration that preattentive vision is more sophisticated than dichotomic theories of visual search suggest, showing the important role that emergent features play in the first stages of information processing.
Keywords: visual attention, guided search, perceived depth

Address correspondence to D. Ponte. E-mail: psdponte@usc.es

Different Priming Effects for Colour and Motion.

X. Ramírez and A. Maiche (Universidad Autónoma de Barcelona).

The colour-motion asynchrony illusion occurs when a stimulus rapidly changes its colour (e.g., from green to red) and its motion direction (e.g., between two opposite directions). Specifically, colour and motion are perceived in phase when, physically, motion is advanced approximately 80 ms with respect to the change in colour. Motion changes, therefore, need more time to be processed than do colour changes.

However, neurophysiological data shows that onset latencies in cortical areas MT and MST are shorter than those in area V4 (Schmolesky et al., 1998). Furthermore, a group of psychophysical findings largely related to the flash-lag phenomenon suggests that there are shorter latencies for moving than for flashing stimuli (considering a flash as a colour change).

We present an experiment that addresses the issue about which attribute is perceived first by means of RT measurements. We ask subjects to detect colour changes (Condition 1) or direction changes (Condition 2). Both changes occur in each trial, but the order in which they appear is random. For example, in Condition 1, there are some trials where colour changes appear first and others where these changes appear after the rebound. In accordance with the method of constant stimuli, we varied the amount of time between both changes.

Our rationale is based on the idea that the first change would act as a primer of the second change. We expect that, when both changes occur very close in time, no priming effect would appear. However, increasing the amount of time between changes, we were able to estimate the time needed for the first change (colour or motion direction) to prime

the second, that is, the time needed for the first change to be perceived as a signal of the occurrence of the second change. Our results suggest that the perception of change in motion become conscious at around 110 ms earlier than for colour changes.
Keywords: priming effect, motion colour asynchrony, differential latencies

Address correspondence to Xavier Ramírez. E-mail: xavier.ramirez@campus.uab.es

When Haptic Perception Hears Auditory Information: Cross-Modality Effects using Virtual Reality.
A. Reyes-Lecuona and M. Ruiz-Soler (Universidad de Málaga).

In ordinary life, when people manipulate objects, they receive multimodal information, and this often improves users' performance. However, there are very few studies examining these kinds of transmodal influence in psychological research. This report describes a psychophysical experiment performed to obtain some insight about how time auditory information may improve or deteriorate the haptic perception of a surface stiffness within a virtual environment (using a haptic force feedback device). A previous experiment carried out in our laboratory showed an interesting pattern: an interaction between time duration of auditory tones and surface stiffness. More specifically, a strong association between short auditory stimuli and stiffness perception, on the one hand, and long auditory stimuli and softness perception, on the other, was found. For this reason, in order to determine the role of a new variable in haptic perception, a within-subjects design was applied with three factors manipulated: object stiffness (0.4, 0.5, and 0.6 N/mm), time exposure to the auditory stimulus (50, 150, and 250 ms) and frequency of the auditory stimulus (500 Hz, 1000 Hz, and 2000 Hz). A reference object with fixed auditory (150 ms; 1000 Hz) and haptic properties (0.5 N/mm) was presented together with another similar object with variable auditory and haptic properties. A matching estimation task was used for the experiments. Subjects were required to report which of the two objects was the stiffest one. The results indicated an interesting interaction among the variables and have provided new information about the influence of auditory stimuli in haptic perception using virtual environments.
Keywords: virtual reality, haptics, stiffness, auditory

Address correspondence to A. Reyes-Lecuona. E-mail: areyes@uma.es

Motion After-Effects Affect the Manual Pursuit of a Moving Target.
B. Rodríguez, D. Linares, and Joan López-Moliner (Universitat de Barcelona).

One of the most studied effects in visual science is the motion after-effect (MAE). It has often been shown that motion adaptation affects the perceived position of moving objects. More recently, it has been shown that MAE also affects pursuit eye movements: smooth pursuit eye movements are favoured by the illusory motion percept that is caused by motion adaptation. Here, we investigated the relationship between MAE and pursuit arm movements. The goal of our research is to analyze possible effects of MAE on arm-tracking the changing position of a moving object. It would be interesting to know whether the MAE interacts with the visuo-motor system in order for it to correct shift positions due to MAE influence. Our results show that subjects' hands tracked the target much less when target and MAE direction was the same. At the end of the pursuit, the subjects caught up with the moving target. In contrast, when target direction was opposite from the MAE, subjects' hands moved more slowly, causing larger lags between the target and the hand position. We then show that motion signals are taken into account when tracking the changing position of a target.
Keywords: motion perception, perceptual illusions, pursuit movements

Address correspondence to Borja Rodríguez. E-mail: borja.rodriguez@ub.edu

Colour Perception Analysis in Half Tone Images
M.A Sanchez-Alandí (Instituto Tecnológico de Óptica, Color e Imagen [AIDO], Spain), V. De Gracia (Instituto Tecnológico de Óptica, Color e Imagen [AIDO], Spain), S. Otero (Instituto Tecnológico de Óptica, Color e Imagen [AIDO], Spain), and S. Donegan (Compose System Europe, United Kingdom).

In recent years, the desire to provide accurate colour reproduction across a range of industry sectors has increased drastically. So much so, that many socio-economic studies have been carried out to reinforce the importance of control

and evaluate small changes in colour. One of these sectors is packaging, especially the packaging of food products where, for instance, a small colour change in the image of a meat product may affect sales adversely. But there are additional issues. The main printing technology used in the creation of these packaged goods uses a very low number of lines per inch (lpi) or screen ruling. The small dots of each ink used in each image is visible to the human eye and consequently, produces deviations in colour perception. This paper studies the influence that these different types of screen frequencies (85, 100, 133, 150, 175, and 300 lpi) have on colour perception in order to obtain more information and to minimize the subjectivity in this kind of process.
A printing test using various colour sets (cyan, magenta, yellow, black, red, green, blue, orange, and purple) and with different percentages was created. The patches were printed using different screen rulings together with a continuous tone reference in order to evaluate the way screening affects visual perception. The sample was shown to a group of respondents aged between 20 and 40 years old. The patches were also measured with a spectrophotometer in D50 and 2º observer and compared with the visual poll results.
As expected, respondents saw no differences between the 75% and 90% patches of the primary colours, but there were more votes favouring the 300-lpi sample over the 175-lpi patches. There were no differences found between the opinion of men or women, or between trained observers and those inexperienced in colour concepts. The only exception to this was when viewing magenta and red; women preferred 85 lpi and men 133 lpi. The other aspect to emphasise is that in small percentages of colour, 300 lpi is preferred, despite giving higher dE values. It is therefore concluded that the higher the lpi, the more favourable the visual response.
Keywords: colour perception, half tones, screening parameters, packaging

Address correspondence to M.A Sanchez-Alandí. E-Mail: asanchez@aido.es

Low Vision and Assistive Products.
M. Sebastián and R. Noya (Instituto de Mayores y Servicios Sociales [IMSERSO], Spain).

Low-vision people show an important reduction of central vision acuity (less than 0.30) or/and considerable visual field loss (less than 30%). Such deficits seriously affect everyday task performance. Low vision frequently derives from congenital malformation, ageing, accidents, or other pathologies. In Spain, the survey "Deficiencia, Discapacidad y Estado de Salud. 1999" [Deficiency, discapacity and Health Status. 1999] found the following incidence rates (for every 1000 inhabitants). Children under six: 3.86; from 6 to 65 years: 9.94; older than 65: 108.44. Low-vision rehabilitation focuses in three activities: assessment of residual vision, technical aid prescription, and equipment training. Functional capacity assessment is carried out through clinical tests. For the prescription of technical aids, a comparison between the functional abilities and the tasks the user wishes to carry out (reading, working with the computer, etc.) is needed. The bigger the difference between abilities and requirements, the higher the compensation needed. Training has two main goals. Firstly, to achieve the best use of residual vision. Secondly, to make the use of technical aid as easy as possible. To understand how these goals can be reached, a brief description of the four types of assistive products available to low-vision people is provided.
Keywords: low vision, universal design, ageing

Address correspondence to M. Sebastían. E-Mail: msebastianh@mtas.es

Analysis of Some Visual Abilities in High-Level Spanish Basketball Players.
M. Sillero, I. Refoyo, C.A. Cordente, and J. Sampedro (Universidad Politécnica de Madrid).

A visual screening was carried out to assess 473 junior players (236 boys and 237 girls, aged 11 to 13 years) selected by the Spanish Basketball Federation. Binocular visual acuity (VAOU) was assessed by the Bringing Nearer Test (Sillero, 2001). Amplitude of the horizontal visual field (HVF) was measured with the Backwards Walking Test (Sillero, 1998). Simple and Choice visual reaction time (VRT) with applications developed with SuperLab (Cedrus, San Pedro, CA, USA), and stereoscopic vision with an RDE Stereotest were also recorded. Additionally, concentration was assessed by a 10×10 concentration grid (Weinberg & Gould, 1996).
The results were analysed by gender and age groups (12 and 13 years old) and they indicated that VAOU of the Spanish junior basketball players was outstanding (VAOU = 1.22, SD = 0.36), and significantly better, $F(1, 472) = 13.5$, $p < .05$, in boys (VAOU = 1.28, SD = 0.35) than in girls (VAOU = 1.16, SD = 0.36). HVF values were very good both in

girls (HVF = 176.5 degrees, *SD* = 12.8) and boys (HVF = 176.6 degrees, *SD* 14.9) and they significantly improved with age, $F(1, 389) = 37.2$, $p < .05$: HVF(12 year-olds) = 173.4 (*SD* = 14.2) and HVF(13 year-olds) = 181.9 degrees (*SD* = 11.6). The players showed outstanding results in stereoscopic vision (3.0 over 2.0 on the RDE Stereotest), and good results in VRT values (Simple VRT = 0.23 s, *SD* = 0.05; choice VRT = 0.47 s, *SD* = 0.12). Concentration results showed very low level of focusing on the task (5.9 numbers/minute, *SD* = 2.4). Girls (6.2 numbers/minute, *SD* = 2.6) concentrated more than boys of the same age (5.6 numbers/minute, *SD* = 2.1), and concentration improved proportionally with the age of the players. An analysis of the players' laterality revealed a large number (28.1%) of subjects with crossed eye-hand dominance.

Percentile values for each test were obtained for use as reference in future assessments.

Keywords: visual abilities, basketball, sport vision.

Address correspondence to Manuel Sillero. E-mail: manuel.sillero@upm.es

Chromatic Perception in Graphic Arts.

I. Tortajada, G. Peris-Fajarnés, T. Magal, M. Aguilella, and B. Defez (Universidad Politécnica de Valencia).

One of the greatest problems of quality control in graphic arts is the reliable reproduction of colour. Traditionally, this control has been left to the so-called "machinists," who are the employees responsible for printing. Once an edition is finished, these machinists visually compare the level of similarity (suitability) to the original document. A possible mechanism to evaluate the adequacy of machinists' visual perception could consist of analysing the level of chromatic discrimination of each machinist. In principle, showing pseudo-chromatic prints (test of Ishihara) may be useful to isolate some chromatic vision deficiency factors, but it is not enough. Fortunately, there is a procedure, known as the Farnsworth-Munsell 100-hue test, which is a simple method, if not to quantify, at least to classify observers into three levels of colour differentiation: high, medium, and low.

In the present work, 25 machinists from the region of "La Plana Baixa" (Valencia, Spain) were requested to perform the Farnsworth-Munsell test. Two essential results were obtained: (a) The machinists' level of chromatic perception was much higher than the normalized values. Altogether, the effect of training (i.e., the daily activity of comparing and differentiating colours) improves individuals' chromatic discrimination capacity. (b) With regard to age, maximum discrimination was observed between 24 and 31 years, decreasing for older and younger operators. Actually, the chromatic discrimination plot— (total error scores)/age— is U-shaped. This form coincides with the latest studies of Kinnear and Sahraie. However, the highest points are slightly shifted towards the left (around 18 years). It is thought that the fact of finding the highest values at more advanced ages is due to the expertise developed by these operators in their jobs.

Keywords: chromatic discrimination, colour, graphic arts

Address correspondence to I. Tortajada. E-mail: itortaja@degi.upv.es

Influence of the Size of Target in a Chromatic Assimilation Effect.

C. Urtubia (Universitat Politecnica de Catalunya), J. L. Miralles (Universitat de Valencia), and M. Aguilar (Universitat Politecnica de Valencia).

The assimilation effect that makes the colour of the "target" seem similar to its context is also known as the inverse contrast, or the Bezold effect. It depends on the context, illumination, and spatial frequency. In this study, the influence of the size of the target on assimilation is tested. The adaptation field was Ronchi's achromatic black and white square grating, horizontally oriented. The test was performed with (virtual) linear sequences in which the illuminated areas were red squares of 1-cm sides (λ_D = 620 nm, purity = 0.56, luminance factor = 0.20), for a visual angle of 12,5' of arc. The test was observed at distances of 12.5', 25', 50', and 100´ of arc in order to have progressively larger square sizes.

A darkening of the red squares was observed, partly due to the Bezold effect (the influence of the black stripes) and partly due to the simultaneous contrast (the proximity of the white stripes). The spatial sequence of black and red squares not only produces the perception of a continuous line of red dots (the principle of good continuity), but also the perception of a darker red colour, with the black expanding along this line.

The Berzold effect is independent of the value of the frequency of the grating for values higher than 0.01 1/min. (the size of the test squares below 50', or squares of 1-, 2-, and 4-cm sides). Nevertheless, as of this value, the relationship decreases with regard to the frequency of the grating until it reaches a critical frequency of 0.005 1/min (the size of the

square at 100’ or of 8-cm sides) at which the effect is cancelled. These results can be explained in terms of the Gestalt principle of good continuity, applicable to the first three experimental conditions but not when the size of the square is 100’. When the size of the grating and the target increase, the effect of good continuity is lost and the disappearance of the Gestalt perception cancels the Bezold effect.
Keywords: assimilation, Bezold effect, inverse contrast, colour vision, Gestalt

Address correspondence to C. Urtubia. E-mail: urtubia@oo.upc.edu

Ionic Currents Involved in the Adaptation to Repetitive Sounds in Primary Auditory Cortex
R. Vergara, M. M. Arnold, D. Pérez-Marcos, and M. V. Sanchez-Vives (Universidad Miguel Hernández-Consejo Superior de Investigaciones Científicas, Spain).

Adaptation to repetitive stimulation is a common characteristic of all sensory systems, often explained as a gain control system that allows better coding of stimuli within different ranges of the spectrum. In particular, adaptation to sound is a feature of the auditory system that has been widely reported. To understand the cellular mechanisms underlying adaptation to repetitive sounds, we first studied the time course of adaptation to sound in awake free- moving rats chronically implanted with tetrodes in the primary auditory cortex. Two identical stimuli were delivered with different intervals ranging from 50 ms to 8 s. Single neuron recordings in the awake animal revealed that the response to a sound (50 ms duration) is influenced by sounds delivered even seconds earlier, the second one usually yielding a weaker response. To further characterize the ionic mechanisms underlying this phenomenon, we obtained intracellular recordings from neurons in primary auditory cortex of the rat in vitro and reproduced the same protocols of adaptation as in the awake animal, here, by means of depolarizing pulses of identical duration and intervals. These protocols revealed a high similarity between the degree and time course of the adaptation in neurons from the alert A1 cortex and from A1 cortical slices. Both, in the alert rat and in the slices from A1, adaptation occurred mainly in two time scales: one of hundreds of ms and another one of seconds (< 10 s). A Ca^{2+}-dependent K^+ current apamine sensitive (SK) and a Na+-dependent K^+ current seem to underlie faster and slower adaptation, respectively. Our results suggest that ionic channels of auditory cortical neurons could explain most of the adaptation to pairs of repeated sounds recorded in A1 in the alert state.
Keywords: sensory systems, adaptation, cellular mechanisms, sound, neuron recordings

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Address correspondence to R. Vergara. E-Mail: r.vergara@umh.es