2013

Scocchia, L. , Cicchini, G.M. & Triesch, J. (2013). What's "up"? Working memory contents can bias orientation processing, Vision Res, (76), 46-55. PDF

We explored the interaction between the processing of a low-level visual feature such as orientation and the contents of working memory (WM). In a first experiment, participants memorized the orientation of a Gabor patch and performed two subsequent orientation discriminations during the retention interval. The WM stimulus exerted a consistent repulsive effect on the discrimination judgments: participants were more likely to report that the discrimination stimulus was rotated clockwise compared to the oblique after being presented with a stimulus that was tilted anti-clockwise from the oblique. A control condition where participants attended to the Gabor patch but did not memorize it, showed a much reduced effect. The repulsive effect was stable across the two discriminations in the memory condition, but not in the control condition, where it decayed at the second discrimination. In a second experiment, we showed that the greater interference observed in the WM condition cannot be explained by a difference in cognitive demands between the WM and the control condition. We conclude that WM contents can bias perception: the effect of WM interference is of a visual nature, can last over delays of several seconds and is not disrupted by the processing of intervening visual stimuli during the retention period.

Cicchini, G. M., Binda, P., Burr, D. C. & Morrone, M. C. (2013). Transient spatiotopic integration across saccadic eye movements mediates visual stability,J Neurophysiol, 4 (109), 1117- 1125. PDF

Eye movements pose major problems to the visual system, because each new saccade changes the mapping of external objects on the retina. It is known that stimuli briefly presented around the time of saccades are systematically mislocalized, whereas continuously visible objects are perceived as spatially stable even when they undergo large transsaccadic displacements. In this study we investigated the relationship between these two phenomena and measured how human subjects perceive the position of pairs of bars briefly displayed around the time of large horizontal saccades. We show that they interact strongly, with the perisaccadic bar being drawn toward the other, dramatically altering the pattern of perisaccadic mislocalization. The interaction field extends over a wide range (200 ms and 20 degrees) and is oriented along the retinotopic trajectory of the saccade-induced motion, suggesting a mechanism that integrates pre- and postsaccadic stimuli at different retinal locations but similar external positions. We show how transient changes in spatial integration mechanisms, which are consistent with the present psychophysical results and with the properties of "remapping cells" reported in the literature, can create transient craniotopy by merging the distinct retinal images of the pre- and postsaccadic fixations to signal a single stable object.

Binda, P., Pereverzeva, M. & Murray, S. O. (2013). Attention to bright surfaces enhances the pupillary light reflex,J Neurosci, 5 (33), 2199-2204. PDF

One longstanding question is how early in the visual system attention exerts its influence. Here we show that an effect of attention can be measured at the earliest possible stage of visual information processing, as a change in the optics of the eye. We tested human subjects and found that covertly attending to bright surfaces results in an enhanced pupillary light reflex (PLR)-the pupillary constriction that occurs in response to light increments. The PLR optimizes the optical quality of the retinal image across illumination conditions, increasing sensitivity by

modulating retinal illumination, and improving acuity by reducing spherical aberrations. The attentional modulation of the PLR that we describe constitutes a new mechanism through which vision is affected by attention; we discuss three alternatives for the neural substrates of this effect, including the possibility that attention might act indirectly, via its well established effects in early visual cortex.

Knoll, J., Morrone, M. C. & Bremmer, F. (2013). Spatio-temporal topography of saccadic overestimation of time,Vision Res, (83C), 56-65. PDF

Rapid eye movements (saccades) induce visual misperceptions. A number of studies in recent years have investigated the spatio-temporal profiles of effects like saccadic suppression or perisaccadic mislocalization and revealed substantial functional similarities. Saccade induced chronostasis describes the subjective overestimation of stimulus duration when the stimulus onset falls within a saccade. In this study we aimed to functionally characterize saccade induced chronostasis in greater detail. Specifically we tested if chronostasis is influenced by or functionally related to saccadic suppression. In a first set of experiments, we measured the perceived duration of visual stimuli presented at different spatial positions as a function of presentation time relative to the saccade. We further compared perceived duration during saccades for isoluminant and luminant stimuli. Finally, we investigated whether or not saccade induced chronostasis is dependent on the execution of a saccade itself. We show that chronostasis occurs across the visual field with a clear spatio-temporal tuning. Furthermore, we report chronostasis during simulated saccades, indicating that spurious retinal motion induced by the saccade is a prime origin of the phenomenon.

Zimmermann, E., Morrone, M. C., Fink, G. R. & Burr, D. (2013). Spatiotopic neural representations develop slowly across saccades,Curr Biol, 5 (23), R193-194. PDF

One of the long-standing unsolved mysteries of visual neuroscience is how the world remains apparently stable in the face of continuous movements of eyes, head and body. Many factors seem to contribute to this stability, including rapid updating mechanisms that temporarily remap the visual input to compensate for the impending saccade [1]. However, there is also a growing body of evidence pointing to more long-lasting spatiotopic neural representations, which remain solid in external rather than retinal coordinates [2-6]. In this study, we show that these spatiotopic representations take hundreds of milliseconds to build up robustly.

Lunghi, C. & Alais, D. (2013). Touch Interacts with Vision during Binocular Rivalry with a Tight Orientation Tuning,PLoS One, 3 (8), e58754. PDF

Multisensory integration is a common feature of the mammalian brain that allows it to deal more efficiently with the ambiguity of sensory input by combining complementary signals from several sensory sources. Growing evidence suggests that multisensory interactions can occur as early as primary sensory cortices. Here we present incompatible visual signals (orthogonal gratings) to each eye to create visual competition between monocular inputs in primary visual cortex where binocular combination would normally take place. The incompatibility prevents binocular fusion and triggers an ambiguous perceptual response in which the two images are perceived one at a time in an irregular alternation. One key function of multisensory integration is to minimize perceptual ambiguity by exploiting cross-sensory congruence. We show that a haptic signal matching one of the visual alternatives helps disambiguate visual perception during binocular rivalry by both prolonging the dominance period of the congruent visual stimulus and by shortening its suppression period. Importantly, this interaction is strictly tuned for orientation, with a mismatch as small as 7.5 degrees between visual and haptic orientations sufficient to annul the interaction. These results indicate important conclusions: first, that vision and touch interact at early levels of visual processing where interocular conflicts are first detected and orientation tunings are narrow, and second, that haptic input can influence visual signals outside of visual awareness, bringing a stimulus made invisible by binocular rivalry suppression back to awareness sooner than would occur without congruent haptic input.

2012

Anobile, G., Cicchini, G. M. & Burr, D. C. (2012). Linear mapping of numbers onto space requires attention,Cognition, 3 (122), 454- 459. PDF

Mapping of number onto space is fundamental to mathematics and measurement. Previous research suggests that while typical adults with mathematical schooling map numbers veridically onto a linear scale, pre-school children and adults without formal mathematics training, as well as individuals with dyscalculia, show strong compressive, logarithmic-like non-linearities when mapping both symbolic and non-symbolic numbers onto the numberline. Here we show that the use of the linear scale is dependent on attentional resources. We asked typical adults to position clouds of dots on a numberline of various lengths. In agreement with previous research, they did so veridically under normal conditions, but when asked to perform a concurrent attentionally-demanding conjunction task, the mapping followed a compressive, non-linear function. We model the non-linearity both by the commonly assumed logarithmic transform, and also with a Bayesian model of central tendency. These results suggest that veridical representation numerosity requires attentional mechanisms.

Pooresmaeili, A., Cicchini, G. M., Morrone, M. C. & Burr, D. (2012). "Non-retinotopic

processing" in Ternus motion displays modeled by spatiotemporal filters,J Vis, 1 (12), PDF

Recently, M. Boi, H. Ogmen, J. Krummenacher, T. U. Otto, & M. H. Herzog (2009) reported a fascinating visual effect, where the direction of apparent motion was disambiguated by cues along the path of apparent motion, the Ternus-Pikler group motion, even though no actual movement occurs in this stimulus. They referred to their study as a "litmus test" to distinguish "non-retinotopic" (motion-based) from "retinotopic" (retina-based) image processing. We adapted the test to one with simple grating stimuli that could be more readily modeled and replicated their psychophysical results quantitatively with this stimulus. We then modeled our experiments in 3D (x, y, t) Fourier space and demonstrated that the observed perceptual effects are readily accounted for by integration of information within a detector that is oriented in space and time, in a similar way to previous explanations of other motion illusions. This demonstration brings the study of Boi et al. into the more general context of perception of moving objects.

Cicchini, G. M., Arrighi, R., Cecchetti, L., Giusti M. & Burr, D. C. (2012). Optimal Encoding of Interval Timing in Expert Percussionists, J Neurosci, 3 (32), 1056-1060. PDF

We measured temporal reproduction in human subjects with various levels of musical expertise: expert drummers, string musicians, andÂ non-musicians. While duration reproduction of the non-percussionists showed a characteristic central tendency or regression to theÂ mean, drummers responded veridically. Furthermore, when the stimuli were auditory tones rather than flashes, all subjects respondedÂ veridically. The behavior of all three groups in both modalities is well explained by a Bayesian model that seeks to minimize reproductionÂ errors by incorporating a central tendency prior, a probability density function centered at the mean duration of the sample. WeÂ measured separately temporal precision thresholds with a bisection task; thresholds were twice as low in drummers as in the other twoÂ groups. These estimates of temporal precision, together with an adaptable Bayesian prior, predict well the reproduction results and theÂ central tendency strategy under all conditions and for all subject groups. These results highlight the efficiency and flexibility of sensorimotor mechanisms estimating temporal duration.

Binda, P., Morrone, M. C. & Bremmer, F. (2012). Saccadic compression of symbolic numerical magnitude,PLoS One, 11 (7), e49587. PDF

Stimuli flashed briefly around the time of saccadic eye movements are subject to complex distortions: compression of space and time; underestimate of numerosity. Here we show that saccadic distortions extend to abstract quantities, affecting the representation of symbolic numerical magnitude. Subjects consistently underestimated the results of rapidly computed mental additions and subtractions, when the operands were briefly displayed before a saccade. However, the recognition of the number symbols was unimpaired. These results are consistent with the hypothesis of a common, abstract metric encoding magnitude along multiple dimensions. They suggest that a surprising link exists between the preparation of action and the representation of abstract quantities.

Panichi, M., Burr, D., Morrone, M. C. & Baldassi, S. (2012). Spatiotemporal dynamics of perisaccadic remapping in humans revealed by classification images,J Vis, 4 (12), 11. PDF

We actively scan our environment with fast ballistic movements called saccades, which create large and rapid displacements of the image on the retina. At the time of saccades, vision becomes transiently distorted in many ways: Briefly flashed stimuli are displaced in space and in time, and spatial and temporal intervals appear compressed. Here we apply the psychophysical technique of classification images to study the spatiotemporal dynamics of

visual mechanisms during saccades. We show that saccades cause gross distortions of the classification images. Before the onset of saccadic eye movements, the positive lobes of the images become enlarged in both space and in time and also shifted in a systematic manner toward the pre-saccadic fixation (in space) and anticipated in time by about 50 ms. The transient reorganization creates a spatiotemporal organization oriented in the direction of saccadic-induced motion at the time of saccades, providing a potential mechanism for integrating stimuli across saccades, facilitating stable and continuous vision in the face of constant eye movements.

Zimmermann, E., Morrone, M. C. & Burr, D. (2012). Visual motion distorts visual and motor space, J Vis, 2 (12), PDF

Mapping of number onto space is fundamental to mathematics and measurement. Previous research suggests that while typical adults with mathematical schooling map numbers veridically onto a linear scale, pre-school children and adults without formal mathematics training, as well as individuals with dyscalculia, show strong compressive, logarithmic-like non-linearities when mapping both symbolic and non-symbolic numbers onto the numberline. Here we show that the use of the linear scale is dependent on attentional resources. We asked typical adults to position clouds of dots on a numberline of various lengths. In agreement with previous research, they did so veridically under normal conditions, but when asked to perform a concurrent attentionally- demanding conjunction task, the mapping followed a compressive, non-linear function. We model the non-linearity both by the commonly assumed logarithmic transform, and also with a Bayesian model of central tendency. These results suggest that veridical representation numerosity requires attentional mechanisms.

Taubert, J., Aagten-Murphy, D. & Parr, L. A. (2012). A comparative study of face processing using scrambled faces,Perception, 4 (41), 460-473. PDF

It is a widespread assumption that all primate species process faces in the same way because the species are closely related and they engage in similar social interactions. However, this approach ignores potentially interesting and informative differences that may exist between species. This paper describes a comparative study of holistic face processing. Twelve subjects (six chimpanzees Pan troglodytes and six rhesus monkeys Macaca mulatta) were trained to discriminate whole faces (faces with features in their canonical position) and feature-scrambled faces in two separate conditions. We found that both species tended to match the global configuration of features over local features, providing strong evidence of global precedence. In addition, we show that both species were better able to generalize from a learned configuration to an entirely novel configuration when they were first trained to match feature-scrambled faces compared to when they were trained with whole faces. This result implies that the subjects were able to access local information easier when facial features were presented in a scrambled configuration and is consistent with a holistic processing hypothesis. Interestingly, these data also suggest that, while holistic processing in chimpanzees is tuned to own-species faces, monkeys have a more general approach towards all faces. Thus, while these data confirm that both chimpanzees and rhesus monkeys process faces holistically, they also indicate that there are differences between the species that warrant further investigation.

Cicchini, G. M. (2012). Perception of duration in the parvocellular system, Front Integr Neurosci 6:14 PDF

Both theoretical and experimental evidence suggests that duration perception is mediated preferentially by the color-blind but high temporally sensitive luminance pathway. In this experiment we tested whether color modulated stimuli and high spatial frequency luminance modulated stimuli, which are known to be relayed mostly by the slow parvocellular system, are able to elicit reliable sense of duration. We show that ramped color modulated stimuli seem to last less than luminance modulated stimuli matched for visibility. The effect is large, about 200 ms and is constant at all durations tested (range 500â€“1100 ms). However, high spatial frequency luminance stimuli obtain duration matches similar to those of low spatial frequency luminance modulated stimuli. The results at various levels of contrast and temporal smoothing indicate that equiluminant stimuli have higher contrast thresholds to activate the mechanisms

which time visual stimuli. Overall the results imply that both the magnocellular and the parvocellular systems access reliably the timing mechanisms with a difference only in the way these are engaged

Turi, M. & Burr, D. (2012). Spatiotopic perceptual maps in humans: evidence from motion adaptation,Proc Biol Sci, 1740 (279), 3091-3097. PDF

How our perceptual experience of the world remains stable and continuous despite the frequent repositioning eye movements remains very much a mystery. One possibility is that our brain actively constructs a spatiotopic representation of the world, which is anchored in external-or at least head-centred-coordinates. In this study, we show that the positional motion aftereffect (the change in apparent position after adaptation to motion) is spatially selective in external rather than retinal coordinates, whereas the classic motion aftereffect (the illusion of motion after prolonged inspection of a moving source) is selective in retinotopic coordinates. The results provide clear evidence for a spatiotopic map in humans: one which can be influenced by image motion.

Anobile, G., Turi, M., Cicchini, G. M. & Burr, D. C. (2012). The effects of cross- sensory attentional demand on subitizing and on mapping number onto space,Vision Res, PDF

Various aspects of numerosity judgments, especially subitizing and the mapping of number onto space, depend strongly on attentional resources. Here we use a dual-task paradigm to

investigate the effects of cross-sensory attentional demands on visual subitizing and spatial mapping. The results show that subitizing is strongly dependent on attentional resources, far more so than is estimation of higher numerosities. But unlike many other sensory tasks, visual subitizing is equally affected by concurrent attentionally demanding auditory and tactile tasks as it is by visual tasks, suggesting that subitizing may be amodal. Mapping number onto space was also strongly affected by attention, but only when the dual-task was in the visual modality. The non-linearities in numberline mapping under attentional load are well explained by a Bayesian model of central tendency.

Gori, M., Tinelli, F., Sandini, G., Cioni, G. & Burr, D. (2012). Impaired visual size-discrimination in children with movement disorders,Neuropsychologia, 8 (50), 1838-1843. PDF

Multisensory integration of spatial information occurs late in childhood, at around eight years (Gori, Del Viva, Sandini, & Burr, 2008). For younger children, the haptic system dominates size discrimination and vision dominates orientation discrimination: the dominance may reflect sensory calibration, and could have direct consequences on children born with specific sensory disabilities. Here we measure thresholds for visual discrimination of orientation and size in children with movement disorders of upper limbs. Visual orientation discrimination was very similar to the age-matched typical children, but visual size discrimination thresholds were far worse, in all eight individuals with early- onset movement disorder. This surprising and counterintuitive result is readily explained by the cross-sensory calibration hypothesis: when the haptic sense is unavailable for manipulation, it cannot be readily used to estimate size, and hence to calibrate the visual experience of size: visual discrimination is subsequently impaired. This complements a previous study showing that non-sighted children have reduced acuity for haptic orientation, but not haptic size, discriminations (Gori, Sandini, Martinoli, & Burr, 2010). Together these studies show that when either vision or haptic manipulation is impaired, the impairment also impacts on complementary sensory systems that are calibrated by that one.

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Tomassini, A., Gori, M., Burr, D., Sandini, G. & Morrone, M. C. (2012). Active movement restores veridical event-timing after tactile adaptation,J Neurophysiol, 8 (108), 2092-2100. PDF

Growing evidence suggests that time in the subsecond range is tightly linked to sensory processing. Event- time can be distorted by sensory adaptation, and many temporal illusions can accompany action execution. In this study, we show that adaptation to tactile motion causes a strong contraction of the apparent duration of tactile stimuli. However, when subjects make a voluntary motor act before judging the duration, it annuls the adaptation- induced temporal distortion, reestablishing veridical event-time. The movement needs to be performed actively by the subject: passive movement of similar magnitude and dynamics has no effect on adaptation, showing that it is the motor commands themselves, rather than reafferent signals from body movement, which reset the adaptation for tactile duration. No other concomitant perceptual changes were reported (such as apparent speed or enhanced temporal discrimination), ruling out a generalized effect of body movement on somatosensory processing. We suggest that active movement resets timing mechanisms in preparation for the new scenario that the movement will cause, eliminating inappropriate biases in perceived time. Our brain seems to utilize the intention-to-move signals to retune its perceptual machinery appropriately, to prepare to extract new temporal information.

Tinelli, T., Cicchini, G.M., Arrighi, R., Tosetti, M., Cioni, G.,Â Morrone M. C. (2012). Blindsight in children with congenital and acquired cerebral lesions, Cortex (published online 10 August 2012) PDF

It has been shown that unconscious visual function can survive lesions to optical radiations and/or primary visual cortex (V1), a phenomenon termed â€œblindsightâ€ . Studies on animal

models (cat and monkey) show that the age when the lesion occurs determines the extent of residual visual capacities. Much less is known about the functional and underlying neuronal repercussions of early cortical damage in humans. We measured sensitivity to several visual tasks in four children with congenital unilateral brain lesions that severely affected optic radiations, and in another group of three children with similar lesions, acquired in childhood. In two of the congenital patients, we measured blood oxygenation level dependent (BOLD) activity in response to stimulation of each visual field quadrants. Results show clear evidence of residual unconscious processing of position, orientation and motion of visual stimuli displayed in the scotoma of congenitally lesioned children, but not in the children with acquired lesions. The calcarine cortical BOLD responses were abnormally elicited by stimulation of the ipsilateral visual field and in the scotoma region, demonstrating a profound neuronal reorganization. In conclusion, our data suggest that congenital lesions can trigger massive reorganization of the visual system to alleviate functional effects of early brain insults.

Manning, C., Aagten-Murphy, D. & Pellicano, E. (2012). The development of speed discrimination abilities,Vision Res, (70), 27-33. PDF

The processing of speed is a critical part of a child's visual development, allowing children to track and interact with moving objects. Despite such importance, no study has investigated the developmental trajectory of speed discrimination abilities or precisely when these abilities become adult-like. Here, we measured speed discrimination thresholds in 5-, 7-, 9-, 11-year-olds and adults using random dot stimuli with two different reference speeds (slow: 1.5 deg/s; fast: 6 deg/s). Sensitivity for both reference speeds improved exponentially with age and, at all ages, participants were more sensitive to the faster reference speed. However, sensitivity to slow speeds followed a more protracted developmental trajectory than that for faster speeds. Furthermore, sensitivity to the faster reference speed reached adult-like levels by 11 years, whereas sensitivity to the slower reference speed was not yet adult-like by this age. Different developmental trajectories may reflect distinct systems for processing fast and slow speeds. The reasonably late development of speed processing abilities may be due to inherent limits in the integration of neuronal responses in motion-sensitive areas in early childhood.

Morrone, M. C. M. (2012). PlasticitÃ ed adattabilitÃ della visione,Giornale Italiano di Psicologia, (3), 517-522. PDF

2011

Burr, D. C., Cicchini, G. M., Arrighi, R. & Morrone, M. C. (2011). Spatiotopic selectivity of adaptation-based compression of event duration, J Vis, 2 (11), 21; author reply 21a. PDF

A. Bruno, I. Ayhan, and A. Johnston (2010) have recently challenged our report of spatiotopic selectivity for adaptation of event time (D. Burr, A. Tozzi, & M. C. Morrone, 2007) and also our claim that retinotopic adaptation of event time depends on perceived speed. To assist the reader judge this issue, we present here a mass of data accumulated in our laboratories over the last few years, all confirming our original conclusions. We also point out that where Bruno et al. made experimental measurements (rather than relying on theoretical reasoning), they too find clearly significant spatiotopically tuned adaptation-based compression of event time but of lower magnitude to ours. We speculate on the reasons for the differences in magnitude.

Pascucci, D., Megna, N., Panichi, M. & Baldassi, S. (2011). Acoustic cues to visual detection: a classification image study,J Vis, 6 (11), PDF

A non-informative sound is known to improve contrast detection thresholds for a synchronous visual target (M. Lippert, N. K. Logothetis, & C. Kayser, 2007). We investigated the spatio-temporal characteristics of the mechanisms underlying this crossmodal effect by using a classification image paradigm specifically suited to investigate perceptual templates across both space and time (P. Neri & D. J. Heeger, 2002). A bright bar was embedded in 2D (space-time) dynamic noise and observers were asked to detect its presence in both unimodal (only visual) and bimodal (audio-visual) conditions. Classification image analysis was performed and the 1st and 2nd order kernels were derived. Our results show that the cross-modal facilitation of detection consists in a reduction of activity of the early mechanisms elicited by the onset of the stimulation and not directly involved in the identification of the target. In fact, the sound sharpens the 2nd order kernels (involved in target detection) by suppressing the activation preceding the target, whereas it does not influence the 1st order kernels. These data suggest that the sound affects some non-linear process involved with the detection of a visual stimulus by, decreasing the activity of contrast energy filters temporally uncorrelated with the target, hence reducing temporal uncertainty.

Burr, D. C., Anobile, G. & Turi, M. (2011). Adaptation Affects Both High and Low (Subitized) Numbers Under Conditions of High Attentional Load,Seeing and Perceiving, (24), 141-150. PDF

It has recently been reported that, like most sensory systems, numerosity is subject to adaptation. However, the effect seemed to be limited to numerosity estimation outside the subitizing range. In this study we show that low numbers, clearly in the subitizing range, are adaptable under conditions of high attentional load. These results support the idea that numerosity is detected by a perceptual mechanism that operates over the entire range of numbers, supplemented by an attention-based system for small numbers (subitizing).

Thompson, P. & Mikellidou, K. (2011). Applying the Helmholtz illusion to fashion: horizontal stripes won't make you look fatter,Iperception, 1 (2), 69-76. PDF

A square composed of horizontal lines appears taller and narrower than an identical square made up of vertical lines. Reporting this illusion, Hermann von Helmholtz noted that such illusions, in which filled space seems to be larger than unfilled space, were common in everyday life, adding the observation that ladies' frocks with horizontal stripes make the figure look taller. As this assertion runs counter to modern popular belief, we have investigated whether vertical or horizontal stripes on clothing should make the wearer appear taller or fatter. We find that a rectangle of vertical stripes needs to be extended by 7.1% vertically to match the height of a square of horizontal stripes and that a rectangle of horizontal stripes must be made 4.5% wider than a square of vertical stripes to match its perceived width. This illusion holds when the horizontal or vertical lines are on the dress of a line drawing of a woman. We have examined the claim that these effects apply only for 2-dimensional figures in an experiment with 3-D cylinders and find no support for the notion that horizontal lines would be 'fattening' on clothes. Significantly, the illusion persists when the horizontal or vertical lines are on pictures of a real half-body mannequin viewed stereoscopically. All the evidence supports Helmholtz's original assertion.

Lunghi C, Burr DC, Morrone C. (2011).Â Brief periods of monocular deprivation disrupt ocular balance in human adultÂ visual cortex,Â Curr Biol. 2011 Jul 26;21(14):R538-9. PDF

Neuroplasticity is a fundamental property of the developing mammalian visual system, with

residual potential in adult human cortex [1]. A short period of abnormal visual experience (such as occlusion of one eye) before closure of the critical period has dramatic and permanent neural consequences, reshaping visual cortical organization in favour of the non-deprived eye [2,3]. We used binocular rivalry [4] - a sensitive probe of neural competition - to demonstrate that adult human visual cortex retains a surprisingly high degree of neural plasticity, with important perceptual consequences. We report that 150 minutes of monocular deprivation strongly affects the dynamics of binocular rivalry, unexpectedly causing the deprived eye to prevail in conscious perception twice as much as the non- deprived eye, with significant effects for up to 90 minutes. Apparent contrast of stimuli presented to the deprived eye was also increased, suggesting that the deprivation acts by up-regulation of cortical gain-control mechanisms of the deprived eye. The results suggest that adult visual cortex retains a good deal of plasticity that could be important in reaction to sensory loss.

Gori, M., Mazzilli, G., Sandini, G. & Burr, D. (2011). Cross-Sensory Facilitation Reveals Neural Interactions between Visual and Tactile Motion in Humans,Front Psychol, (2), 55. PDF

Many recent studies show that the human brain integrates information across the different senses and that stimuli of one sensory modality can enhance the perception of other modalities. Here we study the processes that mediate cross-modal facilitation and summation between visual and tactile motion. We find that while summation produced a generic, non-specific improvement of thresholds, probably reflecting higher-order interaction of decision signals, facilitation reveals a strong, direction-specific interaction, which we believe reflects sensory interactions. We measured visual and tactile velocity discrimination thresholds over a wide range of base velocities and conditions. Thresholds for both visual and tactile stimuli showed the characteristic "dipper function," with the minimum thresholds occurring at a given "pedestal speed." When visual and tactile coherent stimuli were combined (summation condition) the thresholds for these multisensory stimuli also showed a "dipper function" with the minimum thresholds occurring in a similar range to that for unisensory signals. However, the improvement of multisensory thresholds was weak and not directionally specific, well predicted by the maximum- likelihood estimation model (agreeing with previous research). A different technique (facilitation) did, however, reveal direction-specific enhancement. Adding a non-informative "pedestal" motion stimulus in one sensory modality (vision or touch) selectively lowered thresholds in the other, by the same amount as pedestals in the same

modality. Facilitation did not occur for neutral stimuli like sounds (that would also have reduced temporal uncertainty), nor for motion in opposite direction, even in blocked trials where the subjects knew that the motion was in the opposite direction showing that the facilitation was not under subject control. Cross-sensory facilitation is strong evidence for functionally relevant cross-sensory integration at early levels of sensory processing.

Zimmermann, E. & Lappe, M. (2011). Eye position effects in oculomotor plasticity and visual localization,J Neurosci, 20 (31), 7341-7348. PDF

For visual localization to remain accurate across changes of gaze, a signal representing the position of the eye in the orbita is needed to code spatial locations in a reference frame that is independent of retinal displacements. Here we report evidence that the localization of visual objects in space is coded in an extraretinal reference frame. In human subjects, we used outward saccadic adaptation, which can be induced artificially by a systematic displacement of the saccade target. This form of oculomotor plasticity is accompanied by changes in spatial perception, thus highlighting the relevance of saccade metrics for visual localization. We tested the reference frame of outward adaptation for reactive and scanning saccades and visual localization. For scanning saccades, adaptation magnitude was drastically reduced at positions distant from the adapted eye position. Changes in visual localization showed a very similar modulation of eye position. These results suggest that scanning saccade adaptation is encoded in a nonretinotopic reference frame. Eye position effects for reactive saccade adaptation were smaller, and the induced mislocalization did not vary significantly between eye positions. The different modulation of reactive and scanning saccade adaptation supports the idea that oculomotor plasticity can occur at multiple sites in the brain. The findings are also consistent with previous evidence for a stronger influence of scanning saccade adaptation on the visual localization of objects in space.

Tinelli, F., Guzzetta, A., Bertini, C., Ricci, D., Mercuri, E., Ladavas, E., et al. (2011). Greater Sparing of Visual Search Abilities in Children After Congenital Rather Than Acquired Focal Brain Damage,Neurorehabil Neural Repair, PDF

BACKGROUND: Visual search refers to the capacity of an individual to find a target among simultaneously presented distracters and is based on visual abilities such as a fast visual processing and an accurate control of ballistic eye movements (saccades) that guide the fovea to the target location. OBJECTIVE: In adults, visual field defects caused by brain damage are often associated with visual search disorders; in children, little is known about the effects of early brain lesions on visual search abilities. METHODS: To test the presence of visual search defects and to investigate the role of cortical plasticity after early brain lesions, 29 children with congenital or acquired cerebral lesions, with and without visual field defects, underwent a visual search test battery. RESULTS: The children with acquired lesions and visual field defects had longer reaction times (RTs) in the contralesional visual field compared with the ipsilesional, whereas those with congenital lesions and visual field defects did not have differences in RTs between the contralateral and ipsilateral visual fields and had a visual search pattern similar to children without a visual field defect. CONCLUSIONS: These findings support the hypothesis of more effective mechanisms of functional compensation and reorganization of the visual system in children with very early brain lesions, as opposed to those with later damage.

Burr, D. & Thompson, P. (2011). Motion psychophysics: 1985-2010,Vision Res, PDF

This review traces progress made in the field of visual motion research from 1985 through to 2010. While it is certainly not exhaustive, it attempts to cover most of the major achievements during that period, and speculate on where the field is heading.

Baldassi, S. & Simoncini, C. (2011). Reward sharpens orientation coding independently of attention,Front Neurosci, (5), 13. PDF

It has long been known that rewarding improves performance. However it is unclear whether this is due to high level modulations in the output modules of associated neural systems or due to low level mechanisms favoring more "generous" inputs? Some recent studies suggest that primary sensory areas, including V1 and A1, may form part of the circuitry of reward-based modulations, but there is no data indicating whether reward can be dissociated from attention or cross-trial forms of perceptual learning. Here we address this issue with a psychophysical dual task, to control attention, while perceptual performance on oriented targets associated with different levels of reward is assessed by measuring both orientation discrimination thresholds and behavioral tuning functions for tilt values near threshold. We found that reward, at any rate, improved performance. However, higher reward rates showed an improvement of orientation discrimination thresholds by about 50% across conditions and sharpened behavioral tuning functions. Data were unaffected by changing the attentional load and by dissociating the feature of the reward cue from the task-relevant feature. These results suggest that reward may act within the span of a single trial independently of attention by modulating the activity of early sensory stages through a improvement of the signal-to-noise ratio of task-relevant channels.

Knoll, J., Binda, P., Morrone, M. C. & Bremmer, F. (2011). Spatiotemporal profile of peri-saccadic contrast sensitivity,J Vis, 14 (11), PDF

Sensitivity to luminance contrast is reduced just before and during saccades (saccadic suppression), whereas sensitivity to color contrast is unimpaired peri-saccadically and enhanced post-saccadically. The exact spatiotemporal map of these perceptual effects is as

yet unknown. Here, we measured detection thresholds for briefly flashed Gaussian blobs modulated in either luminance or chromatic contrast, displayed at a range of eccentricities. Sensitivity to luminance contrast was reduced peri-saccadically by a scaling factor, which was almost constant across retinal space. Saccadic suppression followed a similar time course across all tested eccentricities and was maximal shortly after the saccade onset. Sensitivity to chromatic contrast was enhanced post-saccadically at all tested locations. The enhancement was not specifically linked to the execution of saccades, as it was also observed following a displacement of retinal images comparable to that caused by a saccade. We conclude that luminance and chromatic contrast sensitivities are subject to distinct modulations at the time of saccades, resulting from independent neural processes.

Burr, D. C. & Morrone, M. C. (2011). Spatiotopic coding and remapping in humans,Philos Trans R Soc Lond B Biol Sci, 1564 (366), 504-515. PDF

How our perceptual experience of the world remains stable and continuous in the face of continuous rapid eye movements still remains a mystery. This review discusses some recent progress towards understanding the neural and psychophysical processes that accompany these eye movements. We firstly report recent evidence from imaging studies in humans showing that many brain regions are tuned in spatiotopic coordinates, but only for items that are actively attended. We then describe a series of experiments measuring the spatial and temporal phenomena that occur around the time of saccades, and discuss how these could be related to visual stability. Finally, we introduce the concept of the spatio-temporal receptive field to describe the local spatiotopicity exhibited by many neurons when the eyes move.

Crespi, S., Biagi, L., d'Avossa, G., Burr, D. C., Tosetti, M. & Morrone, M. C. (2011). Spatiotopic Coding of BOLD Signal in Human Visual Cortex Depends on Spatial Attention,PLoS One, 7 (6), e21661. PDF

The neural substrate of the phenomenological experience of a stable visual world remains obscure. One possible mechanism would be to construct spatiotopic neural maps where the response is selective to the position of the stimulus in external space, rather than to retinal eccentricities, but evidence for these maps has been inconsistent. Here we show, with fMRI, that when human subjects perform concomitantly a demanding attentive task on stimuli displayed at the fovea, BOLD responses evoked by moving stimuli irrelevant to the task were mostly tuned in retinotopic coordinates. However, under more unconstrained conditions, where subjects could attend easily to the motion stimuli, BOLD responses were tuned not in retinal but in external coordinates (spatiotopic selectivity) in many visual areas, including MT, MST, LO and V6, agreeing with our previous fMRI study. These results indicate that spatial attention may play an important role in mediating spatiotopic selectivity.

Taubert, J., Apthorp, D., Aagten-Murphy, D. & Alais, D. (2011). The role of holistic processing in face perception: evidence from the face inversion effect,Vision Res, 11 (51), 1273- 1278. PDF

A large body of research supports the hypothesis that the human visual system does not process a face as a collection of separable facial features but as an integrated perceptual whole. One common assumption is that we quickly build holistic representations to extract useful second-order information provided by the variation between the faces of different individuals. An alternative account suggests holistic processing is a fast, early grouping process that first serves to distinguish faces from other competing objects. From this perspective, holistic processing is a quick initial response to the first-order information present in every face. To test this hypothesis we developed a novel paradigm for measuring the face inversion effect, a standard marker of holistic face processing, that measures the minimum exposure time required to discriminate between two stimuli. These new data demonstrate that holistic processing operates on whole upright faces, regardless of whether subjects are required to extract first- or second-level information. In light of this, we argue that holistic

processing is a general mechanism that may occur at an earlier stage of face perception than individual discrimination to support the rapid detection of face stimuli in everyday visual scenes.

Binda, P., Morrone, M. C., Ross, J. & Burr, D. C. (2011). Underestimation of perceived number at the time of saccades,Vision Res, 1 (51), 34-42. PDF

Saccadic eye movements produce transient distortions in both space and time. Mounting evidence suggests that space and time perception are linked, and associated with the perception of another important perceptual attribute, numerosity. Here we investigate the effect of saccades on the perceived numerosity of briefly presented arrays of visual elements. We report a systematic underestimation of numerosity for stimuli flashed just before or during saccades, of about 35% of the reference numerosity. The bias is observed only for relatively large arrays of visual elements, in line with the notion that a distinct perceptual mechanism is involved with enumeration of small numerosities in the 'subitizing' range. This study provides further evidence for the notion that space, time and number share common neural representations, all affected by saccades.

Arrighi, R., Lunardi, R. & Burr, D. (2011). Vision and audition do not share attentional resources in sustained tasks,Front Psychol, (2), 56. PDF

Our perceptual capacities are limited by attentional resources. One important question is

whether these resources are allocated separately to each sense or shared between them. We addressed this issue by asking subjects to perform a double task, either in the same modality or in different modalities (vision and audition). The primary task was a multiple object-tracking task (Pylyshyn and Storm, 1988), in which observers were required to track between 2 and 5 dots for 4 s. Concurrently, they were required to identify either which out of three gratings spaced over the interval differed in contrast or, in the auditory version of the same task, which tone differed in frequency relative to the two reference tones. The results show that while the concurrent visual contrast discrimination reduced tracking ability by about 0.7 d', the concurrent auditory task had virtually no effect. This confirms previous reports that vision and audition use separate attentional resources, consistent with fMRI findings of attentional effects as early as V1 and A1. The results have clear implications for effective design of instrumentation and forms of audio-visual communication devices.

Burr, D. (2011). Visual perception: more than meets the eye,Curr Biol, 4 (21), R159-161. PDF

A recent study shows that objects changing in colour, luminance, size or shape appear to stop changing when they move. These and other compelling illusions provide tantalizing clues about the mechanisms and limitations of object analysis.

Tomassini A, Gori M, Burr D, Sandini G and Morrone MC (2011) Perceived duration of visual and tactile stimuli depends on perceived speed. Front. Integr. Neurosci. 5:51 PDF

It is known that the perceived duration of visual stimuli is strongly influenced by speed: faster

moving stimuli appear to last longer. To test whether this is a general property of sensory systems we asked participants to reproduce the duration of visual and tactile gratings, and visuo-tactile gratings moving at a variable speed (3.5â€“15 cm/s) for three different durations (400, 600, and 800 ms). For both modalities, the apparent duration of the stimulus increased strongly with stimulus speed, more so for tactile than for visual stimuli. In addition, visual stimuli were perceived to last approximately 200 ms longer than tactile stimuli. The apparent duration of visuo-tactile stimuli lay between the unimodal estimates, as the Bayesian account predicts, but the bimodal precision of the reproduction did not show the theoretical improvement. A cross-modal speed-matching task revealed that visual stimuli were perceived to move faster than tactile stimuli. To test whether the large difference in the perceived duration of visual and tactile stimuli resulted from the difference in their perceived speed, we repeated the time reproduction task with visual and tactile stimuli matched in apparent speed. This reduced, but did not completely eliminate the difference in apparent duration. These results show that for both vision and touch, perceived duration depends on speed, pointing to common strategies of time perception.

Zimmerman, E., Burr D.C., and Morrone, M.C. (2011) Spatiotopic Visual Maps Revealed by Saccadic Adaptation in Humans, Curr Biol. 2011 Aug 23;21(16):1380-4 PDF

Saccadic adaptation is a powerful experimental paradigm to probe the mechanisms of eye movement control and spatial vision, in which saccadic amplitudes change in response to false visual feedback. The adaptation occurs primarily in the motor system, but there is also evidence for visual adaptation, depending on the size and the permanence of the postsaccadic error. Here we confirm that adaptation has a strong visual component and show that the visual component of the adaptation is spatially selective in external, not retinal coordinates. Subjects performed a memory-guided, double-saccade, outward-adaptation task designed to maximize visual adaptation and to dissociate the visual and motor corrections. When the memorized saccadic target was in the same position (in external space) as that used in the adaptation training, saccade targeting was strongly influenced by adaptation (even if not matched in retinal or cranial position), but when in the same retinal or cranial but different external spatial position, targeting was unaffected by adaptation, demonstrating unequivocal spatiotopic selectivity. These results point to the existence of a spatiotopic neural representation for eye movement control that adapts in response to saccade error signals.

Arrighi, R., Cartocci, G. & Burr, D. (2011). Reduced perceptual sensitivity for biological motion in paraplegia patients,Curr Biol, 22 (21), R910-911. PDF

Physiological and psychophysical studies suggest that the perception and execution of movement may be linked. Here we ask whether severe impairment of locomotion could impact on the capacity to perceive human locomotion. We measured sensitivity for the perception of point- light walkers â€“ animation sequences of human biological motion portrayed by only the joints â€“ in patients with severe spinal injury. These patients showed a huge (nearly three-fold) reduction of sensitivity for detecting and for discriminating the direction of biological motion compared with healthy controls, and also a smaller (~40%) reduction in sensitivity to simple translational motion. However, there was no statistically significant reduction in contrast sensitivity for discriminating the orientation of static gratings. The results point to an interaction between perceiving and producing motion, implicating shared algorithms and neural mechanisms.

2010

Schnier, F., Zimmermann, E. & Lappe, M. (2010). Adaptation and mislocalization fields for saccadic outward adaptation in humans,Journal of Eye Movement Research, 4 (3), 1-18. PDF

Adaptive shortening of a saccade influences the metrics of other saccades withina spatial window around the adapted target. Within this adaptation field visualstimuli presented before an adapted saccade are mislocalized in proportion to thechange of the saccade metric. We investigated the saccadic adaptation field andassociated localization changes for saccade lengthening, or outward adaptation. Wemeasured the adaptation field for two different saccade adaptations (14 deg to 20deg and 20 deg to 26 deg) by testing transfer to 34 different target positions. Wemeasured localization judgements by asking subjects to localize a probe flashedbefore saccade onset. The amount of adaptation transfer differed for different targetlocations. It increased with increases of the horizontal component of the saccade andremained largely constant with deviation of the vertical component of the saccade.Mislocalization of probes inside the adaptation field was correlated with the amountof adaptation of saccades to the probe location. These findings are consistent withthe assumption that oculomotor space and perceptual space are linked to each other.

Toscani, M., Marzi, T., Righi, S., Viggiano, M. P. & Baldassi, S. (2010). Alpha waves: a neural signature of visual suppression,Exp Brain Res, 3-4 (207), 213-219. PDF

Alpha waves are traditionally considered a passive consequence of the lack of stimulation of sensory areas. However, recent results have challenged this view by showing a modulation of alpha activity in cortical areas representing unattended information during active tasks. These data have led us to think that alpha waves would support a 'gating function' on sensorial stimulation that actively inhibits unattended information in attentional tasks. Visual suppression occurring during a saccade and blink entails an inhibition of incoming visual information, and it seems to occur at an early processing stage. In this study, we hypothesized that the neural mechanism through which the visual system exerts this inhibition is the active imposition of alpha oscillations in the occipital cortex, which in turn predicts an increment of alpha amplitude during a visual suppression phenomena. We measured visual suppression occurring during short closures of the eyelids, a situation well suited for EEG recordings and stimulated the

retinae with an intra-oral light administered through the palate. In the behavioral experiment, detection thresholds were measured with eyes steady open and steady closed, showing a reduction of sensitivity in the latter case. In the EEG recordings performed under identical conditions we found stronger alpha activity with closed eyes. Since the stimulation does not depend on whether the eyes were open or closed, we reasoned that this should be a central effect, probably due to a functional role of alpha oscillation in agreement with the 'gating function' theory.

Morrone, M. C. (2010). Brain development: critical periods for cross-sensory plasticity,Curr Biol, 21 (20), R934-936. PDF

Recent work has shown that visual deprivation of humans during a critical period leads to motion area MT+ responding to auditory motion. This cross-sensory plasticity, an important form of brain reorganization, may be mediated by top-down brain circuits from pre-frontal cortex.

Schutz, A. C. & Morrone, M. C. (2010). Compression of time during smooth pursuit eye movements,Vision Res, 24 (50), 2702-2713. PDF

Humans have a clear sense for the passage of time, but while implicit motor timing is quite accurate, explicit timing is prone to distortions particularly during action (Wenke & Haggard, 2009) and saccadic eye movements (Morrone, Ross, & Burr, 2005). Here, we investigated

whether perceived duration is also affected by the execution of smooth pursuit eye movements, showing a compression of apparent duration similar to that observed during saccades. To this end, we presented two brief bars that marked intervals between 100 and 300 ms and asked subjects to judge their duration during fixation and pursuit. We found a compression of perceived duration for bars modulated in luminance contrast of about 32% and for bars modulated in chromatic contrast of 14% during pursuit compared to fixation. Interestingly, Weber ratios were similar for fixation and pursuit, if they are expressed as ratio between JND and perceived duration. This compression was constant for pursuit speeds from 7 to 14 deg/s and did not occur for intervals marked by auditory events. These results argue for a modality-specific component in the processing of temporal information.

Giacomelli, G., Volpe, R., Virgili, G., Farini, A., Arrighi, R., Tarli-Barbieri, C., et al. (2010). Contrast reduction and reading: assessment and reliability with the Reading Explorer test,Eur J Ophthalmol, 2 (20), 389-396. PDF

PURPOSE: To investigate the reliability of the Reading Explorer (REX) charts and to assess the impact of text contrast reduction (1.5 cycle/degree) on reading speed in subjects with normal and low vision. METHODS: Standard visual acuity (ETDRS charts), reading speed (MNread charts), and contrast sensitivity (Pelli-Robson charts) measurements were obtained in 3 groups of subjects stratified by visual acuity level in the better eye from 0.0 to 1.0 logMAR, with intermediate cutoffs at 0.3 and 0.6 logMAR. Measurements of reading speed for decreasing levels of text contrast were obtained with the REX charts using a 1.5 cycle/degree text. RESULTS: Since in many patients with lower vision a plateau of maximum reading speed across different levels of text contrast was not found, reliability indexes were computed for average reading speed and reading contrast threshold. In the group with lower visual acuity, 95% limits of agreement were +/-0.134 log word/minute and +/-0.175 log contrast sensitivity, suggesting good reliability. The proportion of subjects with a 20% loss of reading speed from 90% to 45% text contrast was estimated to be 1/3 at 0.6 logMAR visual acuity level and 2/3 at 1.0 logMAR. CONCLUSIONS: The adverse effect of decreased text contrast, which may be found in ordinary reading material, on the reading performance of subjects with advanced and initial low vision is probably underestimated. The REX test proved to be a reliable investigation tool for this phenomenon.

Ricci, D., Cesarini, L., Gallini, F., Serrao, F., Leone, D., Baranello, G., et al. (2010). Cortical visual function in preterm infants in the first year,J Pediatr, 4 (156), 550-555. PDF

OBJECTIVE: To assess visual function in low-risk preterm infants at 3, 5, and 12 months corrected age to determine whether the maturation of visual function in the first year is similar to that reported in term-born infants. STUDY DESIGN: Seventy-five low-risk infants (25.0-30.9 weeks gestation) underwent ophthalmological examinations and a battery of tests (fix and follow, visual fields, acuity, attention at distance, and fixation shift) designed to assess various aspects of visual function at 3, 5, and 12 months corrected age. RESULTS: The results were comparable with normative data from term-born infants in all tests but fixation shift, suggesting that maturation of most aspects of visual function is not significantly affected by preterm birth. In contrast, >25% of preterm infants failed the fixation shift test at 3 months, with a higher percentage of failing at 5 and 12 months. CONCLUSIONS: There is a specific profile of early visual behavior in low-risk preterm infants, with a high percentage of infants failing a test that specifically assesses visual attention and provides a measure of cortical processing.

Zimmermann, E. & Lappe, M. (2010). Motor signals in visual localization,J Vis, 6 (10), 2. PDF

We demonstrate a strong sensory-motor coupling in visual localization in which experimental modification of the control of saccadic eye movements leads to an associated change in the perceived location of objects. Amplitudes of saccades to peripheral targets were altered by saccadic adaptation, induced by an artificial step of the saccade target during the eye movement, which leads the oculomotor system to recalibrate saccade parameters. Increasing saccade amplitudes induced concurrent shifts in perceived location of visual objects. The

magnitude of perceptual shift depended on the size and persistence of errors between intended and actual saccade amplitudes. This tight agreement between the change of eye movement control and the change of localization shows that perceptual space is shaped by motor knowledge rather than simply constructed from visual input.

Guzzetta, A., D'Acunto, G., Rose, S., Tinelli, F., Boyd, R. & Cioni, G. (2010). Plasticity of the visual system after early brain damage,Dev Med Child Neurol, 10 (52), 891-900. PDF

The aim of this review is to discuss the existing evidence supporting different processes of visual brain plasticity after early damage, as opposed to damage that occurs during adulthood. There is initial evidence that some of the neuroplastic mechanisms adopted by the brain after early damage to the visual system are unavailable at a later stage. These are, for example, the ability to differentiate functional tissue within a larger dysplastic cortex during its formation, or to develop new thalamo-cortical connections able to bypass the lesion and reach their cortical destination in the occipital cortex. The young brain also uses the same mechanisms available at later stages of development but in a more efficient way. For example, in people with visual field defects of central origin, the anatomical expansion of the extrastriatal visual network is greater after an early lesion than after a later one, which results in more efficient mechanisms of visual exploration of the blind field. A similar mechanism is likely to support some of the differences found in people with blindsight, the phenomenon of unconscious visual perception in the blind field. In particular, compared with people with late lesions, those with early brain damage appear to have stronger subjective awareness of stimuli hitting the blind visual field, reported as a conscious feeling that something is present in the visual field. Expanding our knowledge of these mechanisms could help the development of early therapeutic interventions aimed at supporting and enhancing visual reorganization at a time of greatest potential brain plasticity.

Gori, M., Sandini, G., Martinoli, C. & Burr, D. (2010). Poor haptic orientation discrimination in nonsighted children may reflect disruption of cross-sensory calibration,Curr Biol, 3 (20), 223-225. PDF

A long-standing question, going back at least 300 years to Berkeley's famous essay, is how sensory systems become calibrated with physical reality. We recently showed [1] that children younger than 8-10 years do not integrate visual and haptic information optimally, but that one or the other sense prevails: touch for size and vision for orientation discrimination. The sensory dominance may reflect crossmodal calibration of vision and touch, where the more accurate sense calibrates the other. This hypothesis leads to a clear prediction: that lack of clear vision at an early age should affect calibration of haptic orientation discrimination. We therefore measured size and orientation haptic discrimination thresholds in 17 congenitally visually impaired children (aged 5-19). Haptic orientation thresholds were greatly impaired compared with age-matched controls, whereas haptic size thresholds were at least as good, and often better. One child with a late-acquired visual impairment stood out with excellent orientation discrimination. The results provide strong support for our crossmodal calibration hypothesis.

Paci, M., Matulli, G., Baccini, M., Rinaldi, L. A. & Baldassi, S. (2010). Reported quality of randomized controlled trials in neglect rehabilitation,Neurol Sci, 2 (31), 159-163. PDF

The aim of this study is to assess the reported quality of randomized controlled trials (RCTs) on the effectiveness of neglect rehabilitation using a standardized scale. A search of seven electronic databases was carried out. Selected articles were scored using the PEDro scale and classified as high or low quality study both with the original cut off of 6 and a modified cut off of 5. A linear regression analysis between year of publication and quality rate was used to test whether the quality of the studies improved with time. A total of 18 RCTs were selected. Six articles (33.3%) and 10 articles (55.56%) were classified as having high quality when the original cut off or the modified cut off of the PEDro scale were used, respectively. Analysis shows no time- related changes in PEDro scores. The results show that reported quality is moderate for RCTs in neglect rehabilitation.

Burr, D. C., Ross, J., Binda, P. & Morrone, M. C. (2010). Saccades compress space, time and number,Trends Cogn Sci, 12 (14), 528-533. PDF

It has been suggested that space, time and number are represented on a common subjective scale. Saccadic eye movements provide a fascinating test. Saccades compress the perceived magnitude of spatial separations and temporal intervals to approximately half of their true value. The question arises as to whether saccades also compress number. They do, and compression follows a very similar time course for all three attributes: it is maximal at saccadic onset and decreases to veridicality within a window of approximately 50ms. These results reinforce the suggestion of a common perceptual metric, which is probably mediated by the intraparietal cortex; they further suggest that before each saccade the common metric for all three is reset, possibly to pave the way for a fresh analysis of the post-saccadic situation.

Morrone, M. C., Cicchini, M. & Burr, D. C. (2010). Spatial maps for time and motion,Exp Brain Res, 2 (206), 121-128. PDF

In this article, we review recent research studying the mechanisms for transforming coordinate systems to encode space, time and motion. A range of studies using functional imaging and psychophysical techniques reveals mechanisms in the human brain for encoding information in external rather than retinal coordinates. This reinforces the idea of a tight relationship between space and time, in the parietal cortex of primates.

Filippi, L., Cavallaro, G., Fiorini, P., Daniotti, M., Benedetti, V., Cristofori, G., et al. (2010). Study protocol: safety and efficacy of propranolol in newborns with Retinopathy of Prematurity (PROP-ROP): ISRCTN18523491,BMC Pediatr, (10), 83. PDF

BACKGROUND: Despite new therapeutic approaches have improved the prognosis of newborns with retinopathy of prematurity (ROP), an unfavourable structural and functional outcome still remains high. There is high pressure to develop new drugs to prevent and treat ROP. There is increasing enthusiasm for anti-VEGF drugs, but angiogenic inhibitors selective for abnormal blood vessels would be considered as an optimal treatment.In an animal experimental model of proliferative retinopathy, we have recently demonstrated that the pharmacological blockade of beta-adrenoreceptors improves retinal neovascularization and blood retinal barrier breakdown consequent to hypoxia. The purpose of this study is to evaluate the propranolol administration in preterm newborns suffering from a precocious phase of ROP in terms of safety and efficacy in counteracting the progression of retinopathy. METHODS/DESIGN: Preterm newborns (gestational age at birth lower than 32 weeks) with stage 2 ROP (zone II-III without plus) will be randomized, according to their gestational age, to receive propranolol added to standard treatment (treatment adopted by the ETROP Cooperative Group) or standard treatment alone. Propranolol will be administered until retinal vascularization will be completely developed, but not more than 90 days. Forty-four participants will be recruited into the study. To evaluate the safety of propranolol administration, cardiac and respiratory parameters will be continuously monitored. Blood samplings will be performed to check renal, liver and metabolic balance. To evaluate the efficacy of propranolol, the progression of the disease, the number of laser treatments or vitrectomies, the incidence of retinal detachment or blindness, will be evaluated by serial ophthalmologic examinations. Visual function will be evaluated by means of behavioural standardized tests. DISCUSSION: This pilot study is the first research that explores the possible therapeutic role of beta blockers in ROP. The objective of this research is highly ambitious: to find a treatment simple, inexpensive, well tolerated and with few adverse effects, able to counteract one of the major complications of the prematurity. Any favourable results of this research could open new perspectives and original scenarios about the treatment or the prevention of this and other proliferative retinopathies. TRIAL REGISTRATION: Current Controlled Trials ISRCTN18523491; ClinicalTrials.gov Identifier NCT01079715; EudraCT Number 2010-018737-21.

Burr, D. C., Turi, M. & Anobile, G. (2010). Subitizing but not estimation of numerosity requires attentional resources,J Vis, 6 (10), 20. PDF

The numerosity of small numbers of objects, up to about four, can be rapidly appraised without error, a phenomenon known as subitizing. Larger numbers can either be counted, accurately but slowly, or estimated, rapidly but with errors. There has been some debate as to whether subitizing uses the same or different mechanisms than those of higher numerical ranges and whether it requires attentional resources. We measure subjects' accuracy and precision in making rapid judgments of numerosity for target numbers spanning the subitizing and estimation ranges while manipulating the attentional load, both with a spatial dual task and the "attentional blink" dual-task paradigm. The results of both attentional manipulations were similar. In the high-load attentional condition, Weber fractions were similar in the subitizing (2-4) and estimation (5-7) ranges (10-15%). In the low-load and single-task condition, Weber fractions substantially improved in the subitizing range, becoming nearly error-free, while the estimation range was relatively unaffected. The results show that the mechanisms operating over the subitizing and estimation ranges are not identical. We suggest that pre-attentive estimation mechanisms works at all ranges, but in the subitizing range, attentive mechanisms also come into play.

Binda, P., Morrone, M. C. & Burr, D. C. (2010). Temporal auditory capture does not affect the time course of saccadic mislocalization of visual stimuli,J Vis, 2 (10), 7 1-13. PDF

Irrelevant sounds can "capture" visual stimuli to change their apparent timing, a phenomenon sometimes termed "temporal ventriloquism". Here we ask whether this auditory capture can alter the time course of spatial mislocalization of visual stimuli during saccades. We first show that during saccades, sounds affect the apparent timing of visual flashes, even more strongly than during fixation. However, this capture does not affect the dynamics of perisaccadic visual distortions. Sounds presented 50 ms before or after a visual bar (that change perceived timing of the bars by more than 40 ms) had no measurable effect on the time courses of spatial mislocalization of the bars, in four subjects. Control studies showed that with barely visible, low-contrast stimuli, leading, but not trailing, sounds can have a small effect on mislocalization, most likely attributable to attentional effects rather than auditory capture. These findings support previous studies showing that integration of multisensory information occurs at a relatively late stage of sensory processing, after visual representations have undergone the distortions induced by saccades.

Zimmermann, E., Schnier, F. & Lappe, M. (2010). The contribution of scene context on change detection performance,Vision Res, 20 (50), 2062- 2068. PDF

The gist of a visual scene is perceived in a fraction of a second but in change detection tasks subjects typically need several seconds to find the changing object in a visual scene. Here, we report influences of scene context on change detection performance. Scene context manipulations consisted of scene inversion, scene jumbling, where the images were cut into 24 pieces and randomly recombined, and scene configuration scrambling, where the arrangement of the objects in the scene was randomized. Reaction times, where significantly lower in images with normal scene context. We conclude that scene context structures scene perception.

Lunghi, C., Binda, P. & Morrone, M. C. (2010). Touch disambiguates rivalrous perception at early stages of visual analysis,Curr Biol, 4 (20), R143-144. PDF

Binocular rivalry is a powerful tool to study human consciousness: two equally salient stimuli are imaged on the retinae, but at any given instant only one is consciously perceived, the other suppressed.The suppression takes place early, probably in V1. However, a trace of the suppressed signal has been detected along the dorsal visual pathway (BOLD responses) and demonstrated with psychophysical experiments. The suppressed image of a rotating sphere during rivalry is restored to consciousness when the observer actively controls the rotation and a similar effect on the suppressed signal has been shown for motion perception and reflexive eye movements (see Supplemental References). Here, we asked whether cross-modal sensory signals could selectively interact with rivalrous visual signals that are analyzed at a very early stage, probably V1. An auditory stimulus, when attended, can influence binocular rivalry, extending dominance times for a congruent visual stimulus. Tactile information can Â also disambiguate unstable visual motion and can fuse with vision to improve discrimination (e.g. slant). Our results indicate that a haptic oriented stimulus can disambiguate visual perception during binocular rivalry of gratings of orthogonal orientation, not only by prolonging dominance but also by curtailing suppression of the visual stimulus of matched orientation. The effect is selective for the spatial frequency of the stimuli, suggesting that haptic signals interact with early visual representations to enhance access to conscious perception.

Ross, J. & Burr, D. C. (2010). Vision senses number directly,J Vis, 2 (10), 10 11-18. PDF

We have recently suggested that numerosity is a primary sensory attribute, and shown that it is strongly susceptible to adaptation. Here we use the Method of Single Stimuli to show that observers can extract a running average of numerosity of a succession of stimuli to use as a standard of comparison for subsequent stimuli. On separate sessions observers judged whether the perceived numerosity or density of a particular trial was greater or less than the average of previous stimuli. Thresholds were as precise for this task as for explicit comparisons of test with standard stimuli. Importantly, we found no evidence that numerosity judgments are mediated by density. Under all conditions, judgements of numerosity were as precise as those of density. Thresholds in intermingled conditions, where numerosity varied unpredictably with

density, were as precise as the blocked thresholds. Judgments in constant-density conditions were more precise thresholds than those in variable-density conditions, and numerosity judgements in conditions of constant-numerosity showed no tendency to follow density. We further report the novel finding that perceived numerosity increases with decreasing luminance, whereas texture density does not, further evidence for independent processing of the two attributes. All these measurements suggest that numerosity judgments can be, and are, made independently of judgments of the density of texture.

Burr, D. C. & Morrone, M. C. (2010). Vision: keeping the world still when the eyes move,Curr Biol, 10 (20), R442-444. PDF

A long-standing problem for visual science is how the world remains so apparently stable in the face of continual rapid eye movements. New experimental evidence, and computational models are helping to solve this mystery.

Campanella, F., Sandini, G. & Morrone, M. C. (2010). Visual information gleaned by observing grasping movement in allocentric and egocentric perspectives,Proc Biol Sci, 1715 (278), 2142- 2149. PDF

One of the major functions of vision is to allow for an efficient and active interaction with the environment. In this study, we investigate the capacity of human observers to extract visual information from observation of their own actions, and those of others, from different

viewpoints. Subjects discriminated the size of objects by observing a point-light movie of a hand reaching for an invisible object. We recorded real reach- and-grasp actions in three-dimensional space towards objects of different shape and size, to produce two-dimensional 'point-light display' movies, which were used to measure size discrimination for reach-and-grasp motion sequences, release-and-withdraw sequences and still frames, all in egocentric and allocentric perspectives. Visual size discrimination from action was significantly better in egocentric than in allocentric view, but only for reach-and-grasp motion sequences: release-and-withdraw sequences or still frames derived no advantage from egocentric viewing. The results suggest that the system may have access to an internal model of action that contributes to calibrate visual sense of size for an accurate grasp.

2009

Burr, D., Banks, M. S. & Morrone, M. C. (2009). Auditory dominance over vision in the perception of interval duration,Exp Brain Res, 1 (198), 49-57. PDF

The "ventriloquist effect" refers to the fact that vision usually dominates hearing in spatial localization, and this has been shown to be consistent with optimal integration of visual and auditory signals (Alais and Burr in Curr Biol 14(3):257-262, 2004). For temporal localization, however, auditory stimuli often "capture" visual stimuli, in what has become known as "temporal ventriloquism". We examined this quantitatively using a bisection task, confirming that sound does tend to dominate the perceived timing of audio-visual stimuli. The dominance was predicted qualitatively by considering the better temporal localization of audition, but the quantitative fit was less than perfect, with more weight being given to audition than predicted from thresholds. As predicted by optimal cue combination, the temporal localization of audio-visual stimuli was better than for either sense alone.

Arrighi, R., Arecchi, F. T., Farini, A. & Gheri, C. (2009). Cueing the interpretation of a Necker Cube: a way to inspect fundamental cognitive processes,Cogn Process, (10 Suppl 1), S95-99. PDF

The term perceptual bistability refers to all those conditions in which an observer looks at an ambiguous stimulus that can have two or more distinct but equally reliable interpretations. In this work, we investigate perception of Necker Cube in which bistability consists of the possibility to interpret the cube depth in two different ways. We manipulated the cube ambiguity by darkening one of the cube faces (cue) to provide a clear cube interpretation due to the occlusion depth index. When the position of the cue is stationary the cube perceived perspective is steady and driven by the cue position. However, when we alternated in time the cue position (i.e. we changed the position of the darkened cube face) two different perceptual phenomena occurred: for low frequencies the cube perspective alternated in line with the position of the cue; however for high frequencies the cue was no longer able to bias the perception but it appears as a floating feature traveling across the solid with the cube whole perspective that returns to be bistable as in the conventional, bias-free, case.

Arrighi, R., Marini, F. & Burr, D. (2009). Meaningful auditory information enhances perception of visual biological motion,J Vis, 4 (9), 25 21-27. PDF

Robust perception requires efficient integration of information from our various senses. Much recent electrophysiology points to neural areas responsive to multisensory stimulation, particularly audiovisual stimulation. However, psychophysical evidence for functional integration of audiovisual motion has been ambiguous. In this study we measure perception of an audiovisual form of biological motion, tap dancing. The results show that the audio tap information interacts with visual motion information, but only when in synchrony, demonstrating

a functional combination of audiovisual information in a natural task. The advantage of multimodal combination was better than the optimal maximum likelihood prediction.

Zimmermann, E. & Lappe, M. (2009). Mislocalization of flashed and stationary visual stimuli after adaptation of reactive and scanning saccades,J Neurosci, 35 (29), 11055-11064. PDF

When we look around and register the location of visual objects, our oculomotor system continuously prepares targets for saccadic eye movements. The preparation of saccade targets may be directly involved in the perception of object location because modification of saccade amplitude by saccade adaptation leads to a distortion of the visual localization of briefly flashed spatial probes. Here, we investigated effects of adaptation on the localization of continuously visible objects. We compared adaptation-induced mislocalization of probes that were present for 20 ms during the saccade preparation period and of probes that were present for >1 s before saccade initiation. We studied the mislocalization of these probes for two different saccade types, reactive saccades to a suddenly appearing target and scanning saccades in the self-paced viewing of a stationary scene. Adaptation of reactive saccades induced mislocalization of flashed probes. Adaptation of scanning saccades induced in addition also mislocalization of stationary objects. The mislocalization occurred in the absence of visual landmarks and must therefore originate from the change in saccade motor parameters. After adaptation of one type of saccade, the saccade amplitude change and the mislocalization transferred only weakly to the other saccade type. Mislocalization of flashed and stationary probes thus followed the selectivity of saccade adaptation. Since the generation and adaptation of reactive and scanning saccades are known to involve partially different brain mechanisms, our results suggest that visual localization of objects in space is linked to saccade targeting at multiple sites in the brain.

Guzzetta, A., Tinelli, F., Del Viva, M. M., Bancale, A., Arrighi, R., Pascale, R. R., et al. (2009). Motion perception in preterm children: role of prematurity and brain damage,Neuroreport, 15 (20), 1339-1343. PDF

We tested 26 school-aged children born preterm at a gestational age below 34 weeks, 13 with and 13 without periventricular brain damage, with four different visual stimuli assessing perception of pure global motion (optic flow), with some form information (segregated translational motion) and form-defined static stimuli. Results were compared with a group of age-matched healthy term-born controls. Preterm children with brain damage showed significantly lower sensitivities relative to full-term controls in all four tests, whereas those without brain damage were significantly worse than controls only for the pure motion stimuli. Furthermore, when form information was embedded in the stimulus, preterm children with brain lesions scored significantly worse than those without lesions. These results suggest that in preterm children dorsal stream-related functions are impaired irrespective of the presence of brain damage, whereas deficits of the ventral stream are more related to the presence of periventricular brain damage.

Pei, F., Baldassi, S., Procida, G., Igliozzi, R., Tancredi, R., Muratori, F., et al. (2009). Neural correlates of texture and contour integration in children with autism spectrum disorders,Vision Res, 16 (49), 2140-2150. PDF

In this study, we have used an electrophysiological paradigm to investigate the neural correlates of the visual integration of local signals across space to generate global percepts in a group of low functioning autistic kids. We have analyzed the amplitude of key harmonics of the Visual Evoked Potentials (VEPs) recorded while participants observed orientation-based texture and contour stimuli, forming coherent global patterns, alternating with visual patterns in which the same number of local elements were randomly oriented in order to loose any globally organized feature. Comparing the results of the clinical sample with those obtained in an age-matched control group, we have observed that in the texture conditions the 1st and 3rd harmonics, containing signature of global form processing (Norcia, Pei, Bonneh, Hou,

Sampath, & Pettet, 2005), were present in the control group, while in the experimental group only the 1st harmonic was present. In the Contour condition the 1st harmonic was not present for both groups while the 3rd harmonic was significantly present in the control group but absent in the group with autism. Moreover, the amount of organization required to elicit significant 1st harmonic response in the texture condition was higher in the clinical group. The present results bring additional support to the idea that texture and contour processing are supported by independent mechanisms in normal vision. Autistic vision would thus be characterized by a preserved, perhaps weaker texture mechanism, possibly mediated by feedback interactions between visual areas, and by a disfunction of the mechanism supporting contour processing, possibly mediated by long-range intra-cortical connections. Within this framework, the residual ability to detect contours shown in psychophysical studies could be due to the contribution of the texture mechanism to contour processing.

Burr, D. C., Baldassi, S., Morrone, M. C. & Verghese, P. (2009). Pooling and segmenting motion signals,Vision Res, 10 (49), 1065-1072. PDF

Humans are extremely sensitive to visual motion, largely because local motion signals can be integrated over a large spatial region. On the other hand, summation is often not advantageous, for example when segmenting a moving stimulus against a stationary or oppositely moving background. In this study we show that the spatial extent of motion integration is not compulsory, but is subject to voluntary attentional control. Measurements of motion coherence sensitivity with summation and search paradigms showed that human observers can combine motion signals from cued regions or patches in an optimal manner, even when the regions are quite distinct and remote from each other. Further measurements of contrast sensitivity reinforce previous studies showing that motion integration is preceded by a local analysis akin to contrast thresholding (or intrinsic uncertainty). The results were well modelled by two standard signal-detection-theory models.

Baldassi, S., Pei, F., Megna, N., Recupero, G., Viespoli, M., Igliozzi, R., et al. (2009). Search superiority in autism within, but not outside the crowding regime,Vision Res, 16 (49), 2151-2156. PDF

Visual cognition of observers with autism spectrum disorder (ASD) seems to show an unbalance between the complementary functions of integration and segregation. This study uses visual search and crowding paradigms to probe the relative ability of children with autism, compared to normal developments children, to extract individual targets from cluttered backgrounds both within and outside the crowding regime. The data show that standard search follows the same pattern in the ASD and control groups with a strong effect of the set size that is substantially weakened by cueing the target location with a synchronous spatial cue. On the other hand, the crowding effect of eight flankers surrounding a small peripheral target is virtually absent in the clinical sample, indicating a superior ability to segregate cluttered visual items. This data, along with evidence of an impairment to the neural system for binding contours in ASD, bring additional support to the general idea of a shift of the trade-off between integration and segregation toward the latter. More specifically, they show that when discriminability is balanced across conditions, an advantage in odd-man out tasks is evident in ASD observers only within the crowding regime, when binding mechanism might get compulsorily triggered in normal observers.

Cicchini, G. M. & Morrone, M. C. (2009). Shifts in spatial attention affect the perceived duration of events,J Vis, 1 (9), 9 1-13. PDF

We investigated the relationship between attention and perceived duration of visual events with a double- task paradigm. The primary task was to discriminate the size change of a 2 degree circle presented 10 degrees left, right, above, or below fixation; the secondary task was to judge the temporal separation (from 133 ms to 633 ms) of two equiluminant horizontal bars (10 deg x 2 deg) briefly flashed 12 degrees above or below fixation. The stimulus onset asynchrony (SOA) between primary and secondary task ranged from -1300 ms to +1000 ms. Temporal intervals in proximity of the onset of the primary task stimuli were perceived strongly

compressed by up to 40%. The effect was proportional to the size of the interval with a maximum effect at 100 ms SOA. Control experiments show that neither primary-task difficulty, nor the type of primary task discrimination (form or motion, or equiluminant or luminance contrast) nor spatial congruence between primary and secondary task alter the effect. Interestingly, the compression occurred only when the intervals are marked by bars presented in separated spatial locations: when the interval is marked by two bars flashed in the same spatial position no temporal distortion was found. These data indicate that attention can alter perceived duration when the brain has to compare the passage of time at two different spatial positions, corroborating earlier findings that mechanisms of time perception may monitor separately the various spatial locations possibly at high level of analysis.

Binda, P., Cicchini, G. M., Burr, D. C. & Morrone, M. C. (2009). Spatiotemporal distortions of visual perception at the time of saccades,J Neurosci, 42 (29), 13147-13157. PDF

Both space and time are grossly distorted during saccades. Here we show that the two distortions are strongly linked, and that both could be a consequence of the transient remapping mechanisms that affect visual neurons perisaccadically. We measured perisaccadic spatial and temporal distortions simultaneously by asking subjects to report both the perceived spatial location of a perisaccadic vertical bar (relative to a remembered ruler), and its perceived timing (relative to two sounds straddling the bar). During fixation and well before or after saccades, bars were localized veridically in space and in time. In different epochs of the perisaccadic interval, temporal perception was subject to different biases. At about the time of the saccadic onset, bars were temporally mislocalized 50-100 ms later than their actual presentation and spatially mislocalized toward the saccadic target. Importantly, the magnitude of the temporal distortions co-varied with the spatial localization bias and the two phenomena had similar dynamics. Within a brief period about 50 ms before saccadic onset, stimuli were perceived with shorter latencies than at other delays relative to saccadic onset, suggesting that the perceived passage of time transiently inverted its direction. Based on this result we could predict the inversion of perceived temporal order for two briefly flashed visual stimuli. We developed a model that simulates the perisaccadic transient change of neuronal receptive fields predicting well the reported temporal distortions. The key aspects of the model are the dynamics of the "remapped" activity and the use of decoder operators that are optimal during fixation, but are not updated perisaccadically.

Burr, D., Silva, O., Cicchini, G. M., Banks, M. S. & Morrone, M. C. (2009). Temporal mechanisms of multimodal binding,Proc Biol Sci, 1663 (276), 1761-1769. PDF

The simultaneity of signals from different senses-such as vision and audition-is a useful cue for determining whether those signals arose from one environmental source or from more than one. To understand better the sensory mechanisms for assessing simultaneity, we measured the discrimination thresholds for time intervals marked by auditory, visual or auditory-visual stimuli, as a function of the base interval. For all conditions, both unimodal and cross-modal, the thresholds followed a characteristic 'dipper function' in which the lowest thresholds occurred when discriminating against a non-zero interval. The base interval yielding the lowest threshold was roughly equal to the threshold for discriminating asynchronous from synchronous presentations. Those lowest thresholds occurred at approximately 5, 15 and 75 ms for auditory, visual and auditory-visual stimuli, respectively. Thus, the mechanisms mediating performance with cross-modal stimuli are considerably slower than the mechanisms mediating performance within a particular sense. We developed a simple model with temporal filters of different time constants and showed that the model produces discrimination functions similar to the ones we observed in humans. Both for processing within a single sense, and for processing across senses, temporal perception is affected by the properties of temporal filters, the outputs of which are used to estimate time offsets, correlations between signals, and more.

Thompson, P. & Burr, D. (2009). Visual aftereffects,Curr Biol, 1 (19), R11-14. PDF