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THE 9TH ASIA-PACIFIC CONFERENCE ON VISION (APCV 2013)

July 7th, Sunday
Morning Sessions
8:30-9:30, Fei Quan Hall
Plenary Speech V

Visual guidance of flight in honeybees and birds and applications to robotics

Mandyam V. Srinivasan
Queensland Brain Institute And School of Information Technology and Electrical Engineering University of Queensland

Flying insects are remarkably adept at seeing and perceiving the world and navigating effectively in it, despite possessing a brain that weighs less than a milligram and carries fewer than 0.01% as many neurons as ours does. Although most insects lack stereo vision, they use a number of ingenious strategies for perceiving their world in three dimensions and navigating successfully in it.

The talk will describe how honeybees use their vision to stabilize and control their flight, and navigate to food sources. Bees and birds negotiate narrow gaps safely by balancing the apparent speeds of the images in the two eyes. Flight speed is regulated by holding constant the average image velocity as seen by both eyes. Visual cues based on motion are also used to compensate for crosswinds, and to avoid collisions with other flying insects. Bees landing on a surface hold constant the magnitude of the optic flow that they experience as they approach the surface, thus automatically ensuring that flight speed decreases to zero at touchdown. Foraging bees gauge distance flown by integrating optic flow: they possess a visually-driven 'odometer' that is robust to variations in wind, body weight, energy expenditure, and the properties of the visual environment.

Some of the insect-based strategies described above are being used to design, implement and test biologically-inspired algorithms for the guidance of autonomous terrestrial and aerial vehicles. Application to manoeuvres such as attitude stabilization, terrain following, obstacle avoidance, automated landing, and the execution of extreme aerobatic manoeuvres will be described.

Grant support: ARC Centre of Excellence in Vision Science Grant CE0561903, ARC Discovery Grant DP0559306, and by a Queensland Smart State Premier's Fellowship.

July 7th, Sunday
Morning Sessions
10:00-10:30, Bai Yun Hall
Special History Talks V

Receptive fields of visual neurons, 75 years and still moving

Lothar Spillmann
University of Freiburg

The function of visual neurons is to represent events and features to the brain to enable a representation of the outside world. Hartline (1938) found that an isolated optic nerve fiber in the frog could be excited by light falling on a small circular area on the retina. He called this area the "receptive field" (RF). In 1953, Kuffler (1953) discovered the antagonistic center-surround organization of cat RFs and Barlow et al (1957) extended this work to the study of stimulus location, diameter and level of background illumination. As a psychophysical analog of the RF, Jung and Spillmann (1971) proposed the term "perceptive field," while Field et al (1993) introduced the "association field".

The years from 1960 were marked by rapid progress. Hubel & Wiesel (1962-1970) recording from neurons in LGN and visual cortex found RFs that were elongated and selective to stimulus wavelength, orientation, position, movement direction, and ocularity. The term RF gained further significance for visual perception by the discovery of input effects beyond "the classical RF" (Nelson & Frost 1978). In 1984, Baumgartner et al proposed the extended response field, which led to the distinction between local versus global stimuli for contextual neurons (Knierim & van Essen 1992). Lesion studies then showed that RFs were not fixed on the retina, but dynamic in size and location (Gilbert & Wiesel 1992).

In higher visual areas such as IT and MT, RFs become very large, losing most of their retinotopic organization; however, the complexity of encoded features increases dramatically. For example, while lower levels RFs mediate perceptual filling-in, contour integration and figure-ground segregation, RFs at higher levels serve the perception of faces and biological motion. Empirical studies in awake monkeys using free viewing of natural scenes show that classical and nonclassical RFs cooperate in forming a sparse representation of the visual world (Vinje & Gallant 2004).

Today the term RF is undergoing a quantum change. It started out as a hierarchical feed-forward concept, yet there are massive feedback projections as well as horizontal interactions in the visual system. These not only modulate the afferent signals, but also contribute to the outer surround (Angelucci et al, 2002). This modulation may account for the dynamic properties required for

higher cognitive functions such as perceptual learning and attention (Cong Yu, 2005). Thus, after 75 years of research, bottom up finally meets top down and feature detection gives way to perception and cognition.

Grant support: University of Freiburg and Teaching Exchange Fellowship, University of Hong Kong

July 7th, Sunday
Morning Sessions
10:00-12:30, Fei Quan Hall
Symposium V
Binocular Vision
Organizer: Yi Jiang

10:00-10:30
Summation and suppression in binocular contrast vision

Tim S Meese
School of Life and Health Sciences, Aston University, Birmingham UK, B4 7ET

I have used the contrast detection and contrast discrimination paradigms in a series of masking and summation experiments to investigate the interactions of contrast signals between the eyes. Several key findings have emerged: 1. The binocular summation ratio at detection threshold is about 1.7: two eyes are not quite twice as good as one, but are markedly better than the √2 ratio widely reported in the literature. 2. By presenting contrast pedestals to both eyes and comparing monocular and binocular contrast increment sensitivity across the eyes it was shown that the process of summation of binocular signals extends across the entire pedestal contrast range. 3. However, this process is obscured when the ocularity of the pedestals and targets are identical: the well known finding that monocular and binocular dipper functions converge. 4. Dichoptic pedestal masking shows only a weak facilitatory 'dipper' effect, obeys Weber's law in its upper limb and is phase dependent. 5. Cross-oriented masks raise thresholds both within and between the eyes, but have different spatio-temporal characteristics indicating at least two routes to cross-orientation suppression. 6. When contrast signals are spatially interdigitated across the eyes, binocular summation ratios are nearly as high as when they are superimposed, as in the classical design. This result is found both with and without binocular contrast pedestals. This shows that the contrast signal can benefit from the combined effects of two summation processes: one across eyes, the other across space. 7. Cross-oriented dichoptic masking can be diminished by adding a monocular mask that is otherwise identical to the dichoptic mask.

Results 1 to 4 are accommodated by a two-stage model of contrast gain control for which there is interocular suppression between monocular pathways followed by binocular summation and further gain control. This model has the benefit of permitting a binocular advantage for weak signals, but achieving binocular averaging and ocularity invariance (the perceived contrast of the world is the same with one eye as with two) above threshold. To accommodate result 5, monocular and dichoptic pathways to cross orientation suppression must assert their influence before binocular summation. To accommodate result 6, the model was extended to include three stages: a binocular stage, a spatial summation stage and an output stage. Result 7 continues to pose a challenge, but implies that binocular matching gates cross-oriented interocular suppression.

10:30-11:00
Binocular interaction in phase, contrast, and depth perception

Zhong-Lin Lu
Laboratory of Brain Processes (LOBES), Center for Cognitive and Behavioral Brain Imaging, Center for Cognitive Science, Department of Psychology, The Ohio State University

How the visual system combines information from the two eyes to form a unitary binocular representation of the external world is a fundamental question in vision science. We investigated binocular phase, contrast, and depth perception through systematic manipulations of monocular image contrast, interocular contrast ratio, interocular phase difference, and interocular disparity. We found that the perceived phase, contrast, and depth of the cyclopean images depended strongly on image contrasts and their ratio in the two eyes. Although the perceived phase depended on the relative phase and contrast ratio of the monocular images, the perceived contrast was independent of the relative phase of the monocular images and the polarity of stereo depth. Base on the binocular phase combination model of Ding & Sperling, we developed a multi-pathway contrast-gain control model (MCM) for binocular combination. In the MCM, each eye exerts gain-control on the other eye's signal in proportion to its own signal contrast energy, and also gain-control over the other eye's gain-control. Phase, contrast, and depth of the cyclopean images are computed in separate pathways but with shared contrast-gain control: (1) perceived phase is computed by the contrast ratio and phase difference between the monocular inputs; (2) perceived contrast is computed by combining contrast energy from the two eyes; and (3) stereo strength is proportional to the product of the signal strengths in the two eyes. The MCM provides an excellent account of our results as well as some challenging results in the literature. Our results have important theoretical and clinical implications for understanding mechanisms of and developing treatments for amblyopia.

Grant support: National Eye Institute grants (R01 EY017491 and R01 EY021553).

11:00-11:30
Pupillometric investigation of interocular suppression

Eiji Kimura
Department of Psychology, Faculty of Letters, Chiba University

Visual processes mediating the human pupillary response are richer in functional capability than generally thought. The pupil

reacts not only to changes in the luminance of light but also to changes in color, spatial pattern, and motion of the stimulus Moreover, there is now good evidence for cortical contribution to the pupillary constriction to changes in color, pattern, and motion, while the pupillary response to luminance changes is believed to be mediated by subcortical pathways. These findings suggest that the pupillary response can be a unique measure for studying visual processing in humans. This talk will review our recent attempts to investigate interocular suppression using the pupillary response. We first investigated the effects of interocular suppression caused by continuous flash suppression on the pupillary response. The results showed that the pupillary responses to luminance as well as color changes were clearly attenuated during suppression. The pattern of attenuation was very similar to that determined psychophysically, but the response attenuation was observed over a wider range of test contrast from near-threshold to suprathreshold levels. In another study, we demonstrated that the pupillary light response exhibited amplitude modulation correlated with changes in apparent brightness as well as in physical stimulation. The different brightness changes were produced with physically identical stimulus sequences by taking advantage of binocular rivalry. The amplitude modulation was observed both in pupillary constriction to brightness increment and in pupillary dilation to brightness decrement. Overall, although the pupillary light response has been considered as a primitive reflex, it can exhibit influences of interocular suppression and possible correlation with visual awareness. Thus, our findings strongly suggest that the pupillary response can be a useful noninvasive measure to investigate binocular interaction. Furthermore, if the pupillary response to luminance changes is exclusively mediated by subcortical pathways as generally believed, the attenuation of the response indicates that interocular suppression adversely affects subcortical as well as cortical visual processing.

Grant support: This work was partially supported by JSPS KAKENHI Grant Numbers 22530789 and 23530964.

11:30-12:00

Binocular rivalry-like neural activities in anesthetized macaque V1

Haidong Lu
Institute of Neuroscience, Chinese Academy of Sciences, Shanghai, China

Area V1 is the first cortical site where inputs from two eyes are combined. While fMRI studies have demonstrated that area V1 involves in binocular rivalry (BR), it is unclear how much the neural activity in V1 contribute to rivalry perception and whether top-down attention is necessary for the rivalry to occur. To investigate this, we examined whether V1 neural activity alternates like the typical rivalry perception when top-down attention is deprived in anesthetized animals.

Intrinsic signal optical imaging was employed to measure population response from V1 of anesthetized and paralyzed macaque monkeys. The stimulus comprised a pair of 45 and 135 degree gratings in green and red colors (diameter: 1.5-3.5 deg, spatial frequency: 2 cpd; speed: 3 dps). In each trial, cortical responses were imaged for 60 seconds at a frame rate of 4 Hz. Usually more than 10 trials were imaged for each stimulus condition. We developed a pattern classifier to determine cortical activation patterns and obtained an eye-dominance score for each single frame (0.25 second). Each eye-dominance score indicates that the response pattern in the frame is more left-eye-like or right-eye-like.

In anesthetized monkeys viewing a BR stimulus, the eye-dominance score fluctuates spontaneously and exhibits a clear alternation between left and right eyes. The mean eye dominance duration is in the range of 2 to 8 seconds. The distribution of dominance time can be fitted with a gamma function. Also revealed is the difference (subtraction) between the classified left and right eye dominance images. We found the subtracted maps closely match the ocular dominance maps obtained with monocular stimulation, confirming the eye-of-origin specificity of the estimated rivalry status. These characteristic optical imaging patterns (ocular dominance map) are not observed in control conditions where the monkeys viewed a non-rivaling binocular stimulus (e.g., plaid patterns or blank conditions). When the parameters (e.g. contrast or surround patterns) of the BR stimuli changes, alternation activity in V1 also changes in a way parallels psychophysics observations.

Our findings demonstrate that there exist eye specific neural activities in V1 that alternate during BR stimulation, such alternation occur without top-down attentional modulation. With the high spatial resolution of optical imaging, the present study not only confirmed previous fMRI findings but also provided the direct evidence that V1 rivalry involves monocular neuron networks (OD columns).

12:00-12:30

Deficient binocular combination reveals mechanisms of anisometropic amblyopia: signal attenuation and interocular inhibition

Chang-Bing Huang
Visual Information Processing and Learning (VisPal), Key Laboratory of Behavioral Science, Institute of Psychology, Chinese Academy of Sciences, Beijing, China, 100101

Amblyopia is a developmental disorder that leads to both monocular and binocular spatial vision deficits. It's presently mysterious whether these deficits result from signal attenuation in the amblyopic eye, stronger inhibition from the fellow eye, or both. In a series of studies, we characterize the mechanisms underlying anisometropic amblyopia using a binocular phase and contrast combination paradigm and a contrast-gain control model. We found that both eyes contributed virtually equally in normal subjects while stimulus of equal contrast was weighted much less in the amblyopic eye relative to the fellow eye in binocular phase combination (14%-51%). The abnormal properties of binocular combination are successfully explained by a combination of (1) attenuated monocular signal in the amblyopic eye, (2) stronger interocular contrast-gain control from the fellow eye to the signal in amblyopic eye (direct interocular inhibition), and (3) stronger interocular contrast-gain control from the fellow eye to the contrast gain control signal from the amblyopic eye (indirect interocular inhibition). Conclusions still hold after getting rid of possible rivalry contaminations. We conclude that anisometropic amblyopia led to both monocular and

interocular deficits, and a complete understanding of the mechanisms underlying amblyopia requires studies of both monocular deficits and binocular interactions. The results from the current study have many important implications in amblyopia research and treatment.

Grant Support: Knowledge Innovation Program of the Chinese Academy of Sciences, and Institute of Psychology.

July 7th, Sunday
Morning Sessions
10:30-12:30, Bai Yun Hall
Talk Session V
Binocular Vision & Awareness
Moderator: Li Zhaoping, Robert S. Allison

10:30-10:50

Dichoptic orientation stimuli show that ocular summation bests ocular opponency in central but not peripheral vision

Li Zhaoping
University College London

V1 encodes both the sum of, and the difference between, the visual inputs to the two eyes, (Li and Atick, 1994, Network,5(2),157-174); however, perception favours the sum. Consider a dichoptic stimulus for which the binocular sum and difference signals are both sinusoidal gratings with the same amplitude, but which drift in opposite directions. This arises from a flashing, but not drifting, grating to each eye, with the spatial and temporal phases of the left eye grating different from those of the right eye grating by 90 degrees. In central vision, subjects more likely see the drift direction associated with the sum rather than the difference (Shadlen and Carney, 1986, Science,232(4746),95-97). However, I recently found that this bias for binocular summation is absent when the gratings were viewed peripherally (about 10 degree eccentricity; stimulus enlarged to counter acuity change), and that reducing the speed of the drifting increases this bias in central, but not peripheral, vision (Zhaoping, submission to ECVP 2013). Here, we extend this study to the case that the binocular sum and difference signals are static gratings, but tilted in opposite directions from horizontal. When the two gratings have equal amplitudes and are viewed centrally and briefly, subjects more likely report the orientation of the sum rather than the difference grating; however, when viewed peripherally, the two orientations are roughly equally likely to be perceived. Furthermore, reducing the duration of stimulus presentation, e.g., from 100 to 50 milliseconds, reduced the bias for binocular summation in central viewing only. Just as for drifting gratings, the probability of perceiving the orientation associated with the sum increases with the amplitude of the sum relative to the difference grating, but for any amplitude, this probability tends to be higher for central than peripheral vision, unless it is too close to zero or one.

Grant support: The Gatsby Charitable Foundation

10:50-11:10

Binocular contributions to linear vection

Robert S. Allison, April Ash, Stephen Palmisano
York University and University of Wollongong

Compelling illusions of self motion, known as vection, can be produced in a stationary observer by visual stimulation alone. The role of binocular vision and stereopsis in these illusions was explored in a series of three experiments. Linear vertical vection was produced by upward or downward translation of stereoscopic surfaces. The surfaces were horizontally-oriented depth corrugations produced by disparity modulation of patterns of persistent or short lifetime dot elements. The experiments demonstrate an increase in vection magnitude and decrease in vection latency with binocular viewing. Experiments utilising short lifetime dot stereograms demonstrated that this binocular enhancement was due to the motion of stereoscopically defined features.

Grant support: Canadian Space Agency and Australian Endeavour Fellowship

11:10-11:30

Interocular integration of motion signal during binocular rivalry - functional roles of magnocellular and parvocellular pathways

Wen Wen[1,2], Peng Zhang[2,3], Xinghuai Sun[1], Sheng He[2,3]
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Purpose: To investigate the spatiotemporal properties of interocular integration of motion signal during binocular rivalry and delineate the functional roles of the magnocellular and parvocellular pathways in binocular rivalry.

Methods: Two orthogonal luminance gratings were dichoptically presented, one on top of an isoluminant red-gray radial grating and the other on top of an isoluminant green-gray pattern of concentric rings. The isoluminant chromatic patterns were used to enhance the form and color conflict between the eyes to ensure they were engaged in perceptual rivalry. The luminance gratings remained orthogonal during each trial, with a spatial frequency of 0.5, 1, or 2 cycle/degree; temporal frequency of 1, 8, or 15 Hz; and luminance contrast at 10% or 20%. In each trial, the stimuli were presented for 2 seconds and then subjects indicated their perceived motion direction as well as the dominant pattern with mouse clicks on direction (16 possible choices) and form (3 possible choices: red circular grating, green radial grating, or a patchy red/green pattern) response templates. Eight subjects (four females) participated in this study.

Results: Observers perceived a single pattern in most trials (87.14% $\pm$ 1.90%), indicating strong rivalry was perceived. With motion integration defined as perceived motion direction between the two orginal orthogonal moving directions, observers perceived

an integrated motion signal frequently, overall in 30.59% (±2.38%) of the trials. In addition, motion integration increased with increasing temporal frquency ($F = 8.256$, $p = 0.004$) and decreased with increasing spatial frequency ($F = 4.437$, $p = 0.032$). Similar pattern of results were observed at 10% and 20% contrast conditions ($F = 2.415$, $p = 0.164$), though intergrated motion was perceived more often in 10% (mean = 35.75, SEM = 6.981) than in 20% (mean = 28.75, SEM = 6.850) contrast condition.

Conclusion: Interocular motion intergration in binocular rivalry is biased towards higher temporal and lower spatial frequency, as well as lower contrast conditions. Our results support the idea that interocular conflicts in parvocellular pathway lead to rivalry while different signals in magnocellular pathway tend to be combined. This mechanism may help to explain the selective functional deficits in certain types of amblyopia.

Grant support: NSFC (81020108017), CSC (2011610066)

11:30-11:50

The effects of small saccades on perceptual switch induced gamma-band responses during binocular rivalry

Laila Hugrass, David Crewther
Swinburne University of Technology

Perceptual switches during binocular rivalry are associated with synchronous neural activity in the gamma frequency band. Single cell studies have shown that gamma-band activity is associated with perceptual awareness, whereas scalp-recorded EEG studies have reported an induced gamma band response (iGBR) at the time of perceptual switches. The discrepancy between single cell and EEG results could be explained by the temporal relationship between saccadic eye movements and perceptual switches. In order to investigate whether saccadic eye movements obscure the perceptual-switch iGBR, we recorded MEG and eye movements while participants experienced binocular rivalry between pairs of stationary and drifting gratings. Eye movement data from the stationary and drifting rivalry conditions were analysed to detect microsaccades and fast-phase optokinetic nystagmus (OKN) saccades respectively. Time-frequency analyses, performed relative to saccade onset, revealed some differences in evoked gamma synchronisation for microsaccades and fast-phase saccades. Consistent with previous reports, induced gamma band responses were observed prior to rivalrous perceptual transitions. Time-frequency plots of the iGBR were compared for perceptual switches that were and were not preceded by saccades. The effects of saccades on the perceptual switch iGBR appeared to be weaker for fast-phase OKN saccades (observed during binocular rivalry between drifting gratings) than for regular microsaccades (observed during binocular rivalry between stationary gratings). These results suggest that the iGBR for binocular rivalry can be obscured by saccade dynamics.

11:50-12:10

When subliminal stimuli fail to transfer across hemispheres: interhemispheric integration of nonconscious information

Jing Chen, Janet Hui-wen Hsiao
Department of Psychology, The University of Hong Kong

In a go/no-go task using left-pointing (<-) and right-pointing (->) arrows, the target arrow in the center was preceded by a masked subliminal arrow prime with a short duration (10, 20, 30, 40 ms) in the left visual field (LVF) or right visual field (RVF). Half of the participants were asked to respond to the left-pointing target, and the other half to the right-pointing target. Each participant used the left and right hand alternatively from block to block to respond. While unaware of the existence of the priming arrow, participants showed slower "go" responses to targets with a congruent prime than to those with an incongruent prime in the 20-, 30-, and 40-ms prime conditions; this effect may be due to response inhibition triggered by invisible primes as revealed by Eimer and Schlaghecken (2002). More interestingly, when participants responded with their left hand (i.e., the non-dominant hand; all participants were right-handed), the priming effect was found only when the prime was presented in the LVF/right hemisphere (RH) but not the RVF/left hemisphere (LH); in contrast, the priming effect was observed in both the LVF and RVF when participants responded with their right hand. This difference in responding hand may be due to difference in the efficiency of interhemispheric transfers between the two hemispheres. Subliminal prime information in the RVF/LH may be insufficient to be transferred to the RH to affect subsequent judgments when probed by the non-dominate left hand/RH. This finding is consistent with the literature reporting that transmission of visuomotor information from the LH to the RH is slower than that from the RH to the LH (see Brown, Larson, and Jeeves, 1994, for a meta-analysis); it also suggests that hemispheric asymmetry effects without contamination from interhemispheric communication can be better observed at subliminal level.

Grant support: the Research Grant Council of Hong Kong (project code HKU 745210H to J.H. Hsiao) and the HKU Seed Funding Program for Basic Research (project code 201011159124 to J.H. Hsiao)

12:10-12:30

Response conflicts cannot be resolved unconsciously

Yu-Feng Huang[1], Chun Siong Soon[1,2], Po-Jang Hsieh[1]
[1]Neuroscience and Behavioral Disorders Program, Duke-NUS Graduate Medical School; [2]Department of Psychology, Technical University Dresden

Priming studies have revealed unconscious processing of perceptual and semantic information. Here we directly investigated whether response conflicts can also be resolved unconsciously. Interocular flash suppression was used to render unconscious a Stroop color-word for 2 seconds to induce unconscious response conflict. The suppression was then removed and participants indicated either the physical color or word-name of the now

consciously visible color-word. Mismatch between color and word information resulted in slower responses. Without priming, this incongruency cost was larger for color-naming (100 ms) than word-naming (44 ms). Following unconscious priming, the incongruency cost was reduced for color-naming (68 ms) but increased for word-naming (66 ms). Notably, despite clear evidence of unconscious processing, incongruency costs were not eliminated completely, but became comparable across the two tasks, indicative of remnant unresolved conflict. This asymmetric modulation of Stroop interference by unconscious priming implied that full resolution of response conflicts requires conscious cognitive resources.

July 7th, Sunday
Afternoon Sessions
14:00-14:30, Bai Yun Hall
Special History Talk VI

Changing views of the role of feedback in visual processing

Shaul Hochstein
Hebrew University, Jerusalem, Israel

The history of cortical feedback pathways and mechanisms has had its ups and downs. Early giants in the fields of vision, including influential pioneers of vision physiology, Hubel and Wiesel, and the father of visual system Artificial Intelligence, David Marr, favored basically feed-forward models. Selective convergence and divergence were seen as the major players in creating neuron receptive field properties. Almost immediately, lateral connections became a major contender for dictating neuronal response properties. Gain control, contrast detection, and orientation tuning were just some of the properties ascribed to being created or at least enhanced by such intrinsic connections. While very early anatomical evidence supported the presence of area-to-area feedback, its physiological role was not well studied for many years. This changed dramatically with the advent of techniques to record from alert, behaving preparations. In parallel, investigators began to focus on mechanisms of attention, which was of major interest in the cognitive psychology domain. Much effort has since been invested in asking if attention – in particular object-based attention – is filter-like selection of feed-forward signals or rather feedback control of lower-level activity. This arena is still open to debate. Very rapid categorization supports feed-forward models, but grouping, indirect vision and conscious control of perception favor the importance of feedback. Due to its long integration time, fMRI has little to say about timing and thus its findings are open to interpretation regarding feedback. On the other hand, novel techniques, including TMS, allow for fine temporal control. Recent results support the importance of feedback mechanisms in determining what is perceived. Finally, current thinking relates to the role of feedback in conscious perception. The transition from early "vision at-a-glance" to later "vision-with-scrutiny" seems to depend on the comparatively slow feedback pathways.

Grant support: Israel Science Foundation

July 7th, Sunday
Afternoon Sessions
14:00-16:30, Fei Quan Hall
Symposium VI
Clinical Vision
Organizer: Lei Liu

14:00-14:30

Abnormal preparatory activity in amblyopia: deficits beyond early visual cortex

Tony Norcia
Department of Psychology, Stanford University

Predictable events in the environment allow us to prepare to process upcoming visual inputs (preparatory attention) and motor responses (motor planning). These preparatory signals originate in frontal and parietal areas that send outputs to motor planning areas and to posterior visual structures. Motivated by the fact that frontal and parietal cortex have long developmental sequences, we have been studying simple visual tasks that require control inputs from these areas in patients with a history of amblyopia, a developmental disorder secondary to abnormal visual experience during the time that these cortical regions are still developing. High-density EEG recordings, combined with source localization methods were used to study the spatio-temporal distribution of the two forms of preparatory activity. Motor planning and preparatory attention networks were studied in a simple go-no/go task in which the first stimulus (S1) provides a cue as to whether a response to a second stimulus presented 1 sec later might require a response (S2). On half of the trials, S1 indicated that a target would be presented at S2 with 50% probability. Trials of this type induce an expectation of the potential need to respond when S2 is presented. These trials generate a large negative going potential in areas associated with motor planning (the Contingent Negative Variation) as well as slow positive potentials in parietal and occipital cortex. While the magnitude of the motor planning potential was comparable between patients and controls, preparatory attention signals were selectively reduced in patients with amblyopia. The loss of top-down attentional inputs may contribute to previously observed behavioral deficits in amblyopia on tasks that require selective visual attention.

14:30-15:00

Training the brain to overcome the effect of aging on the human eye

Uri Polat[1,2], Maria Lev[1], Oren Yehezkel[2,3], Anna Sterkin[1,2]
[1]Faculty of Medicine, Goldshleger Eye Research Inst, Tel-Aviv University, Tel-Hashomer, Israel; [2]Ucansi, Inc. New York, NY 10170; [3]School of Optometry and Helen Wills Neuroscience Institute, UC Berkeley, Berkeley, CA, USA

Task-specific improvement in performance after perceptual learning (PL) is well established. However, specificity of PL that does not transfer well between different tasks may pose a limit for the usage of PL for clinical purposes. Normal balance between neural excitation (E) and inhibition (I) enables neural plasticity. In presbyopia (aging eye), the input transferred to the brain is limited by the degraded optics of the eye, creating a bottleneck for the processing in the primary visual cortex, hence, affecting the visual perception normally relying on feedforward and feedback streams of information between the visual areas. Consequently, there are multiple negative effects on near vision. Specifically, near visual acuity (VA) deteriorates, as well as other perceptual functions, such as contrast sensitivity (CS), reaction time (RT) and processing

speed. We showed that training on a task targeted on increasing neural facilitation and decreasing suppression resulted in changes of the E/I balance, enabling plasticity and thereby inducing visual improvement. Presbyopes were trained on contrast detection of Gabor targets under collinear facilitation and backward masking (BM) conditions, posing spatial and temporal constraints on the visual processing in order to induce changes in the E/I balance. Training (15 minutes / session, 3 times / week) covered a range of spatial frequencies and orientations. Applying our PL technique in young subjects also leaded to a shortening of processing latency and to suppression reduction. In presbyopia, our PL protocol resulted in a remarkable improvement in VA (≈ 81%), CS, contrast discrimination, RT and in decreased BM, with no changes in the optical functions of the eye. Consequently, after training, near visual functions reached the level of young subjects, reducing the effective eye age by an average of 8.7 years. Using mobile iOS-operated devices with higher screen resolution (iPhone, iPad, iPod) as a training tool demonstrated even better results. Therefore, improving CS and temporal processing (decreased BM & shorter RT) by PL may enable presbyopes to recover a reliable percept from the blurred and delayed image received from the aging eye, thus overcoming the bottleneck in the early visual cortex and providing a normal output for the remaining visual stream for further processing. The results thus suggest that the aging brain retains enough plasticity to overcome the natural biological deterioration and regain visual functions. The transfer effect of learning indicate that PL can become a practical tool to improve various visual functions.

15:00-15:30

Myopia: An epidemic with consequences for public health, clinical practice and research

Wendy Marsh-Tootle, OD, MS
School of Optometry, University of Alabama at Birmingham, USA

Increases in the prevalence of myopia have been shown world-wide. The etiology of "simple" myopia; i.e., that presents during the school years and is not related to systemic disorders, remains puzzling. Genetics and environment, both geographic and visual, have been shown to influence the prevalence of myopic refractive error; for example, 80-90% of Asians living in East Asia develop myopia, compared to roughly 30% of Asian children living in the US. Intensive near work has been shown to influence myopia onset and progression among genetically heterogeneous Israeli school children. The influence of ethnicity, geography and culture seem to combine in East Asia leaving 10-20% of young adults with higher amounts of myopia and longer eyes. Young adults living in Asia today can no longer benefit from attempts to reduce myopia or its progression, and instead will require increased services from tertiary level ophthalmologists to treat the pathological consequences of high myopia: increased susceptibility to damage from glaucoma, retinal morbidity (detachments, tears, macular holes and choroidal neovascularization) and complications from cataract surgery.

Despite many attempts to control myopia progression, no optical or pharmacological therapy has been demonstrated to be efficacious and free from unwanted side effects. Optical therapies, aimed to reduce hyperopic blur on the retina (which has been shown to promote axial elongation and myopia in animals), have shown limited effects. Atropine eye drops have shown the largest benefit, but must be used for many years, and have unwanted effects on focusing, and possibly alignment and retinal function. Various factors in the visual environment have been shown to exert their effects after the onset of myopia, while only hours spent outdoors seems to have a protective effect. Results from a randomized trial evaluating the effect of increased outdoor exposure on myopia in first graders in Gangzhou are eagerly awaited.

The consequences of myopia on eye research in Asian adults are staggering; attempts to define the pathology of any eye disease will be confounded by changes from myopia that will co-exist in most eyes. While the consequences of uncorrected refractive error are more obvious, fully corrected myopes have some perceptual differences, including reduced sensitivity to optically induced blur, and a tendency to under-accommodate especially to blur imposed by diverging lenses. The financial burden of detecting and correcting myopia itself, as well as its related conditions, will drain the resources that can be otherwise spent elsewhere.

15:30-16:00

Improving low vision orientation and mobility training

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Mobility is the ability to travel independently, safely and efficiently. Orientation and Mobility (O&M) training is the only proven remedy to restore functional mobility in low vision patients. However, O&M evaluation and training are typically done in a one-on-one manner between an instructor and a patient on real streets, which imposes severe restrictions on the efficiency, affordability and accessibility of this valuable treatment. Clinical researches are conducted to improve three aspects of O&M training. 1. Predicting mobility from visual function tests. Visual function tests such as visual acuity, visual field or contrast sensitivity are easy to administer in clinics but have only limited ability to predict a patient's mobility needs. Studies of legally-blind patients' feature search behavior demonstrated that search reaction times can account for 60-70% of variance in speed and obstacle contact when the patients walking through an indoor obstacle course. This suggested the feasibility of using simple search tests to assess functional mobility. 2. Search training as a supplement to O&M training. While O&M training emphasizes high level visual skills for specific mobility tasks such as crossing the street or negotiating crowded environment, reprogramming low level visual routines, such as oculomotor control and attention deployment, may help to compensate for lost vision and thus improve mobility. In a visual search training study, it was found that legally-blind patients made significantly fewer obstacle contacts on an obstacle course after 5 sessions of feature search training, compared to their pre-training walks. This study demonstrated the feasibility of using unstructured, goal-driven perceptual/oculomotor training to improve functional mobility. The relatively small training effect might have been related to the small room for improvement offered by the simple

feature search task. Training on a more demanding search task may help to bring out more pronounced mobility improvement. 3. Visual skill training in a virtual environment. A large portion of O&M training is spent on acquiring visual/auditory skills that ensure speedy and reliable acquisition of critical information for safe travel. Computer-generated virtual environment has the potential to facilitate such training in a more flexible, affordable and efficient way. A semi-CAVE virtual reality simulator is built to present visuoauditory information of virtual street intersections modeled after real street intersections. Legally-blind patients were asked to perform a set of information gathering tasks for safe crossing of streets in paired real and virtual street intersections. It was found that the patients' ability or inability to perform the tasks in virtual intersections was highly correlated with their ability or inability in the corresponding real intersections, and vice versa. The high degree of agreement demonstrated the validity of using virtual scenarios to supplement real street O&M training.

16:00-16:30
Neuroprotection in glaucoma

Kwok-Fai So
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Glaucoma is a progressive neuropathy characterized by loss of vision as a result of death of retinal ganglion cells (RGCs). There are currently no effective neuroprotectants to treat this disorder. In this series of study, we have used LINGO-1 antagonists, Nogo-66 receptor (NgR1) antagonists, sNgR-Fc, BDNF, and Wolfberry to study the neuroprotection of RGCs in a rat glaucoma model with chronic ocular hypertension.

LINGO-1 was expressed in RGCs and up-regulated after intraocular pressure elevation. Blocking LINGO-1 function with LINGO-1 antagonists, sLINGO-1-Fc and LINGO-1mAb 1A7 significantly reduced loss of RGCs 2 and 4 weeks after ocular hypertension. LINGO-1-Fc treatment blocked the RhoA, JNK pathway and promoted Akt activation. LINGO-1 formed a receptor complex with TrkB and negatively regulated its activation in the retina after ocular hypertension injury. Blocking LINGO-1 function with sLINGO-1-Fc or 1A7 upregulated phospho-TrkB phosphorylation after high intraocular pressure injury. BDNF antibody significantly blocked the neuroprotection of LINGO-1-Fc on RGC survival. Similarly, in combination with BDNF, LINGO-1-Fc provided significantly more protection to RGCs in the 4 weeks glaucoma animals. LINGO-1 antagonism therefore promotes RGC survival by regulating the BDNF and TrkB signaling after ocular hypertension.

NgR1 was expressed in RGCs and upregulated after intraocular pressure elevation. There was synaptic disconnection for RGCs after ocular hypertension and preceded the cell death in the ealy stage. The upregulation of NogoA may be a possible mechanism of RGC death and synapse degeneration in the glaucoma. Treatment with sNgR-Fc significantly reduced loss of RGCs at 2 and 4 weeks after the induction of ocular hypertension. Furthermore, administration of s-NgR-Fc attenuated synaptic degeneration at 5 days, and at 2 and 4 weeks. This would suggest that there may be an opportunity for the rescue of RGCs that are undergoing synapse alteration, but possibility not yet committed to die.

Anti-aging drugs from Chinese medicinal herbs may be one of the possible interventions for glaucoma. The fruits of Lycium barbarum (Gou Qi Zi, or Wolfberry), has been used for thousands of years in China and is believed to be effective as an anti-aging agent as well as nourishment of eyes, livers and kidneys. We have shown that aqueous extract of Wolfberry containing polysacacharide provides neuroprotection to the RGCs against degeneration in an experimental model of glaucoma via up-regulation of crystallins and IGF-1 and down-regulation of endoethelin-1.

These data suggest that LINGO-1, NgR1 antagonists, and Wolfberry may provide an attractive therapeutic strategy to prevent neurogeneration in glaucoma.

Grant support: The Jessie Ho Endowed Professorship in Neuroscience, and the Azalea (1972) Ednowment Fund, The University of Hong Kong.

July 7th, Sunday
Afternoon Sessions
14:30-16:30, Bai Yun Hall
Talk Session VI
Multi-facets of Vision I
Moderator: Samuel G. Solomon, Ling Li

14:30-14:50
Older adults fail to alter toe clearance in response to texture cues to material changes when climbing a step

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Older adults show a reduced sensitivity to second-order modulations of second-order (texture) contrast (Habak, Faubert, 2000, Vision Research, 40,943-950), however the resultant behavioral deficits are unclear. Second-order cues are known to contribute to the differentiation of material versus illumination changes (Schofield et al, 2006, Vision Research, 46, 3462-3482) and we hypothesized that appropriate manipulations applied to a step should alter toe clearance in younger but not older adults. We covered a 150 mm high curved step with printed textures and illuminated the step with a spotlight. We used two textures: (i) the uniform contrast texture had no second-order variation and so appeared as a normally shaded undulating surface. (ii) The low-contrast step had a region of reduced contrast on the riser so as to mimic a subtle material change. On each trial participants were asked to first estimate the step height by raising one foot and then walk up the step. Each participant completed 10 trials for each texture in counter balanced order. Eight younger (mean age 28 years) and eight older (mean age 70 years) adults took part, all wearing their normal optical correction. Toe positions were recorded using a Vicon motion capture system. There

was a significant main effect of age on estimated step height but no effect of texture type. When climbing the step younger adults allowed an additional 9.6 mm clearance for the low contrast step compared to the uniform step. Older adults did not make this adjustment. The interaction between age and texture was significant ($F(1,14) = 7.189$ $p = 0.018$). Thus although the texture manipulation did not affect perceptual estimates of step height it did alter stepping behavior in the younger, but not older, adults. This result suggests that subtle texture cues to material changes can affect toe clearance when stepping but are not available to older adults.

14:50-15:10

Structure of neural correlations in the middle temporal area of the marmoset monkey

Selina S. Solomon, Spencer C. Chen, John W. Morley, Samuel G. Solomon
University College London

Shared connectivity causes the activity of sensory cortical neurons to fluctuate together. These correlations depend on the functional similarity of the neurons and their relative position in the cortex. We investigated how neuronal correlations in the middle temporal (MT) area depend on distance and direction tuning. Methods: Extracellular recordings were made from area MT in 6 adult male marmosets, Callithrix jacchus, anaesthetised with sufentanyl forte (9 ug/kg/hr). A 10×10 array of single electrodes (spacing 0.4 mm) was inserted to a depth of 1 mm. The stimulus was either a dot field, or a sine-wave grating, drifting for 2 s in one of 4 directions. Spike-count correlations (rSC) and cross-correlograms between pairs of direction-selective neurons were estimated. Results: We recorded from 2497 (dot-fields) or 2850 (gratings) pairs of single-units. rSC between pairs of neurons with similar preferred direction, and within 0.4 mm of each other, was ~0.18. rSC decreased with distance, and with difference in preferred direction. Dependence of rSC on distance was associated with changes in the cross-correlogram at all time scales. Dependence of rSC on preferred direction was associated with large changes in the cross-correlogram over long time-scales (~500 ms), with less difference at short time-scales (~50 ms). Neuronal correlations were similar for gratings and dot-fields, but stimulation with gratings was associated with slightly higher rSC, and higher peaks in the cross-correlograms, that extended over greater distances and were less dependent on difference in preferred direction. Conclusion: Neurons in area MT are more likely to show correlation in spike rate when they are close together, and thus their receptive fields overlap in space, and when they have similar preferred directions. The strength of neuronal correlations depends on stimulus and is less for a dot-field, which contains a wide range of spatial and temporal frequencies, and therefore drives a wider range of the afferent input to area MT.

15:10-15:30

Apparent motion traversing horizontal and vertical meridians.

Takao Sato, Maata Fujita, Hidetoshi Kanaya
Department of Psychology, University of Tokyo

We examined the effect of crossing vertical or horizontal meridian of the visual field on perception of classical apparent motion. We used motion quartet, a stimulus display comprised of a pair of two disks placed at two diagonally opposite corners of a virtual square that induces a multistable perception of horizontal and vertical apparent motions. By manipulating the ratio between the length of vertical and horizontal edges of the vertical square, it is possible to match the percentages of perception for horizontal and vertical motions. The matching point, the ratio of edge lengths, indicates the relative strength of vertical and horizontal motion signals. The ratio should be 1 when the strength of vertical and horizontal motion signals are equal.

In the experiment, we first used a small (1×1 deg) motion quartet and manipulate the edge-ratio. The center location of the display was varied on the horizontal and vertical meridians, and several other positions were tested, too. The results indicated that the V/H ratio was close to one at all the places except for locations with high excentricity (>10 deg) on the horizontal meridian, where the vertical length was shorter than horizontal by 30%. Results were almost the same when a larger (8×8 deg) stimulus was used. These results indicate that motion signals were weakened for apparent motions crossing horizontal meridian than for other motions including those crossing vertical meridian. These rather counterintuitive results suggest that classical apparent motion is not mainly processed in V1 where right and left hemi-fields were represented in separate hemisphere. Instead, it is processed mainly in V2 or V3 where the upper and lower hemispheres were represented in separate areas located on the opposite sides of V1.

15:30-15:50

Space perception favors the tall with a larger eye height above the ground surface

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Large background surfaces, particularly the ground surface, act as a reference frame for space perception in the intermediate distance range. Arguably, the perceptual mechanisms underlying space perception are shaped by our terrestrial environment and habitat. After all, we often function in rooms defined by wall, ceiling and ground surfaces. Moreover, our daily activities frequently involve objects at, or below, the eye level. These considerations lead to the hypothesis that space perception is more accurate and reliable below the eye level (ground as reference) than above (ceiling as reference). There is empirical support for this response asymmetry. Here, we tested a related hypothesis that tall observers exhibit a stronger asymmetry in space perception about the eye level than short observers. This is because tall observers typically have a larger eye-height relative to the ground than the ceiling. We tested observers in a dark condition and a reduced cue condition where an array of dimly lit texture elements served as the background surface either above (as ceiling), or below (as ground), the eye level. A dimly lit target was presented 1.5-7.0 m above or below the eye level, and the blind walking-gesturing task was used to measure the perceived location. We also used a verbal report task to measure the perceived eye-to-target distance. Tall (eye height = 1.75 ± 0.03 m) and short (eye height = 1.49 ± 0.05 m) groups of observers were tested. We found that both groups were more accurate in localizing

the target below the eye level both in the dark and reduced cue conditions. However, the tall group exhibited a larger response asymmetry. The tall group also perceived the eye-to-target distance more accurately than the short group when the target was seen below the eye level. Altogether, our results suggest that the ecological constraint regarding eye height influences space perception when depth information is insufficient.

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15:50-16:10

Neuronal coherence of frontal and parietal brain areas in visual working memory maintenance

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Visual working memory (VWM) helps us temporarily maintain and manipulate coherent visual information for cognitive task. Although the fronto-parietal network is central to VWM, the underlying neuronal mechanism related to early and late maintenance of the contents in WM, is unclear; it might act by the same mechanism or not. To address both possibilities, we recorded electrophysiology in humans while subjects performed a VWM task requiring retention of objects information across a delay lasting for 900 ms, which was divided into early and late retention intervals. During early retention, frontal activities in low frequency band (delta/theta) were VWM load-dependent, but during late retention, both frontal and posterior activities, and frontal-posterior coherence in high frequency band (alpha/beta) were load-dependent. Furthermore, during early retention frontal activities and frontal-posterior coherence in low frequency band were partially correlated with behavior, but during late retention, frontal-posterior coherence in high frequency band was partially correlated with behavior. These results provide a new line of two different neuronal mechanisms for fronto-parietal network related to early and late maintenance, in which early maintenance modulates the δ-, and θ-frequency bands and late maintenance modulates the α-, and β-frequency bands. This working mechanism might promote efficient maintenance of information in VWM.

Grant support: NSFC (91120016)

16:10-16:30

The transfer of left side bias in the perception of simplified and traditional Chinese characters

Tianyin Liu, Su-Ling Yeh, Janet Hsiao
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Chinese character recognition expertise involves a left side bias (LSB) effect in similarity judgments of mirror-symmetric characters, i.e., judging a chimeric character made from two left-halves of the original character being more similar to the original than one made from two right-halves (Hsiao & Cottrell, 2009), and this effect is stronger in characters in familiar fonts than in unfamiliar fonts (Tso, 2012). Here we examined whether the LSB effect can transfer across the simplified and traditional Chinese scripts in familiar and unfamiliar fonts in simplified Chinese readers from Mainland China and traditional Chinese readers from Taiwan. We found that in general the LSB effect in expert Chinese character processing can be transferred to the Chinese script that the readers are unfamiliar with. In contrast, the font specificity in the LSB effect (i.e., a stronger LSB in characters in familiar fonts than in unfamiliar fonts) is limited to characters with the visual complexity of the script that the readers are most familiar with. This effect suggests that the font specificity in the LSB effect emerges late in the development of Chinese character recognition expertise, and is consistent with the font tuning effect observed in visual word recognition, which refers to the phenomenon that expert readers are more sensitive to font variations than novice readers (e.g., Gauthier, Wong, Hayward & Cheung, 2006).

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July 7th, Sunday
Afternoon Sessions
17:30-18:30, Fei Quan Hall
Plenary Speech VI

Sophisticated information processing in the retina

Masao Tachibana
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Retinal synapses and circuits are specialized and fine-tuned to minimize noise, to extract features, to adapt environment, and to convert signals to spike discharges. Importantly, the brain knows only spike discharges conveyed through the optic nerve. It is widely believed that the retina is a simple spatiotemporal prefilter, and that the brain performs complex information processing. The retinal function is frequently speculated based on the receptive field properties of ganglion cells. However, we still do not understand how the ganglion cell's receptive field is created by retinal circuits, and whether each ganglion cell analyzes only the visual inputs falling upon its receptive field independently. Many ganglion cells show the center-surround antagonistic receptive field. The receptive field surround is created not only by horizontal cells but also by amacrine cells, which send direct inhibitory inputs to ganglion cells and presynaptic inhibitory inputs to bipolar cell terminals. We examined the properties of presynaptic inhibition at bipolar cell terminals. We found that reciprocal and lateral inhibition regulated the bipolar cell output independently. Reciprocal inhibition was local and driven by strong output from each bipolar cell terminal, whereas lateral inhibition was global and driven by output from a population of bipolar cell terminals. Dual inhibition contributed to efficient signal transmission to postsynaptic neurons. We also

examined the relationship between the dendritic arborization of ganglion cells and the summation area of the receptive field center. We found that the summation area matched well to the effective diameter of the dendritic arborization, irrespective of ganglion cell subtypes. However, the receptive field center estimated by a moving bar was wider than that estimated by a flashed bar, and the moving bar generated spike discharges earlier than the flashed bar. These results suggest that the anticipation of moving object may start even in the retina. To examine whether each ganglion cells could code information independently, we analyzed the spike discharges recorded from multiple ganglion cells. We found that synchronization of spike discharges among specific subtype of ganglion cells seemed to be important for feature extraction. These results indicate that the retina is incredibly sophisticated system.

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July 7th, Sunday
Poster Sessions
Perceptual learning, Social cognition,
Disease, Development, Other
9:30-17:30, Bai Yun Hall

D3-001
Unconscious contingency learning modulates conscious visual perception

Qian Xu, Li Wang, Yi Jiang
Institute of Psychology, Chinese Academy of Sciences

Living in an ever-changing world, humans own an incredible ability to detect critical contingencies between objects or events in the environment. Here we report that contingency learning can take place even when the stimuli are not consciously perceived and in the absence of any external reinforcements (e.g., rewards or punishments). In a modified cue-target paradigm, a pair of cueing stimuli (i.e., faces with neutral and fearful expressions or Gabor patches with horizontal and vertical orientations) was rendered invisible through continuous flash suppression, and systematic contingency was arranged between a designated cue and the spatial location of a subsequently presented target. Results revealed that, though outside of conscious awareness, observers could nonetheless learn the spatial contingency and automatically direct their attention to the invisible cue associated with the target. More important, the unconscious learning significantly boosted the visual dominance of the learned fearful facial expression, but not neutral expression or Gabor orientation, during binocular rivalry, suggesting that the conscious impact exerted by unconscious learning is tuned to biologically prepared stimuli with the amygdala likely being a key mediator. Our findings shed new light on the mechanisms underlying contingency learning, and provide a potential avenue for attentional bias modification, which may have important clinical implications.

Grant support: This research was supported by grants from the National Basic Research Program of China (No. 2011CB711000), the National Key Technology R&D Program of China (No. 2012BAI36B00), and the Strategic Priority Research Program of the Chinese Academy of Sciences (No. XDB02010300).

D3-002
Motion perceptual learning in noise

Nihong Chen, Hanyu Shao, Xuchu Weng, Fang Fang
Department of Psychology and Key laboratory of Machine Perception (Ministry of Education), Peking University; Center for Cognition and Brain Disorders, Hangzhou Normal University

Practice substantially improves motion direction discrimination. However, the neural mechanism of motion perceptual learning in visual noise is little understood. We studied this mechanism with functional magnetic resonance imaging (fMRI) before and after training. During training, subjects practiced six daily sessions (6,000 trials total) to discriminate motion directions of two successive random-dot kinematograms at 35% coherence, with the method of constant accuracy at 75% correct. Each subject was trained along one of the following eight directions that started from 22.5° and with an increment of 45°. Before, immediately after and two weeks after training, subjects' motion direction discrimination thresholds were measured along the directions that were 0°, 30°, 60°, and 90° away from the trained direction. Blood-oxygenation-level-dependent (BOLD) signals were also measured in a 3T GE magnet while subjects performed the same motion discrimination task along these motion directions at 75% correct. Behaviorally, practice gave rise to 48% improvement along the trained direction immediately after training and 45% improvement two weeks later, which transferred little to the untrained directions. BOLD signals were analyzed in V1, V2, V3, V3a, V5/MT+, and intra-parietal sulci (IPS), all of which were sensitive to visual motion. Compared to stimuli along the untrained directions, no significant amplitude change of BOLD signal responding to stimuli along the trained direction was found in the above ROIs. Using multi-voxel pattern analysis method, we discovered a persistent improvement of decoding accuracy in V5/MT+ for the trained direction, which lasted up to two weeks. These findings suggests that, after practice, the trained motion signal in noise could be represented and read out more accurately in the visual cortex and in the higher-level cortex respectively.

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D3-003
Functional and structural correlates of face perceptual learning in human brain

Taiyong Bi, Juan Chen, Tiangang Zhou, Yong He, Fang Fang
Department of Psychology, Peking University

Object recognition and discrimination can be significantly improved by perceptual learning. However, the neural mechanism of object perceptual learning remains illusive. In this study, we searched for the functional and structural correlates of face view discrimination learning in human brain. Subjects were trained to discriminate face views around an in-depth face orientation of 30°over eight daily sessions, which resulted in a significant improvement in sensitivity to the face view orientation. This improved sensitivity was highly specific to the trained orientation and persisted up to one month. Before, immediately after and one-month after training, subjects underwent MRI scans to obtain functional and structural brain images. We first performed univariate amplitude analysis and multivariate pattern analysis of BOLD signals responding to the trained and untrained face views in six face selective cortical areas (OFA, STS and FFA in both hemispheres). We found that, relative to the untrained views, the mean amplitude of BOLD signal in the left and right FFA increased for the trained view immediately after training. But the increase was short-lived and it disappeared one month later. On the other hand,

training improved the stability of the spatial activity pattern for the trained view in the left FFA. The improvement persisted even one month later and was correlated with the behavioral improvement. Then, we performed an ROI analysis of the face selective areas and a whole cortical surface analysis to measure cortical thickness before and after training. Although little cortical thickness change was detected after training, we found that the cortical thickness of the left FFA before training was inversely correlated with the behavioral improvement. That is, the thinner the cortex in the left FFA, the greater the learning effect. Taken together, these findings provide converging evidence that the left FFA plays a pivotal role in adaptive face processing.

D3-004
Perceptual learning improves neural processing in myopic vision

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The quality of visual perception is jointly determined by the efficiency of optical transmission and neural processing in visual system. As an optical condition that defocuses (blurred) retinal image of distant objects, myopia affects ~70% teenagers in China and impacts a variety of visual functions if uncorrected. In this study, we tested to what extent the optics-related visual deficits in myopia can be compensated through perceptual learning. Twenty myopic subjects were divided into training (N = 12, 23.0 ± 1.7 yrs) and control groups (N = 8, 23.6 ± 2.0 yrs). Subjects in the training group took pre-training measurements of the contrast sensitivity function (CSF) and visual acuity (VA) in both eyes, a ten-day monocular training of grating contrast detection near their cut-off spatial frequencies, and a counterbalanced post-training measurements of CSF and VA. Subjects in the control group only participated in the pre- and post- measurements. Refractions were evaluated before and after experiments. We also adopted a noise-titration method to investigate the mechanism(s) underlying contrast sensitivity improvements in the trained eyes of three observers in the training group. We found that 1) training significantly improved CS at the trained spatial frequency and VA in both eyes (trained eye: CS by 4.5 dB and VA by 5.1 dB; untrained eye: CS by 2.4 dB and VA by 4.1 dB); 2) CS over a wide range of spatial frequencies also improved (by 4.0 dB); 3) training did not lead to any significant refractive changes; 4) CS improved as a result of decreased internal additive noise and increased ability of external noise exclusion; 5) improvements in CS and VA were almost fully retained for at least four months in the three subjects tested. These results suggest that neural plasticity may be robust in adults with myopia and perceptual learning may be a potential non-invasive treatment to compensate the optical deficits in myopia.

D3-005
Perceptual learning improves stereoacuity in anisometropic amblyopia

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Purpose: Amblyopia is a developmental disorder that results in deficits of monocular and binocular vision. Although traditional treatment in clinical practice, i.e. patching the fellow eye, is effective in restoring monocular visual acuity, it is limited in reshaping binocular function, especially stereopsis. This study was conducted to evaluate the effects of perceptual learning on stereopsis in adult observers with anisometropic amblyopia.

Methods: The stimuli used in this experiment were three different desultory textures which were red-green anaglyphed. Ordinary Red-green glasses were used to manipulate the disparity of the stimuli under fixed exposure duration. The observers were seven adults who had anisometropic amblyopia. Stereo acuity and visual acuity of both eyes were measured and compared before and after training.

Results: The results showed that training significantly reduced disparity threshold (mean = 49.1%) for all seven adult amblyopic observers. Stereoacuity tested with the Titmus Fly test improved 50.9% on average. Visual acuity also improved by 13.3% in the amblyopia eye after training. Moreover, the learning effects were largely retained over a test period of five months.

Conclusions: Perceptual learning is effective in restoring stereoacuity in adults with anisometropic amblyopia. Structured monocular and binocular training might be necessary to fully recover degraded visual functions in amblyopia.

Grant support: The Knowledge Innovation Program of the Chinese Academy of Sciences (CAS) and Institute of Psychology supported the research.

D3-006
Perceptual learning of direction discrimination modifies interaction between neuronal populations

Ke Jia, Sheng Li
Department of Psychology, Key Laboratory of Machine Perception (Ministry of Education), and PKU-IDG/McGovern Institute for Brain Research, Peking University

Purpose: Previous neurophysiological studies of perceptual learning (PL) have found that a consequence of extensive perceptual training is the modification of interneuron interaction. However, behavioral experimental evidence that supports this proposal is limited. Here, we investigate the effect of PL of motion direction

discrimination on the mutual inhibition between direction-tuned neurons by measuring the change in motion repulsion (MR) size before and after the training.

Methods: The experiment consisted of a pre-training test phase (session 1-2), a training phase (session 3-8) and a post-training test phase (session 9-10). In the training phase, 32 participants were randomly assigned to one of four training groups (2 tasks × 2 base direction; tasks: luminance or direction discrimination; base direction: 240 deg or 300 deg). Classical 3-up-1-down staircase procedure was used during training. Constant stimuli method was used to measure participants' discrimination threshold and size of MR in the pre- and post- training tests. The stimuli were dynamic random-dot displays (coherence level: 100%, speed: 4 deg/s, stimulus diameter: 10°) generated with Movshon /Newsome algorithm (Pilly & Seitz, 2009).

Results: (1) Training significantly decreased motion direction discrimination threshold along the trained direction ($p < 0.001$). This learning effect transferred little to the untrained direction ($p = 0.054$). (2) Motion direction discrimination training reduced bilateral MR size ($p < 0.01$). (3) Luminance discrimination training improved luminance discrimination capability in both directions ($p < 0.001$), but did not reduced the MR size (trained direction: $p = 0.51$, control direction: $p = 0.069$), confirming that the aforementioned reduction of bilateral MR size cannot be attributed to the training induced attentional shift or adaptation.

Conclusion: These results demonstrate that interaction between motion direction-tuned neuronal populations can be modulated by PL. Further investigations with modeling and brain imaging are required for better understanding of such interaction.

Grant support: National Natural Science Foundation of China (31271081, 31230029, 31070896), NationalHigh Technology Research and Development Program of China (863 Program) (2012AA011602)

D3-007
Spatiotopic perceptual learning mediated by retinotopic processing and attentional remapping

En Zhang, Gong-Liang Zhang, Wu Li
Beijing Normal University

Visual processing takes place in both retinotopic and spatiotopic frames of reference. While visual perceptual learning is usually specific to the trained retinotopic location, our recent study has shown spatiotopic specificity of learning in motion discrimination that putatively engages the dorsal visual pathway. To explore the mechanisms underlying spatiotopic processing and learning, and to examine whether similar mechanisms exist in the ventral pathway, we trained human subjects to discriminate an orientation difference between two successively displayed stimuli, with a gaze shift in between to manipulate their positional relation in the spatiotopic frame of reference without changing their retinal locations. Training resulted in better orientation discriminability for the trained than untrained spatial relation of the two stimuli. This learning-induced spatiotopic preference was seen only at the trained retinal location and orientation, suggesting experience-dependent spatiotopic form processing directly based on a retinotopic map. Moreover, a similar but weaker learning-induced spatiotopic preference was still present even if the first stimulus was rendered irrelevant to the orientation discrimination task by having the subjects judge the second stimulus' orientation relative to its mean orientation in a block of trials. However, if the first stimulus was absent and thus no attention was captured before the gaze shift, the learning produced no significant spatiotopic preference, suggesting an important role of attentional remapping. Taken together, our results suggest spatiotopic visual processing and learning mediated by interactions between retinotopic processing and attentional remapping.

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D3-008
The N2pc is increased by TDT learning but is unnecessary for the transfer of learning

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Practice improves human performance in many psychophysical paradigms. This kind of improvement is thought to be the evidence of human brain plasticity. However, the role of spatial attention is not fully understood during perceptual learning. An ERP markers of selective attention—N2pc component might help us understand the role of spatial attention during learning. In this study, we used event-related potentials (ERPs) to investigate whether the N2pc component changed during long-term visual perceptual learning. Fifteen subjects completed several days of training in a texture discrimination task (TDT), and were given a final test 14 days later. The results showed that behavioral TDT thresholds significantly decreased across training sessions, and this decrement was also present in the untrained visual field. ERPs showed training significantly increased the N2pc amplitude, and this effect could be maintained for up to 2 weeks. However, the increase in N2pc was specific to the trained visual field. Training caused spatial attention to be increasingly focused on the target positions. However, this process was not transferrable from the trained to the untrained visual field, which suggests that the spatial attention may be unnecessary for the location transfer of behavioral improvements.

D3-009
Learning to discriminate crowded orientations

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It has been shown that crowding could be alleviated by perceptual training. The underlying mechanism of the phenomenon has yet to

be clarified. Here we tackled this issue through investigating the specificity and generalization of perceptual learning of crowded orientation. Experiment 1 consisted of five phases – pre-test, training, mid-test, training and post-test. Subjects were trained to perform an orientation discrimination task with a target grating (radius: 1.5°; spatial frequency: 2 cycles/°; contrast: 1; orientation: 22.5° or -67.5°; eccentricity: 10°). The target was flanked by two different gratings positioned radially, which were identical to the target except that their orientations were randomized. In the tests, subjects' orientation discrimination thresholds were measured with the target and its orthogonal version, which were presented either alone or with the flankers. After practicing about 1700 trials, subjects' performance with the crowded target was significantly improved and the crowding effect was completely eliminated. In other words, subjects performed equally well when the target was present alone or with the flankers. More importantly, the improvement can completely transfer to the crowded orthogonal grating, but the transfer to the isolated gratings was weak. Subjects were further trained for 7200 trials over six days. Their performance improvement was found to be largely specific to the trained orientation. Experiment 2 further showed that the orientation discrimination training in Experiment 1 could even break motion crowding. Experiment 3 demonstrated that the learning effect with the crowded orientation transferred little to a different visual quadrant. These findings suggest that perceptual learning of crowded orientation comprises two stages. In the early stage, subjects acquired a general ability to separate the target and the flankers, thereby alleviating or eliminating crowding. In the late stage, they learned to process the target more accurately and more specifically.

D3-010
Improving spatial contrast sensitivity of older adults with contrast perceptual learning

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Widespread visual deficits accompany normal aging, and most of these deficits are attributed to a functinal degradation of the visual cortex. It has been reported that many visual functions can be improved by perceptual learning in older adults, which therefore provides an effective approach for recovering from age-related declines in visual processing. However, whether the spatial contrast sensitivity, a basic descriptor of visual function, can be improved in older adults with perceptual learning is still unknown. To address this question, we conducted three perceptual training experments on 40 older adults. Experiment 1, subjects were trained with a grating detection task near pre-training cut-off spatial frequency. Most of them (15/16) showed significant improvement of contrast sensitivity, mainly at high spatial frequencies. Experiment 2, subjects initially received repeated spatial contrast sensitivity function measurements, and then received the same training protocol as experiment 1. Again, most of them (15/16) showed substantial improvement of spatial contrast sensitivity, at both intermediate and high frequencies. Experiment 3, subjects were trained with a pattern containing information of multiple, both intermediate and high, spatial frequencies. They showed a similar improvement pattern in spatial contrast sensitivity with that in experiment 2. In all three experiments, the visual acuity of older adults increased slightly after training. All these results suggest that contrast perceptual learning can significantly improve the degraded spatial contrast sensitivity of older adults, which may be helpful to the recorvery of age-related visual deficits. Considering the results of contrast perceptual learning in normal adults reported in our previous studies, the improvement pattern of older adults found here may also suggest that the age-related decline in spatial contrast sensitivity occurs not only at high but also at intermediate frequencies, which challenges the traditional high-spatial-frequency decline theory.

D3-011
Unconscious orientation exposure in TPE training enables transfer of foveal orientation learning to orthogonal orientations

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Foveal orientation discrimination learning can transfer completely to an orthogonal orientation with training-plus-exposure (TPE) training, in which the observers practice one orientation while being exposed to an orthogonal transfer orientation in an irrelevant task (Zhang et al., JN2010). We propose that perceptual learning is high level, but multi-session training and focused attention at the trained orientation may suppress untrained orientation, which blocks learning transfer. It is the exposure that reactivates the suppressed orientation inputs, so that high-level learning can connect to these inputs to allow learning transfer.

Here we show that the exposure is equally effective without awareness. Specifically, an observer either practiced Gabor orientation discrimination (126/36 degree, 1.5 cpd/6 cpd, 0.47 contrast) or was exposed to the orthogonal Gabor (36/126 degree) in one same eye in alternating blocks of trials. In the exposure condition the observers judged whether the stimulus was a Gabor or a letter C while the fellow eye was presented with flashing white noise to suppress the awareness of the Gabor/C stimulus, which led to chance-level performance. However, learning still transferred completely to the orthogonal orientation, suggesting that the exposure enabled learning transfer without stimulus awareness. Learning did not transfer in a control condition in which no Gabor/C stimulus was present, although the observers were unaware of the stimulus absence due to flashing noise suppression, so the transfer could not result from the presence of the flashing noise.

These results suggest that the exposure part of TPE training requires no conscious monitoring and attentional modulation. The unconscious orientation exposure may reactivate V1 inputs representing the transfer orientation that are likely suppressed by training-related focused feature attention on a different orientation, which establishes functional connections between high-level learning and the untrained orientation to allow learning transfer.

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D3-012
Push-pull training reduces interocular suppression in amblyopic vision

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Amblyopia is characterized by poor visual acuity in the amblyopic eye (AE) and degraded stereoacuity. Perceptual learning, in which observers practice visual discrimination with their AEs, improves these visual functions to some degree. Here we asked whether a push-pull training method would reduce interocular suppression, in order to further improve visual acuity and stereoacuity in amblyopes who have previously participated in many hours of perceptual learning experiments. In push-pull training, AE practiced contrast discrimination with two 45° Gabors (SF = 1/2 cutoff frequency) whose contrasts differed by 1.5 times threshold while NAE was presented with bandpass noise (centered at 1/2 cutoff frequency). A staircase measured the tolerable noise contrast in NAE to allow successful contrast discrimination in AE during push-pull training. In pre- and post-tests, AE and NAE stimuli were switched to measure the tolerable noise contrast in AE. Interocular suppression was defined by the difference between AE and NAE tolerable noise contrasts. After 10-days (20-hrs) training, interocular suppression was reduced by 57.3% ($p < 0.001$). This reduction was specific to the trained orientation (12.9% improvement with 135° Gabors, $p = 0.36$) and task (0.3% improvement in tumbling-E orientation judgment, $p = 0.43$), but the tolerable noise contrast in NAE was reduced by 49.3% ($p = 0.015$) with a new bandpass noise at a 2-octave lower center frequency. Stereoacuity was improved by 25.2% ($p = 0.001$), on top of the 54.7% improvement after perceptual learning, but AE visual acuity was not further improved (by 1.5%, $p = 0.33$). Our results show that push-pull training can reduce interocular suppression in an orientation and task specific manner in amblyopes even after many hours of previous perceptual learning experiments. Push-pull training further improves stereoacuity, but has no extra impact on AE visual acuity.

D3-013
Brain mechanisms associated with background-orientation specificity and target-location specificity of texture discrimination learning

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This study used high-density event-related potentials (ERPs) to investigate the brain mechanisms associated with background-orientation specificity and target-location specificity in texture discrimination task (TDT) learning. Human adults were trained for a single session of 1.5 hour and their ERPs were recorded on the following test day. Although behavioral performance showed only background-orientation specific learning effect, ERPs revealed both background-orientation and target-location specific changes associated with TDT learning. While the background-orientation specificity mainly involved amplitude enhancement of early N2pc over occipital cortex, the target-location specificity engaged modulation of spatio-temporal configurations of N2pc component (shifting from the late-high to the early-low pattern) and decrease of frontal P2 amplitude. The differential effects associated with target-location specificity versus background-orientation specificity indicate dissociable brain mechanisms are involved in perceptual learning (PL) of task-relevant and task-irrelevant features. Task-irrelevant PL effect mainly involves changes of activity in the early visual cortical areas, Task-relevant PL engages, however, not only the early visual cortical processing, but also the top-down attentional modulation originating from higher frontal cortex. These two processes may induce opponent effects on the specificities observed in behavioral improvement. A compensation role of top-down reactivation mechanism in the generalization of PL is proposed.

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D3-014
Eye position distribution depending on head orientation in watching ultra high definition television

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A gaze is directed to a point of interest in the visual field and the shift of gaze is accomplished with combinations of eye, head and body movements. Previous studies showed a unique correlation between horizontal eye position and horizontal head orientation during visual search experiment with simple stimuli (Fang et al., VSS2012), or during observation of the stationary scenes (Nakashima et.al, APCV2012). When the head is oriented to the left or the right with respect to the body, the eye tends to look left or right relative to the head. In this study, we investigated the collaborative movements between the eye and the head while viewing videos in a much more realistic condition than previous ones. We used an 85 inch 8K ultra high-definition television (UHDTV) display, which had a resolution of 7680×4320 pixels (33.2 megapixels). Participants on a chair watched video clips of several types of scenes made for UHDTV without any restriction of head movements (the body seldom moved in the chair). The video was displayed for about 15 minutes and the participants performed two simple tasks: to press a key when they noticed the change of scene (usually between clips) and to estimate the degree of blur when they noticed blurring of the image (sometimes fast motion created image blur). The results showed a correlation between horizontal eye position and head orientation, which is similar to that of our previous studies. That is, when the head is oriented to the left or the

right with respect to the body, the eye tends to look left or right relative to the head. The findings suggest that head movements may be an important factor to evaluate the viewing condition of large field display such as that of a UHDTV.

D3-015
Different eye-movement patterns between own-race and other-race faces in Chinese children

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A typical adult eye-tracking finding shows that individuals use different fixation pattern when viewing own-race and other-race faces producing the other-race effect (ORE). For example, adult fixate more on the eyes for other-race faces, but on the nose and mouth for own-race faces. There however has been little research on how children recognize own-face and other-race faces differently and how those patterns change with the change of time. The present study explored this topic in 4- to 6-years-old Chinese children using eye-tracking techniques. Forty-eight children (24 female) learned 32 own-race faces (Chinese) and 32 other-race faces (Caucasian) one by one and tested immediately after learning while their eye-movement were recorded with Tobii 1750 eye-tracker. Each face was presented for 6s for study followed by a 3s fixation. A probe face then appeared and children had to indicate whether or not the probe face was the same as the study face. For both the learning and the testing phases, the total duration of fixation on each pixel of the entire face was computed using the iMap toolbox. For the testing phase, percentage of shift between 4 AOIs (Area-of-interest, two eyes, nose, and mouth) were computed using scan path analysis. During the learning phase, results showed significantly more fixations on the eyes for other-race faces but on mouth for own-race faces. For own-race faces, children looked more at the eyes and mouth in the early study period (1-4s) but more to the nose in the late period (5-6s). For other-race faces, eyes, mouth and nose were all fixated and this pattern remained unchanged from the early to the late periods. During the testing phase, for own-race faces, children tended to look at the eyes. For other-race faces, the fixation pattern was no different from the learning phase. Results from the scan path analysis showed significantly more gaze shifts between the two eyes for other-race faces than own-race faces. In conclusion, several eye-movement measures indicate a clear difference between recognizing own-race and other-race faces in Chinese children. In addition, compared to adult's fixation pattern children tend to spend less time to look at nose.

D3-016
Material perception of Japanese lacquer (Urushi); Effects of luminance gradient and binocular convergence on perceptual glossiness

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Japanese lacquer (Urushi), derived from the natural resin obtained from the tree, Toxicodendron vernicifluum, is a remarkable material in the repertoire of traditional Japanese craftsmanship. Physical properties of lacquer are well known, but its perceptual impact has not been objectively analyzed. Interestingly, Japanese art experts perceptually evaluate its quality by moving the lacquer board, apparently to look at changes in observed glossiness, suggesting that image motion information and perception of material lacquer are somehow related. In this study, perceptual image cues and motion image information - which indicate gloss perception of lacquer - were investigated by optical measurement and psychological experiment. Lacquer boards of twelve different gloss-levels were used as stimuli. Optical stimulus properties were quantified using a two-dimensional luminance profile and its spatial gradient obtained from reflection images of a light-source. Magnitude Estimation (ME) revealed a well-behaved, non-linear relation between subjective responses and optical properties. However, this statistically significant relation was observed in ME responses of only three gloss-levels. The gloss recognition experiment clarified that the motion image information was actually a hindrance to non-expert subjects. During the recognition experiment, subjects' eye movements were recorded, and convergence angles were calculated. The convergence angle showed that subjects changed the distance of fixation point, suggesting that the three-dimensional image cue was used for judgment of glossiness, and the specific image cue used for gloss judgment varies according to the level of the glossiness.

D3-017
Do we really look up inside when facing dignitary?

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Growing evidence showed that power was linked with vertical space. High power is "up", and low power is "down". Here we further investigated the relationship between power and eye-movement in vertical space or snobbery phenomenon. In Experiment 1 and 2, words of power were presented in the center of screen. Participant was only required to finish naming task and data of eye-movements was recorded. Results showed that high power words led to relatively high position of eye-movement in vertical space. Moreover, there was a significant linear relationship between the degree of power and eye-movement position in vertical space. These results clearly suggested that we inherently have snobbish attitude to others. We look up inside when facing dignitary, but look down when facing nonentity.

D3-018
Infants' perception of cast shadows

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Cast shadows are formed when an object that blocks the light from illumination project onto another surface. Previous studies

suggested that 6-7-month-old infants could perceive the depth from cast shadows (Yonas & Granrud, 2006; Imura et al., 2006). However they did not examine whether infants could perceive the region of shadow as the cast shadow. In this study, we investigated this question in 5-8-month-olds. If infants perceive cast shadows; they could distinguish whether the shape of object is congruent with that of the cast shadow. We created the congruent and incongruent figures in which the object was presented with a cast shadow that originated from the original object (congruent figure) or a different object (incongruent figure). In Experiment 1, we tested whether 5-8-month-olds could detect the incongruence between objects and cast shadows by familiarization method. Infants were familiarized with two kinds of congruent figures and then tested for novelty preference with a congruent figure and an incongruent figure simultaneously. If infants detect the incongruence between objects and cast shadows, they would show the novelty preference to the incongruent figure. Result revealed that only 7-8-month-olds showed novelty preference to the incongruent figure. This result suggested that 7-8-month-olds could detect the incongruence between objects and cast shadows. Changing of the appearyance of the shadow could change the perception of the cast shadow (Hering, 1874/1964). If infants could perceive cast shadows same as adult, the novelty preference shown in Experiment 1 would disappear. In Experiment 2, we test this possibility by used the stimuli which were added outlines on the penumbra of shadow so that the region of shadow was perceived as a dark area but not the shadow. The result revealed that infants did not show any novelty preference observed in Experiment 1. These findings indicated that 7-8-month-olds could perceive cast shadows.

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D3-019
Three-quarter view preference for three-dimensional objects in 8-month-old infants

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It has been reported that human adults perceive object images in a view-dependent manner: three-quarter views are often preferred to other views, and the sensitivity to object orientation is lower for three-quarter views than for other views. In this study we examined infants' visual perception of three-dimensional common objects. We tested whether adult-like characteristics were observed in 6- to 8-month-old infants by measuring their preferential looking behavior. In Experiment 1 we examined 190- to 240-day-olds' sensitivity to orientation change and in Experiment 2 we examined these infants' preferential looking for the three-quarter view. Results showed that in Experiment 1the 240-day-olds' sensitivity to orientation was lower at the three-quarter view than for other views for some objects, while the 190-day-olds' sensitivity was not shown such characteristics. In Experiment 2 the 240-day-old infants showed preference for three-quarter views for some objects, while the 190-day-old infants did not. The 240-day-old infants' perception of object view is (partly) similar to that of adults. These results suggest that human visual perception of three-dimensional objects develops at 6 to 8 months of age.

D3-020
Cooperation and competition affect distance perception

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It has been revealed that social information affects our basic information processing. However, as an important type of social information in our daily life, cooperation and competition, so far few studies have explored their influence on our cognitive processing (e.g., perception). Here we investigated this issue by examining whether cooperation and competition affect our distance perception. In a 3-seconds-video, two circles tracked a square in three patterns: in cooperation, in competition, or in random. After that, all these objects were replaced by two static circles with a certain distance between. Participants were required to adjust the distance between the static circles as the one exhibited at the moment the two moving circles disappeared. The distance between cooperation and random conditions was equal at the disappeared moment, so was the distance between competition and random conditions. We found that the distance adjusted by the participants was significantly longer in the cooperation condition than in the random condition; yet no difference was found between competition and random condition. These results, for the first time, provide evidence suggesting that cooperation and competition affect our distance perception.

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D3-021
Where your eyes fall? Exploring Taiwanese adults' eye tracking for own-, near-, and other-race faces

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Backgrounds: The other-race effect (ORE) is a long-standing observation that human adults can recognize own-race faces better than other-race faces (Meissner & Brigham, 2001; Hsu & Chien, 2011). Wang et al. (2011, July) explored Taiwanese adults' discriminability for other-race and near-race faces, and found that Philippine faces were seen as more like own-race faces than other-race faces. The present study aims to further scrutinize the looking pattern for own-, near-, and other-race faces with an eye tracking device.

Methods: We used Tobii T120 Eye Tracker to record 13 Taiwanese adults' eye movements real time while performing a visual paired-comparison face recognition task. The face stimuli contained female faces of four ethnic groups (Taiwanese, Caucasian, African, Filipino) with four levels of difficulty manipulation (Easy, Medium, Hard-eye, and Hard-mouth).

Results: We examined the accumulated fixation times within four AOIs of each face (whole face area, the eyes, the mouth, and the nose regions). Adults showed the best performances for Taiwanese and Philippine faces in easy, medium, and hard-eye conditions, however, the performance for African faces was the worst in all conditions. In terms of local feature analysis, the eyes region received the most attention across races. The participants can quickly discriminate faces by detecting the eyes for Taiwanese, Philippine, and Caucasian faces in easy, medium, and even hard-eye conditions. Moreover, the difference in the mouth area can only be detected for Taiwanese and Philippine faces, and not for Caucasian or African faces.

Conclusion: Overall, the eye tracking results showed strong evidence for other-race effect, and lend support to Wang et al.'s finding at a more mechanistic level. In addition, we seemed to adopt a better strategy in scrutinizing the eye and mouth regions for own- and near-race faces, but not as efficient in scrutinizing the local features for the other-race faces.

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D3-022
Developing a word-puzzle game to increase reading speed in peripheral vision

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Age-related macular degeneration (AMD) is a prevalent condition among elderly people. Patients often develop lesions in their central retina, causing bilateral central scotomas. As a result, they must rely on their peripheral vision to read, which is slow and difficult. A series of studies in our lab, beginning with Chung, Legge & Cheung (Vision Research, 2004), demonstrated that after four daily training sessions on a trigram (three adjacent letters) letter-recognition task, peripheral reading speed of normally sighted subjects increased by 40% or more. Despite this promising improvement, the training procedure suffers from being laborious and tedious. To make it more engaging and motivating, and given the potential merits of video games for enhancing perceptual performance, we set out to embed our perceptual-learning procedure in a game context. We modeled our game on the popular American TV show Wheel of Fortune, where the goal is to guess items from a given category (e.g., movie stars, or food). In our version of the game, a subject's correct peripheral letter-recognition responses to trigrams produce corresponding clues for guessing the items. In a block of 55 trials, the more correct responses the subject makes, the more clues available. Our preliminary work with normally sighted subjects has revealed their elevated interest and motivation in performing the task compared to the traditional training, and the subjects were able to utilize the instant feedback from the game to improve their performance. Preliminary results showed that this modified version of our perceptual-learning paradigm does result in improved reading speed, and our ongoing experiment will determine if the improvement exceeds that obtained from the same number of training trials conducted without the game context.

If our final results indicate that this game effectively enhances peripheral reading performance, we will consider adapting it to reading rehabilitation for AMD patients.

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D3-023
The behavioral characteristic of collinear facilitation in primary glaucoma

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Primary glaucoma is a major cause of blindness and is determined by optic nerve damages. It is difficult to diagnose definitely for good visual fields in an early stage. Instead, human performance in a kind process of higher level processing stage by visual cortex could be a compensatory way to detect functional loss. As one important characteristic in secondary level functions, collinear facilitation has been believed to be based on the interactions of cortical neurons. In this study, we investigated whether the behavioral performance of collinear facilitation could help diagnose primary glaucoma earlier than visual field loss.

We used the classical experimental paradigm which was 3 Gabors arranged from top to bottom with different target-flanker separation to compare the strength of collinear facilitation for glaucoma patients and healthy adults. 13 glaucomatous and 12 normal eyes were measured to detect Gabor either appeared individually or with flankers in the center vision. All the glaucomatous eyes contained less than 3 scotomas (including 6 eyes containing none) within eccentric 30° field of vision. Our results showed that the facilitation effects were decreased along with the increased separation in both groups. Interestingly, compared with independent Gabor, the threshold of contrast-detection by glaucomatous eyes were significantly lower at 4λ, 6λ and 8λ separation (λ: defined in multiples of the wavelength of the Gabors) respectively, and at 4λ and 6λ separation in normal eyes. Meanwhile, the performance improvement at 8λ separation in glaucomatous eyes were significantly higher than in normal eyes.

Our preliminary results indicated that the scope of collinear facilitation in fovea had enlarged earlier than peripheral visual field loss in glaucomatous eyes, providing a meaningful method for early diagnosis of primary glaucoma. Moreover, the increase in the range of neurons interaction suggested a compensatory change related to optic nerve injuries in primary glaucoma.

D3-024
Can infants tell the difference between gold and yellow?

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There is a large literature focused on the color perception of matte surface. However, recent research (Okazawa et al., 2011) showed

that the component of surface specular reflection, such as glossiness, also affects categorical color perception. For instance, the color term "gold" was used to name high specular stimuli within a specific range of chromaticity, which overlaps with those of yellow and orange for low specular stimuli. In the present study, we investigated whether the component of surface specular reflectance affects the color perception of 5- to 8-month-old infants by using the preferential looking technique. In the first experiment, we conducted a simple test to determine whether infants perceive yellow and gold as the same color by comparing their preference for these colors over green. If the infants perceive yellow and gold as the same color, they would show similar preference scores over green. On the other hand, if infants show different preference scores over green, it indicates that infants do not perceive yellow and gold as the same color. Only the 7-8 month-old infants showed different preference scores for gold and yellow over green. This result indicates that the 7-8 month-old infants perceive gold and yellow as different colors. In Experiment 2, we eliminated the component of specular reflectance on the gold surface and presented it against green to infants. A similar preference score of yellow over green was obtained. This result suggests that the difference between the preference scores for gold and yellow over green in Experiment 1 was based on representations of glossiness.

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D3-025
Effects of the exposure time on accuracy of eyewitness

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The accuracy of eyewitness was tested in briefly presented conditions. Acurracy of eyewitness about facial information were compared among 12 ms, 36 ms and 60 ms conditions of exposure time. Perceived ages were measured for examining accuracy of eyewitness. Stimulus were pictures of Japanese female faces from 20s to 60s age groups. All of participants were 20s. The results showed that participants recognized age of faces accurately in all conditions but main effects were not existed. They recognized more accurately when they saw faces from their own age group than faces from different age groups. These results suggest that eyewitnessed information is significantly accurate when face observed during very short time.

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D3-026
Social status affects size representation

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Recent studies have revealed a metaphorical association between physical height and social experience of human beings. For example, Duguid and Goncalo (2012) found that the experience of power makes people feel themselves taller than they are. However, few studies so far have concerned whether social information (e.g., social power, status) affects our daily visual perception. Here we explored the influence of social status on visual representation of physical size. In a change-detection task, we displayed two scene images in sequence with a blank interval between. The scene images conveyed social hierarchical interaction, for instance, an employee was reporting to a boss who was listening carefully. The participants were required to judge whether the physical size of the target person (50% was employee, 50% was boss) was increased or decreased relative to the one in the previous scene. In two experiments we shown that the superiors (e.g., the boss) were perceived larger while subordinates (e.g., the employee) were smaller relative to the size shown in the first scene; and this effect was not due to the specific gesture adopted by the target person herself (or himself). This work is the first to show that the information from social status affects size representation of vision.

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D3-027
Boundary contour of binocular rivalry stimulus affects activities in ocular dominance columns (V1) of anesthetized macaque monkeys

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Psychophysical studies reveal that perceptual dominance during binocular rivalry (BR) is predisposed to the rivaling image with the strong boundary contour (BC) (Ooi and He, 2006). To reveal whether such a BC-based BR perception can be contributed by activities in cortical area V1, we used intrinsic signal optical imaging to measure the neuronal population response in anesthetized and paralyzed macaque monkeys. The basic BR stimulus comprised a 1.5 deg grating disc (3 cpd) surrounded by an orthogonal grating background (5x5 deg) in one half-image (fixed-BC). The other half-image had a grating disc whose orientation was orthogonal to the fixed-BC grating disc. The saliency of the disc's BC was manipulated by phase-shifting its grating relative to the surrounding grating of the same orientation (variable-BC). Increasing the phase-shift strengthens the BC. We rendered the BR stimulus in orthogonal motion (2 c/sec) and measured cortical activities in 3.5-second windows. We found clear ocular dominance maps corresponding to the eye exposed to the fixed-BC half-image. The strength of the ocular dominance pattern decreases as the BC strength in the fellow half-image (variable-BC) increases. This

trend parallels the human psychophysical observations of BC strength influence on BR. We also found the ocular dominance/suppression-like activities are stronger in the cortical areas representing the BC than those representing the interior of the grating disc. Separately, we used pattern classification method to estimate the dynamic dominance scores based on sampling at 4 Hz over 60 seconds. We found a longer mean dominance duration associated with the eye simulated with strong BC. Altogether, the similarity between the macaque V1 neuronal population responses and human psychophysics indicates V1 contributes to BC-based BR. More generally, the data suggest BR is an integral mechanism in binocular surface representation.

D3-028
Looking at the big picture: Broadening attention elevates positive emotions and relieves depression

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Human attention varies in scope. Sometimes we see a forest; sometimes we only see a tree. That is, attentional scope can be broad or narrow. Previous researches have suggested that mood is an influential factor on attentional scope. It has been found that negative mood narrows and positive mood broadens attentional scope (e.g., Derryberry & Tucker, 1994; Fredrickson & Branigan, 2005; Rowe, Hirsh, & Anderson, 2007). In this study, we ask a different question by looking at the other side of the coin. What happens when we change people's attention? If we intentionally widen or narrow people's attentional scope, will this change people's mood for the better, or for the worse? In three studies, we found that sceneries with broad view may be able to make us feel relaxed and happy. In a two-week intervention by SMS via cellphone, broadening people's attentional scope in their daily lives enhanced their positive mood and reduced depression. Moreover, in a lab study, viewing gradually broadening sceneries from near to far eliminates the negative emotion resulting from watching a horror movie to a greater degree than viewing narrowing sceneries from far to near. While cognitive therapy is aiming at changing people's maladaptive thinking patterns and behavioral therapy is to change people's maladaptive behavioral patterns, our findings raise the possibility to intervene at a lower level process like attention and perception to change people's maladaptive attentional patterns. If negative mood is indeed associated with attentional bias, attention therapy may be able to reduce depression. Looking at the big picture cheers people up.

D3-029
A new set of 832 color pictures of objects with Chinese norms for 13 relevant psycholinguistic dimensions

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There have been plenty of published picture norms in many different languages for visual and cognitive science research. But to our knowledge, an original set of normative object photos have not yet existed for Chinese by far. The present study aims to propose Chinese normative date of a new and large set of object pictures that will be standardized on as many as 13 dimensions, which includes familiarity, age of acquisition, name agreement, category agreement, typicality, visual complexity, viewpoint agreement, image agreement, image variability, color diagnosticity, shape diagnosticity, manipulability, and degree of grasp/use experience. This new set of photo stimuli is characterized by its high quality, comprehensive categories and basic-level concepts selected, and relevant psycholinguistic dimensions. It provides normative color pictures of objects with Chinese norms for researchers from different areas of psychology, cognitive science, and computer science whose interests are focused on vision and psycholinguistics, and specifically on visual object processing and recognition in Chinese culture.

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D3-030
Double fusion in Wheatstone-Panum's limiting case depends on the disparity gradient of dichoptic features and monocular cues besides the disparity

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Panum's limiting case generally refers to the phenomenon occurring when two features are presented to one eye and a single feature is presented to the other, producing an effect in which two features are perceived to be at different depths. It is still not clear why experimental results derived from Panum-type stimulus configurations support double fusion viewpoint under small disparity, while Wheatstone-type stimulus configurations have produced a balanced percentage of results supporting and opposing it. It was shown that for a small disparity, altering the vertical gradients of the disparity of dichoptic feature pairs in Wheatstone-type stimulus configurations would alter the results reported in previous studies. Moreover, changing the degree of similarity/conflict between binocular cues and monocular cues resulted in corresponding changes in the per capita frequency of reported double fusion. These results indicated that, apart from the influence of disparity, double fusion, as the common foundation for all kinds of Panum effects, was also constrained by the vertical gradient of disparity and influenced by degree of similarity/conflict between binocular cues and monocular cues. The disruption of double fusion under small disparity was due to inappropriate values for these factors.

D3-031
Intersection points of subjective contours in the reversed Poggendorff illusion

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In the Poggendorff illusion there is apparent misalignment between the two visible or 'end' segments of a diagonal line that is inter-

rupted by a horizontal or vertical rectangle. Curiously, the illusion reverses direction when the diagonal line is formed by pacmen-generated subjective contours intersecting the rectangle at <45 deg (Rose and Bressan, ECVP 2011, 2012). Here, we investigate whether the interpolated diagonal contours remain straight or whether they curve or bend as they approach the rectangle. Subjects (N = 40) were presented with reversing-Poggendorff figures with horizontal rectangles demarcated by either real or subjective contours. They were asked to mark with a pen the perceived points of intersection of the interpolated diagonal with the horizontal lines/edges. The subjects placed the marks veridically for the acute angle of the intersection, but offset towards the figure centre for the obtuse angle. These distortions are insufficient to explain either the reversed or the normal Poggendorff illusions, which may depend on a more global or contextual style of processing of the whole configuration.

D3-032
Does wholist-analytic cognitive style affects conflict processing?: an ERP study

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The wholist-analytic cognitive style is conceptualized as an individual's tendency to process information either in complete wholes or in discrete parts. It is assumed that analytic individuals prefer to abstract things from their environments and to process information in a deeper degree, while wholists are more likely to see "the whole picture" and to process information in a superficial way. Thus, their different ability in mobilizing and/or allocating mental-attentional capacity was considered to be the most possible explanation for the wholist-analytic cognitive style. In line with this explanation, a recent study implied that the "cognitive control" systems are different between wholist and analytic cognitive styles (Meng, Mao, Sun, et al. (2012)). However, no study so far has explored this important question directly. The present study investigated this issue by examining whether the wholist-analytic cognitive style affects conflict processing in brain. We adopted a change-detection task, and focused on an ERP component anterior N2. Anterior N2 is elicited when incoming information is in conflict with the one stored in working memory, reflecting the neural activity from our control system anterior cingulate cortex. We used colored shapes as stimuli, and required the participants to remember color while ignoring shapes. This setting allowed us to examine the conflicts from both relevant and irrelevant information. We found that participants from both wholist and analytic groups elicited similar anterior N2 regardless of color change or shape change. We conclude that a similar conflict processing mechanism is shared between wholist and analytic individuals.

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D3-033
The influence of attractiveness on time perception

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It has been revealed that negative emotion can dramatically affect our time perception. On the other hand, as a common sense, we usually feel that time passes rapidly in a positive situation. However, rare studies have explored whether positive emotion can affect our time perception. To this end, the current study explored this issue by examining the influence of attractiveness on time perception, since attractiveness can arouse positive emotion effectively. We manipulated the level of attractiveness by presenting pretty female images (attractive) versus presenting plain female (non-attractive) images, the validity of which was confirmed by a questionnaire survey after the experiment. All the participants were males, and they were shown attractive or non-attractive images randomly in a temporal bisection task. In Experiment 1 the participants were required to view female faces, estimating the duration of the image being displayed after being erased. We found that the time estimates were not influenced by the attractive level of images. To ensure the participants to process the stimuli, we added a secondary task to the bisection task in Experiment 2. We required the participants to recall the repeated times of each image at the end of experiment. A similar result as in Experiment 1 was revealed. Taken together, these results suggest that at least for attractiveness, it has no influence on our time perception.

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D3-034
The Effect of indoor thermal comfort on learning task performance in learning environments

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This study examined the effect of indoor thermal comfort which students perceived in learning environments on their performances of learning task. To do this, participants who attending high school checked the scale of indoor thermal comfort in the simulated learning environment, and they performed the visual search task which reflects the selective attention as a learning task. As a result, the correlation between indoor thermal comfort and learning task performance was high regardless of task-difficulty, but the increase of indoor thermal comfort caused poorly performances on the learning task. It is different from common perspective that comfort environments improves occupant's performances. This results would be affected by students' arousal-level or perceived sensitivity on environments. However,

these variables didn't make the relationship between indoor thermal comfort and learning task performance in reverse. This results suggest that the composition of comfortable learning environments for students does not improve their performance.

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D3-035
Local cues drive population responses to second-order contour stimuli in macaque V1 and V2

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In primate V1 and V2, most neurons with small spatio-temporal receptive fields respond selectively to oriented luminance contours (first-order), while only a subgroup of neurons signals non-luminance defined contours (second-order). These properties raise the question whether population responses of V1 and V2 mainly reflect the global representation of second-order contours or the processing of the local luminance inducers that define second-order contours? Here we compared the population responses of macaque V1 and V2 to three types of second-order contour stimuli generated either by motion (kinetic contours), modulation of contrast, or phase reversal. Using both intrinsic optical imaging and spatio-temporal energy model simulation, we found that the local visual cues within these second-order contour stimuli drove the population responses within the orientation columns of both macaque V1 and V2. These results suggest that the primate early visual system initially makes use of local luminance and motion cues for processing the orientation of second-order contours, prior to form-cue invariant shape processing in higher-tier visual cortices. Our results of population responses to second-order contour stimuli defined by luminance inducers also suggest that the orientation maps within primate V1 and V2 can be described as a spatial-temporal energy map.

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D3-036
Effects of mobile phone on developmental lens in chick embryo

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To gain the effects of mobile phone microwave radiation in "call" position on developmental lens in chick embryo, microstructural, ultrastructural and macroscopic features of the developmental lens were observed by histological and histochemical methods and statistics. The results were as follows.

Compared with the developmental lens microstructure of the control groups, the fibrae lentis in the exposure group, to connect with the epithelium lentis, had been disrupted when hatched on 5th day. On 7th day, the results were similar to features of developmental lens of 5th day. Until 10th day, the fractures were more aggravated. Not only were the fibrae lentis disrupted but also they had slight vacuoles, and lens capsula were swelling till 15th day. Cellulae lentis aggravated vacuolization when embryos were hatched till 21th day.

Compared with the developmental lens ultrastructure of the control groups, the intercellular spaces and subcellular structures were normal when hatched till 10th day, but some of mitochondria in cellulae lentis cells were swelled or had disrupted crista. In addition, the quantities of endoplasmic reticulum reduced in the epithelial cells. On 15th day, a myriad of mitochondria membrane structures had been destroyed or vacuolar in fibrous lamina and the quantities of the endoplasmic reticulum in the epithelial cells were obviously reduced. On 21th day, all mitochondria were nearly damaged and the connection among the lens fiber cells occurred pathological change, where were liquor matters. The observation had shown from the ultrastructure, the 3h/d radiation doses induced the lens damages and these damages aggravated along with the development of chick embryos.

The more radiation dose was accumulated, the more serious turbidity of lens cortex was by the stereology observation on 10th, 15th and 21th day developmental embryos. On the 10th, 15th and the 21th day, the averages of lens weight and hydration level in the exposure group were higher than in the control group obviously ($p < 0.05$). The 3 h/d mobile phone microwave radiation energy (Frequency: 900-1,800 MHz, SAR: 1.07 W/kg) might induce the injury of tissue, microscopic structure and ultrastructure in lens, and then caused cataract.

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