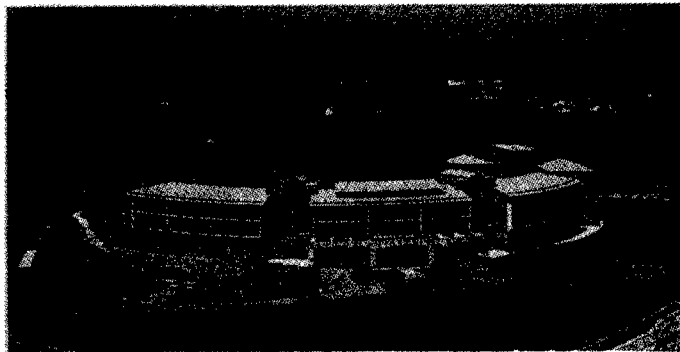




*First Asian Conference on Vision
(1st ACV)*



*July 30-31, 2001
Shonan Village Center, Hayama, Japan*

*The Vision Society of Japan
and
The Vision Research Group in Korea*

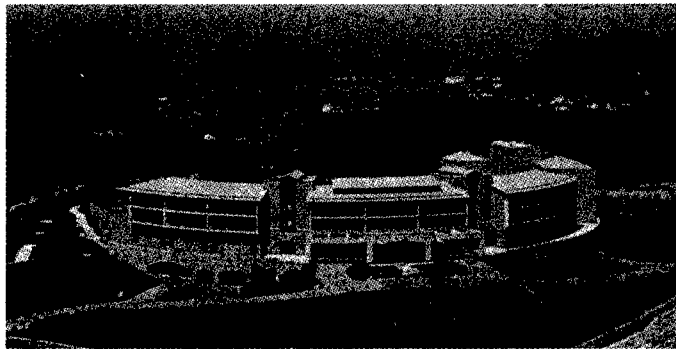
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Proceedings of the First Asian Conference on Vision

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Message from the Conference Chairs

It is our great pleasure to have the First Asian Conference on Vision organized in cooperation with the Vision Society of Japan and the Vision Research Group in Korea. We welcome all participants in this memorial conference. This conference is the first international vision research conference held in East Asia. It would not be too much to say that all participants in this conference share the historical moment of the new era of vision research in Asia.

Vision research is now no doubt one of the most important and active research areas in basic science and engineering fields. The vision researchers in East Asia, however, have been suffering from difficulty to present their papers in an international conference since in East Asia there has been no international vision specific conference. Needless to say, it is most important and stimulating, especially for young researchers, to discuss and communicate one another in the international conference like this opportunity.

In 1999 the Vision Society of Japan and the Vision Research Group in Korea agreed with each other on having a new international vision conference held in Asia. After two-year preparing period we finally came to this stage today being supported by many people including Chinese vision researchers. We really hope that this conference will help all participants to understand various research topics, to develop your own research interests, and also hope you will fully enjoy the conference.

We wish to thank the following for their contribution to the success of this conference: U.S. Air Force Office of Scientific Research, Asian Office of Aerospace Research and Development.

Keiji Uchikawa
Organizing Committee Chair
First Asian Conference on Vision

Chan-Sup Chung
Organizing Committee Co-Chair
First Asian Conference on Vision

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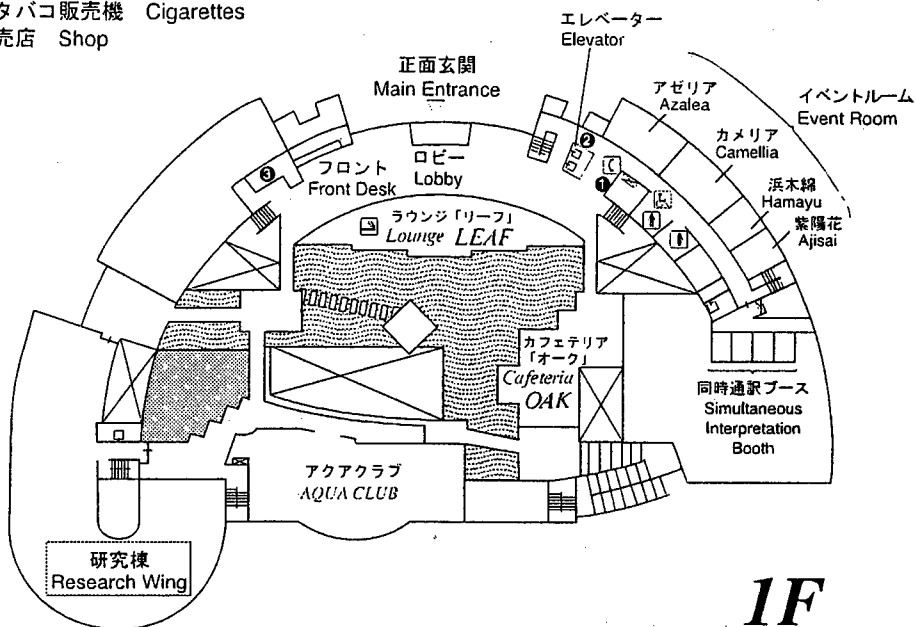
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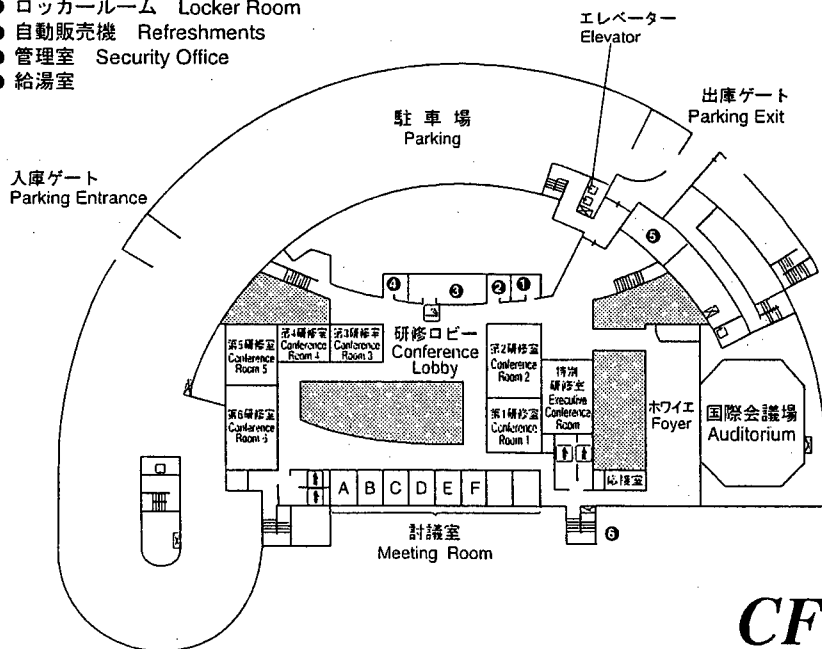
Guideboard for the meeting place and accommodation

- ① キャッシュコーナー (ATM)
- ② タバコ販売機 Cigarettes
- ③ 売店 Shop



1F

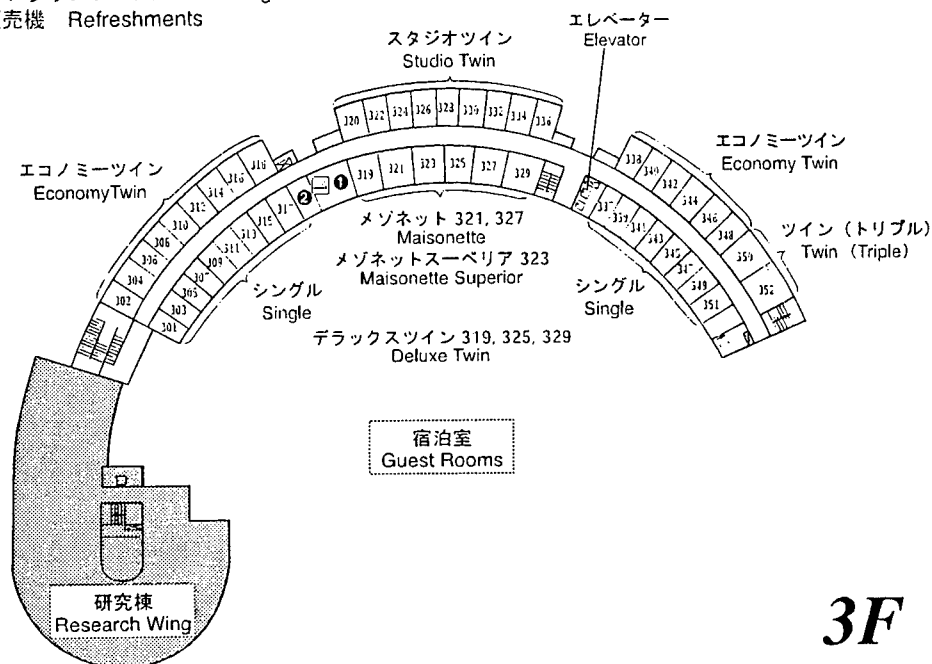
- ① コピー室 Copy Room
- ② コンピュータールーム Computer Room
- ③ ロッカー室 Locker Room
- ④ 自動販売機 Refreshments
- ⑤ 管理室 Security Office
- ⑥ 給湯室



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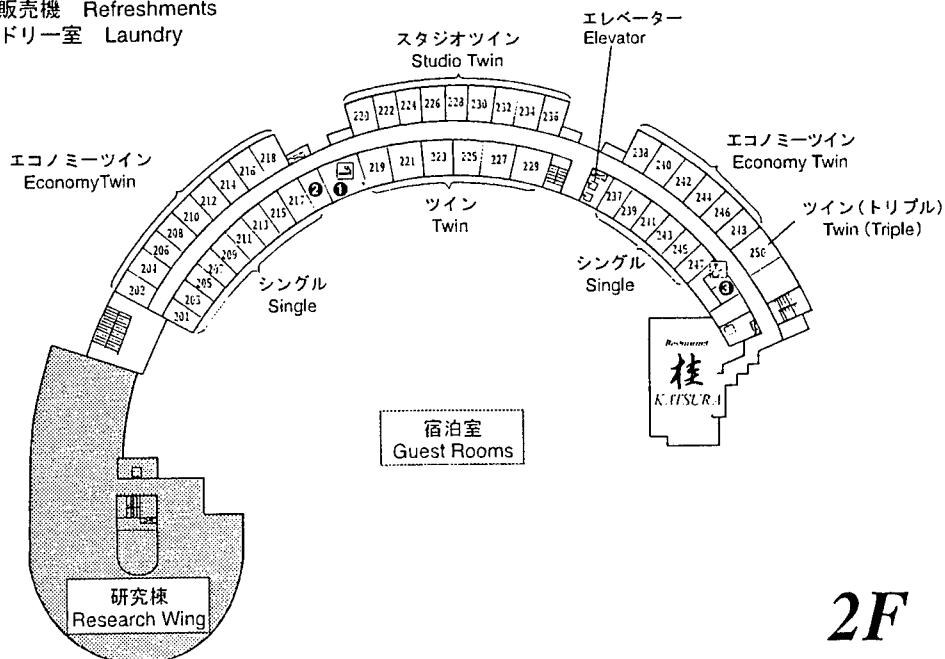
Guideboard for the meeting place and accommodation

- ① ポケットラウンジ Pocket Lounge
- ② 自動販売機 Refreshments



3F

- ① ポケットラウンジ Pocket Lounge
- ② 自動販売機 Refreshments
- ③ ランドリー室 Laundry



2F

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Timetable

July 30 (Mon)	
10:00	Registration
12:30	Opening Remark
12:40	Invited Lecture 1
13:30	Oral Session 1
15:00	
15:20	Poster Session 1
16:20	
16:40	Oral Session 2
17:55	
17:55	Invited Lecture 2
18:45	
19:30	Social party
21:30	

July 31 (Tue)	
8:00	Breakfast
9:00	Invited Lecture 3
9:50	Oral Session 3
11:20	
11:40	Poster Session 2
12:40	
	Lunch
13:40	Oral Session 4
15:10	
15:10	Invited Lecture 4
16:00	
16:00	Closing Remark

 ... coffee breaks & meals

Instructions for presentation

For oral presentation:

- Oral sessions are held in AUDITORIUM.
- Each speaker has 15 minutes time, including 5 minutes for questions and also time for machine set up if necessary. As the conference schedule is very tight, we appreciate your cooperation for strict time management.
- A slide projector, overhead projector, VCR (VHS) and LCD projector for computers (D-SUB15 VGA connector) are available. Computers are not supplied. If you are to use the LCD projector, please check whether it works with your computer before your session.

For poster presentation:

- Poster sessions are held in FOYER.
- All of the posters must be mounted between 12:00 and 15:20, July 30 (Mon.), with the Program Number in large type adjacent to the title. Posters must remain on display all day and be removed between 12:40 and 13:10, July 31 (Tue.). Each presenter is assigned the poster session 1 (EVEN number, 15:20-16:20, July 30 (Mon.)) or the poster session 2 (ODD number, 11:40-12:40, July 31 (Tue.)) when the presenter must be at the Poster.
- The image area of the poster board is 90cm in height x 120cm in width. Pushpins for mounting are supplied.

Program

July 30 (Mon.)

10:00 Registration starts

12:30	Opening remark	K. Uchikawa (Tokyo Institute of Technology)
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12:40~13:30 Invited lecture 1 Chair: H. Komatsu (National Institute for Physiological Sciences)

IL1 Perspectives on the neural basis of stereoscopic vision

I. Ohzawa (Osaka University)

13:30~15:00 Oral session 1 Chair: K. Oda (Tokyo Woman's Christian University)

O1 Viewing distance with minimum heterophoria

A. H. Chen, A. A. Md Dom (Universiti Kebangsaan Malaysia)

O2 Monocular alignment in different depth planes

K. Shimono, N. J. Wade (Tokyo University of Mercantile Marine, Dundee University)

O3 The depth separation modulates heading bias in the presence of moving objects

M. Kitazaki, K. Yokotsuka (Toyohashi University of Technology)

O4 Effect of pursuit eye movement on spatial vision

H.-C. O. Li, K. Kham, E. S. Kim, J.-H. Yoon (Kwangwoon University, Yonsei University)

O5 Character superiority effect in Korean characters modeled by using IAM

S. Y. Bang (Pohang University of Science and Technology)

06 Gaze control in reading horizontally and vertically arranged texts

C. Lee, H. Seo (Seoul National University)

15:00~15:20	Break
-------------	-------

15:20~16:20 Poster session 1 (Even numbers, see below for titles and authors)

16:20~16:40 Break

16:40~17:55 Oral session 2 Chair: H.-C. O. Li (Kwangwoon University)

07 Brain activity related to velocity perception during the motion aftereffect investigated by
magnetoencephalogram (MEG)

K. Amano, I. Kuriki, T. Owaki, T. Takeda

(University of Tokyo, NTT Communication Science Laboratories)

- O8 Second-order chromatic motion is not influenced by luminance masking
T. Yoshizawa, M. J. Hawken (New York University)
- O9 Characteristics of chromatic motion processing
J. Kim (Korea Advanced Institute of Science and technology)
- O10 Phase-dependent motion-aftereffect in rotating sinusoidal gratings: A phenomenon that goes beyond mere an adaptation effect
C. S. Chung, K. Kham (Yonsei University)
- O11 Attentional modulation of adaptation to radial motion.
K. Kham, C. S. Chung (Yonsei University)

- 17:55~18:45 Invited lecture 2 Chair: S. Nishida (NTT Communication Science Laboratories)
- IL2 Functional MRI reveals form-dependent involvement of the visual form pathway in long-range apparent movement in the absence of activation of area MT
L. Chen (Chinese University of Science and Technology)
- 19:30~21:30 Social party

July 31 (Tue.)

- 9:00~ 9:50 Invited lecture 3 Chair: K. Uchikawa (Tokyo Institute of Technology)
- IL3 Challenge toward visual prosthesis
T. Yagi (Nagoya University)
- 9:50~11:20 Oral session 3 Chair: S. Shioiri (Chiba University)
- O12 Visual attention modifies contrast sensitivity in LMS cone space
K. Uchikawa, T. Sasaki, H. Atsumori (Tokyo Institute of Technology)
- O13 Effects of eccentricity on temporal phase shifts between L- and M- cone signals
S. Tsujimura, W. H. Swanson, B. B. Lee (State University of New York)
- O14 Color induction phenomenon analyzed in the new uniform color space
Y. Nakano, T. Enya, K. Suehara, T. Yano (Hiroshima City University)
- O15 Presence of structure dependent system for human color constancy
I. Kuriki, S. Nakadomari, H. Takeuchi, A. Kandatsu, S. Miyauchi, K. Kitahara
(NTT Communication Science Laboratories, The Jikei University School of Medicine,
Communications Research Laboratory)
- O16 Recording local spatial lateral interaction with M-sequences
X. Zhang (Columbia University)

O17 Caspase-3 is activated in the progression in epiretinal membrane of proliferative vitreoretinopathy (PVR)

X. Zhang, S. Chang, Y. Liu, W. Schiff, Y. Lu, J. Sparrow, G. R. Barile

(Columbia University)

11:20~11:40 Break

11:40~12:40 Poster session 2 (Odd numbers, see below for titles and authors)

12:40 Lunch

13:40~15:10 Oral session 4 Chair: J. Kim (Korea Advanced Institute of Science and Technology)

O18 The flash-lag effect as a spatiotemporal correlation between the moving stimulus and the flash's position judgment

I. Murakami (NTT Communication Science Laboratories)

O19 Where bottom-up and top-down processing meet

G. J. van Tonder, Y. Ejima (Kyoto University)

O20 Gaze direction modulates visual aftereffects

S. Nishida, I. Motoyoshi, S. Shimojo (NTT Communication Science Laboratories,
Japan Society for the Promotion of Science, California Institute of Technology)

O21 Ambiguous contours in shape-from-shading

K. Sakai, T. Monma (University of Tsukuba)

O22 Limiting factors for human gaze perception

T. Sato, N. Matsuzaki (University of Tokyo)

O23 Toward a neurophysiologically-based theory of eye movement control during reading

S. Yang, G. W. McConkie (University of Illinois at Urbana-Champaign)

15:10~16:00 Invited lecture 4

Chair: Y. Lee (Yonsei University)

IL4 Wearable machine vision technologies for the visually impaired

S.-W. Lee (Korea University)

16:00~16:10 Closing remark

C. S. Chung (Yonsei University)

Poster presentations

- PA-1 Left/right asymmetries in the oculomotor gap effect
H. Honda (Niigata University)
- PA-2 Flickering retinal signal induce longer perceived length than continuous retinal signal at about the saccades onset
A. Noritake, A. Yagi (Kwansei Gakuin University)
- PA-3 Detectability of stimulus displacement across saccade depends on the apparent direction of displacement
H. Mizushima, K. Uchikawa (Tokyo Institute of Technology)
- PA-4 Not presented
- PA-5 The eye-movement responds to the difficulty of a calculation task during a subsequential ocular task
K. Takahashi, M. Nakayama, Y. Shimizu
(The Center for Research and Development of Educational Technology, Tokyo Institute of Technology)
- PA-6 Disparity tuning of the transient-vergence system revealed by disparity adaptation
M. Sato, M. Edwards, C. M. Schor (University of California, Berkeley)
- PA-7 The apparent displacement of the part of a vertical line viewed monocularly relative to those parts that are viewed binocularly
S. Nakamizo, H. Kawabata (Kyushu University)
- PA-8 Stereo sensitivity to moving stimuli
S. Lee, S. Shioiri, H. Yaguchi (Chiba University)
- PA-9 Influence of object shape for depth difference perception
N. Hiromitsu, M. Idesawa (University of Electro-Communications)
- PA-10 The effect of haptic learning on the process of depth cue integration for perceptual and motor response
Y. Sakano, H. Kaneko (Tokyo Institute of Technology)
- PA-11 Brain activity related to stereoscopic perception in visually triggered movement task: A magnetoencephalographic study
T. Owaki, T. Takeda (University of Tokyo)
- PA-12 Velocity discrimination of moving gratings with different spatial frequencies
T. Tayama (Hokkaido University)
- PA-13 Asymmetry of motion perception in the lower and upper visual field with motion-defined motion stimulus
K. Maruya, T. Sato (University of Tokyo)
- PA-14 Color input to first-order motion detectors
T. Takeuchi, K. K. De Valois, J. L. Hardy
(NTT Communication Science Laboratories, University of California, Berkeley)
- PA-15 Contribution of color to motion in depth
S. Shioiri, A. Nakajima, H. Yaguchi (Chiba University)

- PA-16 Visual determination of equal color-difference contours
H. Xu, H. Yaguchi, S. Shioiri (Chiba University, Zhejiang University)
- PA-17 Color discrimination under chromatic adaptation by pre-presented equiluminance stimuli
Y. Fukada, K. Shinomori (Kochi University of Technology)
- PA-18 Color appearance of chromatic lights in the entire visual field
M. Sakurai, C. Sakamoto, M. Ayama (Utsunomiya University)
- PA-19 Color opponent is a dominant mechanism to discriminate inhomogeneous colors
T. Uchida, K. Uchikawa (Tokyo Institute of Technology)
- PA-20 Influences of categorical color perception on heterochromatic visual search
K. Yokoi, K. Uchikawa (Tokyo Institute of Technology)
- PA-21 Contrast dependency of orientation filling-in
Y. Sakaguchi (University of Electro-Communications)
- PA-22 Effects of peripheral stimulation on foveal contrast sensitivity
R. Kaneko, N. Uwa
(National Institute of Advanced Industrial Science and Technology, Sanyo Electric Co., Ltd.)
- PA-23 Age-related change in impulse response functions for a luminous pulse
K. Shinomori, J. S. Werner (Kochi University of Technology, University of California, Davis)
- PA-24 Age-related nonlinear compensation in the color vision mechanism
K. Okajima, N. Tsuchiya, K. Yamashita
(National Defense Academy, Toyo Ink MFG. Co., Ltd., Toppan Printing Co., Ltd.)
- PA-25 Retinal mechanism of color multi stage model
H. Kawai, I. Kuriki, T. Takeda (University of Tokyo, NTT Communication Science Laboratories)
- PA-26 Sustained pupillary constriction driven by (L-M) cone-opponent signals
E. Kimura (Osaka Prefecture University)
- PA-27 Neural representation of surface luminance and brightness in the macaque primary visual cortex (V1)
M. Kinoshita, H. Komatsu (National Institute for Physiological Sciences)
- PA-28 The human V4 complex is more activated by color picture gradually changing in saturation
– An fMRI study
K. Asakawa, K. Kitahara, A. Kandatsu, S. Nakadomari, H. Takeuchi, Y. Ichihara, S. Miyauchi
(The Jikei University School of Medicine, Kanagawa Rehabilitation Hospital,
Hosen Gakuen College, Communications Research Laboratory)
- PA-29 VEP study on visual processing of global structure
S. Oka, Y. Ejima (Kyoto University)
- PA-30 Visual size induction: An effect of attentional allocation
J. Hamada, G. V. Paramei, W. H. Ehrenstein (University of Tokushima, Universitaet Dortmund)

-
- PA-31 Predominance of shape from global shading in figure and ground segregation
T. Kawabe, K. Miura (Kyushu University)
- PA-32 Extraction of the information about the direction of illumination for shape from shading
T. Sawada, H. Kaneko (Tokyo Institute of Technology)
- PA-33 Lightness constancy disrupts pop-out visual search
H. Mitsudo (Kyushu University)
- PA-34 Effects of spatial position and light source direction on visual search asymmetry for viewing direction
H. Umemura, H. Watanabe, K. Matsuoka (National Institute of Advanced Industrial Science and Technology)
- PA-35 Can inhibitory tagging operate on randomly moving objects?
H. Ogawa, Y. Takeda, A. Yagi
(Kwansei Gakuin University, National Institute of Advanced Industrial Science and Technology)
- PA-36 Targets are facilitated in counting: Evidence from probe detection
Y. Takeda, T. Kumada (National Institute of Advanced Industrial Science and Technology)
- PA-37 A study on sampling strategy in the figure cognitive procession
L. Cao (Zhejiang University)
- PA-38 A computational model for character recognition based on multi-resolution channels IAM
S. K. Kim, S. Y. Bang, D. J. Kim (Pohang University of Science and Technology)
- PA-39 The effect of the mental rotation on the matching task
N. Kanamori, A. Yagi (Kwansei Gakuin University)
- PA-40 A patient complained that the right side of the face looked paler and smaller than the left
S. Nakadomari, K. Kitahara, Y. Kamada
(Kanagawa Rehabilitation Hospital, The Jikei University School of Medicine)
- PA-41 Reaction times in a finger-lift and manual aiming tasks at a visual target
M. Ishihara, K. Imanaka, I. Kita (Tokyo Metropolitan University)

(End of List)

Abstracts (Invited lectures)

Perspectives on the neural basis of stereoscopic vision

Izumi Ohzawa

Department of Biophysical Engineering, Graduate School of Engineering Science, Osaka University,
1-3 Machikaneyama, Toyonaka 560-8531 Osaka, Japan
<http://www.bpe.es.osaka-u.ac.jp/ohzawa-lab/>

Abstract

Ever since the discovery of V1 neurons that are sensitive to changes in binocular disparity (Barlow et al. 1967), the neural basis of stereoscopic vision has been an important subject of research in vision science. How is stereoscopic depth information represented in V1 and subsequent visual areas? Studies in the past 30+ years have produced an approximate view of what it is like in V1, but the implications of this view have not yet been sufficiently clarified. We also know very little about how that representation is used in the next stages of visual information processing by the brain. In this talk, I wish to outline my perspectives on our understanding of the binocular vision and look into future directions of research in this area.

Early attempts at making sense of disparity-tuned neurons adopt a view that there is a direct correspondence between the activation of a neuron and the location of an object in three-dimensional space. For stereopsis, the notion of "depth detectors", though the term is rarely used explicitly, is still very popular. It is probably because such a notion is easy to conceptualize, and consequently one tends to apply criteria to responses of neurons based on a set of features that make an ideal form of detectors for a given perceptual function. For example, we tend to think that an ideal disparity detector should uniquely and unambiguously signal the presence of a specific disparity in stimuli, but not to changes in any other parameter. There are at least two problems with such a view. First, it ignores the fact that, when a neuron under study is activated, it is just one of many neurons that are firing at the same time. Second, it also ignores other stimulus dimensions that neurons do respond to. Complex cells that are disparity selective, are also selective for stimulus orientation, spatial and temporal frequencies, direction and speed of stimulus motion to name a few. Yet, it is still rare to see sufficient considerations given to these facts in the majority of physiological studies.

Take an example of the disparity energy model that we have proposed (Ohzawa et al. 1990, 1997). The model provides a computationally specific wiring diagram for building individual V1 complex cells that are selective for binocular disparity, using input from lower-order simple cells. It has since been shown that the model successfully explains nearly all known binocular properties of real complex cells. The model has also been used successfully as a "front end" to computational models for extracting the depth profile from 3D scenes. To this extent, the model appears highly appropriate for describing V1 complex cells. However, as physiologists, we wonder why these complex cells do not signal depth as we perceive it. We do not perceive depth in anti-correlated random-dot stereograms. Anti-correlated stereograms are those in which the contrast polarity (black/white) of dots is reversed for one eye. Yet disparity sensitive complex cells respond well to such stimuli. And this disparity between the perception and neural responses is a subject of discussion on the seat of conscious perception (Cumming and Parker, 1997). This is a problem that primarily results from our conceptual tendencies we tend to adopt, rather than a problem for the visual system.

I will discuss the implications of the response properties of V1 neurons in the context of responses of many neurons that are firing and not firing for a given stimulus, and results from a study in which responses of individual neurons are studied along multiple stimulus dimensions simultaneously (Anzai et al. 2001).

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- Ohzawa, I., DeAngelis, GC, and Freeman, RD (1990) *Science* 249:1037-1041.
- Ohzawa, I., DeAngelis, GC, and Freeman, RD (1997) *J Neurophysiol.* 77:2879-2909.
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Functional MRI Reveals Form-dependent Involvement
of the Visual Form Pathway in Long-range Apparent
Motion in the Absence of Activation of Area MT

Lin Chen

Beijing Laboratory of Cognitive Science

University of Science and Technology of China

Brain activity in response to long-range apparent motion (AM) was measured in a series of functional MRI experiments. Comparisons were made between long-range AM and real motion or flicker; between luminance-contrast forms and motion-defined forms; and between various geometric forms that represented different levels of structural stability, and controlled for various features commonly considered. The common belief is that area MT mediates motion perception in general and that structural forms play no role in determining AM. However, the present fMRI results show that long-range AM activated the form visual pathway in the absence of activation of area MT, and, furthermore, the magnitude of the activation is greater the structural stability of the forms.

Challenge toward Visual Prosthesis

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<http://www.cmplx.cse.nagoya-u.ac.jp/research/retinal/>

A visual prosthesis is a device to restore visual sensation in blind patients. It electrically stimulates the visual nervous system. Currently, several types of visual prostheses have been studied. They are classified into four different groups with respect to the implantation site and the components including: cortical implant, optic nerve implant, retinal implant, and hybrid retinal implant.

A cortical implant stimulates the visual cortex directly. Since its electrode array is implanted on the visual cortex, this implant will be applicable to any retinal or optic nerve disease. Human perceptual testing has demonstrated that electrical stimulation to the visual cortex actually induced light sensation, so called "phosphenes". However, one potential problem is that biological rejection or inflammation in the cortex may lead to fatal damage. In the case of an optic nerve implant, its electrode array is implanted to wrap around the optic nerve. In addition to the retinal implant mentioned shortly, it is required that the optic nerve and the retinal ganglion cells must be intact; therefore, the retinitis pigmentosa or the age-related macular degeneration could be treated with this implant. This implant is relatively safer than the cortical implant. Human testing has indicated that this implant is also feasible to restore phosphenes; however, the current configuration of this implant hardly enables the stimulation signal to be transferred retinotopically since the optic nerve is stimulated externally.

On the other hand, a retinal implant is believed to be more promising. It stimulates the retina from the epi- or sub-retinal surface; therefore, they are named as epi-retinal implants or sub-retinal implants respectively. The former stimulates the retina from the optic nerve fiber layer side. It consists of an external video camera, a data-transmitter, and an implantable electrode array with data-receiver, as well as other prostheses, i.e., a cortical and optic nerve implant. In human perceptual tests, the retina is stimulated electrically by placing electrodes into the eye. These experiments have demonstrated that patterned electrical stimulation can induce patterned perceptions, at least in the best cases. In the case of a sub-retinal implant, the retina is stimulated from the outer nucleus layer. The sub-retinal has a relatively simple configuration since only a photo-diode array with some electric circuits is implanted in order to obtain image data and to generate electric pulses. The technological challenge here is to fabricate a much thinner and large-power emitted photoelectric device.

The hybrid retinal implant is similar to the epi-retinal implant in many ways; but its components are different. It consists of not only an outer apparatus and an implanted device but also transplanted neurons. In this implant, the neurons are cultured on the top of an electrode array. In order to connect the device and the central nervous system (CNS), their axons are guided with the peripheral nerve graft, or an artificial optic nerve, which is a tube filled with Schwann cells and an extra cellular matrix. After the axons reach towards the CNS to make the proper synaptic connection with the CNS neurons, the adequate amount of electrical stimulation will enable those cultured neurons to produce the action potential. Therefore, the transplanted neurons will be used as living electric wires in order to connect the device and the CNS. Since the hybrid retinal implant requires neither the retinal ganglion cells nor the optic nerve, it will be more applicable to blind-cause diseases where the retinal ganglion cells and/or the optic nerve are NOT intact.

Although several research groups in Europe, Japan and the U.S. have been attempting the development of a visual prosthesis, it will take many years to reach this goal. Many hurdles must be overcome, for example, fabrication of a low-powered microelectronic implant, electronic-neural interface, development of chronically biocompatible materials, determination of adequate charge levels required for neural activation within acceptable standards for long-term stimulation, and so on. It is not known yet if a clinically useful device will appear within a decade. As the modest success of human experimentation indicated, however, a visual prosthesis will someday become a reality. The pace of progress is rapidly accelerating, giving us hope that in the near future, a visual prosthesis can give to the blind what the cochlear prosthesis has given to the deaf.

Wearable Machine Vision Technologies for the Visually Impaired[†]

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Abstract

In this lecture, we introduce a state of the art in computer vision technologies for the visually impaired by describing the OpenEyes system, which has been developed at Center for Artificial Vision Research, Korea University. OpenEyes is a walking guidance system that helps the visually impaired to respond naturally to various situations that can occur in unrestricted natural outdoor environments during walking and reaching the destination. The developed prototype system can guide the visually impaired in a building, a restricted environment, due to the limitation of current computer vision technology and computing power. The prototype system has the following functions:

- Passageway guidance through a path
- Obstacle avoidance during walking
- Face and facial expression recognition of the people that could be met during walking
- Character extraction and recognition of the texts that exist in a natural image
- Voice interfacing

Currently, it functions only in a limited environment, hallway within a building, and has disadvantage of short running time due to a limitation on having to be a wearable computer. However, the fact that a walking guidance system is developed with the computer vision technique holds significance. The present prototype system will be improved in two directions in the future.

The first is to maximize the computing capacity and minimize the size of the system. It will be possible to wear it more conveniently and casually and develop a wearable computer that has relatively long running time when the problem is solved. Second is to expand the area of application for the software from within the building environment to an unlimited natural environment. Also, since the computer vision can process only local information in a field of view, it is not acceptable in processing global information (decision making on walking path to the destination and current location of the pedestrian) that is needed by the pedestrian. We shall solve this problem with technical developments such as GPS (Global Positioning System), electrical map for walking and map-matching.

OpenEyes will be extended to a more general walking guidance system through continuous research for improvement as mentioned before.

[†] This research was supported by Creative Research Initiatives of the Ministry of Science and Technology, Korea

Abstracts (Oral presentations)

Viewing Distance With Minimum Heterophoria

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Abstract

Background: The purposes of this study are to determine the viewing distance with minimum heterophoria and its relationship with refractive error and the resting position of accommodation. **Methods:** The heterophoria and the accommodation response of thirty-six optometry students (25 emmetropes and 11 myopes) were tested. Heterophoria was measured with the Free-Space Heterophoria Card at five different viewing distances (25cm, 33cm, 50cm, 100cm, 300cm). The dioptric viewing distance with minimum heterophoria for each individual was estimated from the graph where heterophoria in prism diopters was plotted against viewing distance in centimeters. The Canon R-1 autorefractor was used to determine the accommodation response at six different viewing distances (25cm, 33cm, 50cm, 100cm, 300cm, 600cm). The resting position of accommodation for each individual was estimated from the graph where the accommodative stimulus in diopters was plotted against the accommodative response in diopters. **Results:** The dioptric viewing distance with minimum heterophoria ranges from 0.003D to 0.65D in emmetropes and ranges from 0.03D to 2.36D in myopes. There is no difference in the dioptric viewing distance with minimum heterophoria between myopes and emmetropes. Our results show a weak correlation between the dioptric viewing distance with minimum heterophoria and the resting position of accommodation. **Conclusions:** The viewing distance with minimum heterophoria is not affected by refractive error (myopia – stable early onset myopia) and is poorly correlated with the resting position of accommodation.

Monocular alignment in different depth planes

Koichi Shimono (TUMM, Japan) and Nicholas J. Wade (Dundee University, Scotland)

Introduction

It is generally believed that monocular lines would appear in the same visual direction when they have the same visual line values. We found, however, that monocular lines having different visual line values can appear aligned when they are presented in binocularly fused areas.

Methods

2.1.1 Apparatus. Stimuli were stereograms. They were generated by NEC PC-9801 computer and displayed on NEC colour monitor (PC- KD853). One of them is schematically shown in Figure 1.

There were two sets of stereograms: random-dot and rectangular stereograms. The lower rectangular areas of each set had a crossed disparity of 10.4 min arc, zero, or an uncrossed disparity of 10.4 min arc, with respect to the upper rectangular areas. One pair of red lines was presented to the left eye; one line was a fixed standard stimulus and the other line was a moveable comparison stimulus.

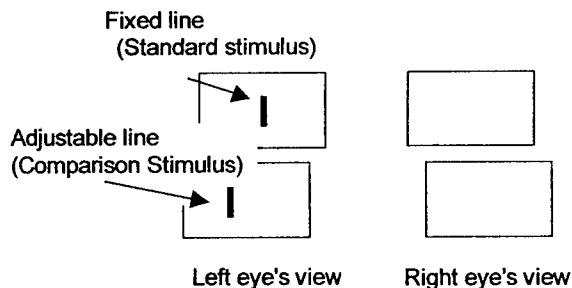


Figure 1. Schematic of a stereogram

Procedure. Each observer was asked on each trial (a) to report whether or not the two perceived rectangular planes appeared in the same plane, and if they were not, which rectangular appeared closer and (b) to adjust the lower red line until it appeared to be aligned with the upper reference line.

The experimental trials were the combination of the two stereograms (random-dot and rectangular) and three binocular disparities (uncrossed, zero and crossed) with the left or right initial position of the comparison stimulus.

Observers. Fourteen students (2 females and 12 males) and one professor (male) participated. They reported having normal or corrected-to-normal acuity and binocular stereopsis.

Results

The different horizontal positions between the adjusted comparison and fixed standard were coded for each trial. A value of zero was assigned when there was no difference in the horizontal position between the two stimuli. When the comparison was on the left side of the standard stimulus, a negative value was given; conversely, a positive sign was given when the comparison was on the right side of the standard stimulus.

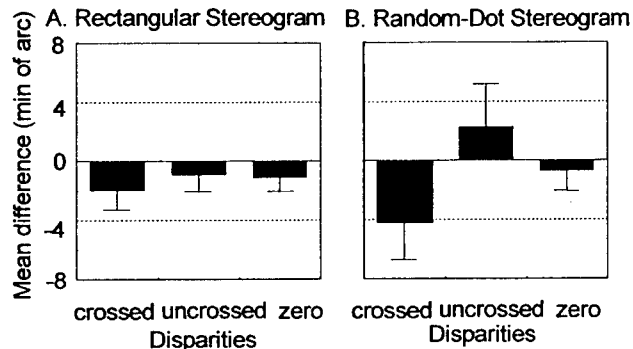


Figure 2. Mean difference of the horizontal location between the comparison and standard.

Figure 2 showed the averages over 15 observers, separately for the stereograms with three different disparity types. For the rectangular stereograms, the comparison was always on the left side of the standard in the three disparity conditions and the difference of the horizontal position between the comparison and the standard was nearly zero in each disparity condition. For the random-dot stereograms, in contrast, the horizontal position of the comparison with respect to the standard differed depending on the three disparity conditions. The results for the random-dot stereogram clearly show that the visual line value of a monocular line can appear aligned when the line is presented on a binocular stimulus. The results can be explained by assuming that the visual system treats the monocular line as a part of the surrounding binocular elements in a random-dot pattern (Ono, et al., 2000; Shimono, et al., 1998).

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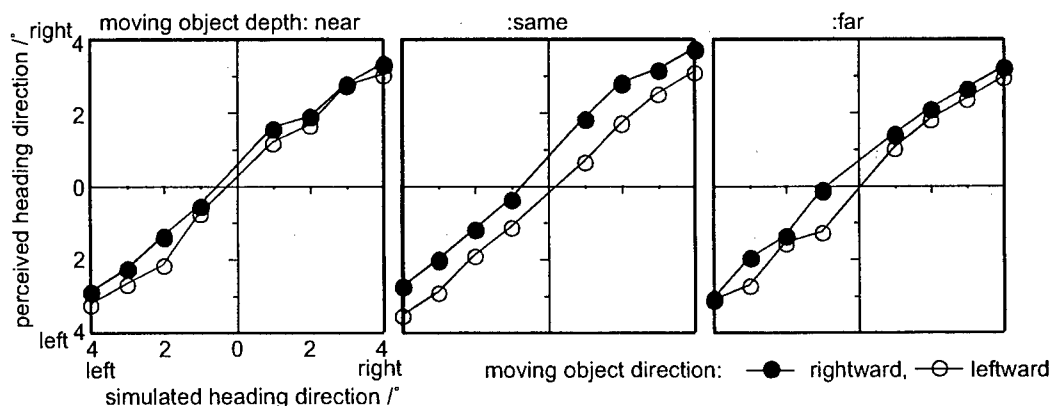
The depth separation modulates heading bias in the presence of moving objects.

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Purpose: Human observer is able to judge its heading very accurately from the optic flow of the stationary scene. The heading judgment is, however, slightly biased by the presence of moving objects (Royden & Hildreth, *Perception & Psychophysics*, 1996; Warren & Saunders, *Perception*, 1995). For objects moving translationally in the front-parallel plane, the bias is in the same direction of the objects' motion. The purpose of our study is to investigate the processing level of the heading perception and this bias by manipulating the depth separation between the moving object and the stationary scene. **Method:** We assumed an observer moving toward a stationary scene consisting of a front-parallel plane (800 random dots; rectangular region: 35(width)x28(height) cm) at the initial distance of 57 cm from the observer (velocity 16.8 cm/s). The heading direction was simulated toward a point that was 4°, 3°, 2°, or 1° to the left and 1°, 2°, 3°, or 4° to the right of the central fixation point. The viewing window was 35°(width)x28°(height) and clipped when the dots moved beyond this window. An independently moving object consisting of front-parallel plane (200 random dots; circular region: diameter 10 cm) was superimposed at the center of the scene and horizontally translated to left or right (velocity 8.4 cm/s). The window of the moving object was stationary and the inside dots appeared at one edge of the object, moved across, and disappeared on the other edge. This moving object was presented at the near (binocular disparity 0.4'), the same, or the far (0.4') depth of the stationary scene. The binocular disparity was only introduced to make depth separation between the moving object and the stationary scene and was not applied to the simulated observer motion. The subject observed the stimulus for 1 s at a viewing distance 57 cm while fixating a central fixation point, and was asked to point the perceived heading direction by the mouse cursor. Each condition was repeated 20 times. **Results:** The perceived heading was relatively accurate for all conditions, but it was biased in the same direction of the moving object. These results were consistent with the findings of Royden & Hildreth (1996). Moreover, we found that the heading bias decreased when the moving object was located at the far or the near depth separated from the stationary scene. **Conclusion:** The moving object in the same depth of the stationary scene more affected the heading perception than that in the different depth. This result suggests that human heading perception in the presence of moving objects concerns the processing level of the object segregation by binocular-disparity depth.

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EFFECTS OF PURSUIT EYE MOVEMENT ON SPATIAL VISION

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Despite continuous eye movement, our percept of the environment is quite stable. According to the efferent copy theory, the visual system compensates eye movement with image movement on the retina to achieve 'position constancy'. Is the eye movement compensation sufficient enough to hold the spatial relationships among the objects in the world? Which stage of the information processing does the eye movement compensation occur at? To answer these questions we ran a series of experiments. When a luminance-defined horizontal line passes behind an imaginary object (e.g, rectangle), i.e. one having the same luminance with its background, the spatiotemporal pattern of occlusion provides information about the object's shape. Can we perceive the shape of the object using pursuit eye movements, and is this facilitated by the presence of a reference frame surrounding the object ? Can we obtain the similar pattern of results in path perception of a luminance defined moving dot with pursuit eye movement? We manipulated the direction and the amount of the eye movements, and the adjacency of the reference frame to the rectangle/dot. The reference frame was a luminance-defined rectangle surrounding the target object or a vertical line adjacent to the dot. Subjects reported the perceived 2D shape/path by adjusting a comparison shape or two dots comprising the starting/ending points of the path. Subjects perceived a parallelogram rather than a rectangle with pursuit eye movements. Perceived path of the moving dot was also distorted, but not as much as the 2D shape was. The amount of perceptual distortion was proportional to that of the eye movement. The systematic distortion was observed even with the presence of the reference frame, although the amount of the distortion decreased as the reference frame became closer to the target object. Perceived 2D shape/path of a moving dot appear to reflect the content of the retinal rather than physical image. These results imply that the visual system cannot properly estimate extra-retinal information when deducing the shape of a spatiotemporally defined object. The visual system may use object-relative information to improve shape perception, and the eye movement compensation appears to occur before the binocular processing.

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Character Superiority Effect in Korean Characters Modeled by using IAM

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Abstract

Originally the Interactive Activation Model(IAM) was developed to explain Word Superiority Effect(WSE) in the English words. It is known that there is a similar phenomena in Korean characters. In other words people perceive a grapheme better when it is presented as a component of a character than when it is presented alone. We modified the original IAM to explain the WSE for Korean characters. However it is also reported that the degree of WSE for Korean characters varies depending on the type of the character. Especially a component between components was reported to be hard to perceive even though it is in a context. It was supposed that this special phenomenon exists for WSE of Korean characters because Korean character is a two-dimensional composition of components(graphemes). And we could explain this phenomenon by introducing weights for the input stimulus which are calculated by taking into account the two-dimensional shape of the character.

Gaze Control In Reading Horizontally and Vertically Arranged Texts

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A previous study examining eye and head movements in reading showed that head movements were a primary target of cognitive control during reading, and suggested that controlling the timing and strength of head movement command enables eye and head movements to couple or decouple depending on text familiarity [1]. In the current study, we quantitatively compared parameters of eye and head coordination in reading horizontally and vertically arranged Korean texts.

Six college students read two texts in 8 horizontal (left to right) or vertical (up to down) lines that were rear-projected onto a tangent screen. Horizontal and vertical positions of the eye and head were recorded with the scleral search coil technique [2], and sampled at a rate of 500Hz.

Reading was faster for horizontally-arranged than for vertically-arranged texts by 24%, primarily due to larger gaze amplitude for horizontal reading, and thus less frequent fixation. There was no statistically significant difference in duration of fixation between horizontal and vertical reading conditions. The higher velocity of gaze saccades for given amplitudes in horizontal than vertical reading also contributed to the difference in reading speed. These differences probably reflect an intrinsic anisotropy of the oculomotor system, because they were also observed in a control experiment devoid of lexical load, where a sequentially-stepping laser target was tracked. The analysis of instantaneous phase of eye and head movements with the Hilbert transform suggested that eye and head coupling was dynamic and stronger for vertical than for horizontal reading. However, the mean amplitude of head movement during gaze saccades and the range of head position were similar between horizontal and vertical reading. These results are different from those for a single centrifugal gaze shift where head movements contribute more to horizontal than vertical gaze shifts.

Thus, eye-head coupling during reading is variable depending on text familiarity and direction of typography, and in that sense similar to cardiac and respiratory rhythms that show different periods of synchronization of several phase-locking ratios [3]. This context-dependent coupling between eye and head movements, combined with the similar head contribution in both reading directions, suggests a high level modulation of gaze decomposition into eye and head motor commands proposed in most gaze control models [e.g., 4], and is contrasted with previous ideas on eye and head movements: coupled or independent motor systems.

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Brain activity related to velocity perception during the motion aftereffect investigated by magnetoencephalogram (MEG)

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The motion aftereffect (MAE) is a modification of visual motion perception following prolonged observation of a regularly moving stimulus (adaptation to the stimulus). MAE involves the apparent motion of a stationary stimulus in the opposite direction to a previously observed one. The relationship between temporal or spatial frequency of the stimulus and the motion perception during MAE had been investigated in detail by psychophysical studies. Electrophysiological studies on cats and monkeys reported the existence of direction selective cells in MT (middle temporal area), whose firing rates are known to decrease by adaptation to constantly moving stimulus. Recently, some non-invasive functional brain imaging studies on human beings have reported the activity in area MT/V5 (5th visual cortex), V3a (3rd visual cortex accessory), pSTS (posterior end of superior temporal sulcus) by visual motion stimulus. Concerning MAE, however, motion perception only from static stimulus was investigated in previous studies, therefore not sufficient study on the relationship between brain activity and velocity perception during MAE has been conducted. So, we investigated this relationship using both moving and static stimulus presented after adaptation, which were perceived to move at the velocity different from the physical velocity by MAE. Brain activities were recorded using magnetoencephalogram (MEG), while perceived velocities were measured by psychophysical experiment.

We used concentric half rings, that moved in either contracting or expanding direction, as visual stimuli. MEG responses were recorded in synchrony with the instance of eight kinds of changes in the velocity of motion (from -3dps to 6, 3, 1.5, 0.75, 0, -0.75, -1.5, -6dps) under adapted or non-adapted conditions. Negative values and positive values indicate contraction and expansion of stimuli respectively. Perceived velocities were measured before and after the velocity change of the stimuli. Additionally, we measured the MEG responses when subjects' perceptions are equal (subjectively static) between adapted and non-adapted conditions to investigate the effect of adaptation on brain activity. Subjectively static stimulus was defined by psychophysical measurement in a preliminary session.

As the results, (1) MEG peak latency did not change by adaptation. (2) Typical MEG responses in right hemisphere were recorded in both right and left hemifield stimulus conditions. (3) MEG response were remarkably large when the stimulus velocity was changed to 6, 0, -6dps in adapted state. (Subjects perceived visual motion by MAE, even when the stimulus velocity was 0dps.) (4) There exists the brain area whose activity clearly increases by adaptation.

Measured MEG intensity was not simply correlated with the perceived velocity during the MEG recording, and an effect of adaptation on the intensity is significant. These results with previous electrophysiological study suggest the possibility that the direction selective cells that are sensitive to the opposite direction to adaptation stimulus increase in firing rates.

Second-order chromatic motion is not influenced by luminance masking

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Purpose Previously it was reported that there was an effect of luminance masking on direction discrimination of linear (first-order) chromatic motion but no effect on nonlinear (second-order) chromatic motion using Gabor micropattern kinematogram (GMK) (Vision Research, 40, 1993-2010, 2000). The purpose of this study is to investigate whether luminance noise masks the identification of motion-direction produced by second-order chromatic targets.

Methods We examined effects of luminance masking noise on direction discrimination of envelope motion of a chromatic drifting grating and detection of the chromatic stimulus using 2AFC methods. To produce envelope component, contrast of red and green sinusoidal gratings were modulated in anti-phase. A 1cpd-carrier component (red and green sinusoidal grating) moves in either the same or the opposite direction of a 0.25cpd-envelope motion. The contrast of 1D-spatial luminance noise, superimposed on the chromatic stimuli, was varied. All stimuli and noise were presented on RGB display at 150 Hz. We confirmed that the dynamic luminance noise we used effectively masks the motion identification of luminance stimuli.

Results For chromatic stimuli, detection threshold does not change with low to intermediate level of luminance noise contrast. Furthermore, the threshold of direction discrimination of second-order chromatic motion does not increase systematically as contrast of luminance masking noise increases. On the other hand, detection and direction discrimination thresholds for luminance stimuli increase monotonically as luminance noise contrast increases.

Conclusions Second-order chromatic motion (envelope chromatic motion) is mediated by a genuine chromatic mechanism since there is little effect of luminance masking on motion identification. This is consistent with our previous study using GMK.

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CHARACTERISTICS OF CHROMATIC MOTION PROCESSING

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Research Background

Given parallel and independent processing streams for color and motion, it is worth to investigate the mechanism for an isoluminant chromatic motion, which has long been denied but now psychophysically demonstrated in many studies. To explain the chromatic motion, one suggests two motion streams differing in temporal characteristics, while the other suggests a 3rd-order motion processing.

Purpose

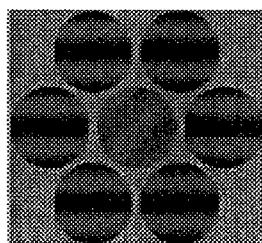
I investigated characteristics of interaction of chromatic motion across cardinal axes and luminance motion to get an insight regarding the underlying mechanism of isoluminant chromatic motion.

Methods

Using a plaid composed of isoluminant chromatic gratings modulating along the same/different cardinal axes and luminance gratings, perceived motion coherence/transparency and direction were psychophysically measured in Expt. 1 & 2. Chromatic and luminance contrast modulating gratings were also used. A multi-aperture pattern, inside which moving chromatic and luminance gratings were shown, was used in Expt. 3.

Results

In Expt. 1, for Type I plaids made of components modulated along the same cardinal axis, coherent motion was perceived at all angular differences (from 36 to 142 deg). However, for plaids made of components modulated along different cardinal axes and plaids made of a luminance grating and a cardinal chromatic grating, transition from motion coherence to transparency was observed at the angular difference



of around 120 deg. For plaids made of luminance and/or chromatic contrast modulating gratings, motion coherence/transparency was depended on the angular difference. In Expt. 2, for Type II plaids made of luminance and/or chromatic gratings and plaids made of luminance and/or chromatic contrast modulating gratings, the perceived directions were determined at the vector sum directions of the moving components. In Expt. 3, for the multi-aperture patterns with chromatic gratings at the same and different cardinal axes, as shown in the

figure, and patterns made of chromatic and luminance gratings, the perceived direction of the center grating deviated from its defined motion direction as much as 30 deg.

Discussion

Results show that chromatic motion processing is very analogous to luminance motion processing. It seems that there are two processing streams, one responsible for pure chromatic modulation and the other for 2nd-order chromatic contrast profile (at low temporal frequency), indicating there is no reason to construct a 3rd-order structure for chromatic motion. Results also show the interaction of chromatic and luminance motion.

Phase-dependent motion-aftereffect in rotating sinusoidal gratings: A phenomenon that goes beyond mere an adaptation effect

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A disk subtending about 6° visual angle and having 15 sinusoidal rotating gratings was used to examine motion aftereffect (MAE). The disk was divided into two parts, an inner disk and the outer annulus, and the gratings in either the inner disk or the annulus was made to rotate in the adaptation period. In the testing period, the rotating gratings in the adaptation field stopped either in phase or off phase with the gratings in the stationary field. Marked differences in resulting MAEs were found depending on which part was rotated and in what phase it was stopped. With the annular rotation, only the gratings in the annular area showed MAE when they were off phase, but when in phase the entire disk including the gratings in the inner disk showed MAE in unison. With the inner-disk rotation, the same tendency was observed for the two phase-conditions. In this case, however, instead of after-motion of entire disk an after-motion pattern of spiral traction toward the center of the disk similar to that of twisted dough on a stuffed bun top was found as if the broader and thus massier outer area resisted the energy of inner spiral traction due to inertia. Findings that MAE occurs in the unadapted stationary gratings and the twisted-dough-like MAE presumably due to inertia require explanation beyond what provided by traditional adaptation theories. Traditionally, a large field MAE with rotating gratings or spiral is known to occur as a result of the adaptation effect of MT or MST cells (Anstis, Verstraten, & Mather, 1998; Niedeggen & Wist, 1998). However, illusory after-motion of gratings in the unadapted field found in this study indicates that more complicated mechanisms can be involved in MAE.

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Attentional modulation of adaptation to radial motion

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Motion perception enables us to extract variety of information related to both object motion and self-motion from the environment. Contrary to the traditional ((consideration of)) thoughts considering motion perception as a pure bottom-up process, many psychophysical and physiological studies confirmed attentional effects on the perception of 2-dimensional motion, suggesting top-down influences. In 3-D motion perception, however, there is a controversy on the attentional influence. Royden and Hildreth (1999) reported that the accuracy for heading judgment with dot displays in radial motion was little affected by attention manipulated by a dual task. Based on this finding, they proposed that the heading judgment from radial motion is globally computed and needs not focused attention. On the other hand, Gray (2000) found that the perception of an object motion in depth simulated by making it approaching or receding was influenced by attention in a task detecting its expansion or contraction. Moreover, attentional modulation of fMRI signal was found when the observer attended expanding dots superimposed on the dots in translational motion (Watanabe et. al. 1998). We investigated the influence of attention on the perception of expanding or contracting motion using motion aftereffect (MAE). Either expanding or contracting dot pattern used as an adapting stimulus. During the adaptation period, an observer was instructed to perform an additional character-number discrimination task in the diverted attention condition, while instructed to passively view adapting stimulus in the passive fixation condition. As the control condition, trials were included where no adapting stimulus was presented. We varied the signal-to-noise ratio of a real motion signal in the testing stimulus to find neutral point where the impression of real motion disappears. As an index of the strength of MAE, the difference in neutral points between each experimental condition and the control condition was taken. A large difference in the strength of MAE was found between a diverted-attention and passive-fixation conditions. These results suggest that attention may modulate the activation of the mechanism responsible for the processing of radial motion.

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Visual Attention Modifies Contrast Sensitivity in LMS Cone Space

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Introduction

It is well known that visual attention influences performance of a visual task [1]. Although it is likely that visual attention has significant effects in higher levels of the visual system there have been some evidences that visual attention may influence visual sensitivity in lower levels of the visual system [2]. In the present study, we aim to investigate whether there is any selective effect of visual attention in contrast sensitivity along different directions in the LMS cone space. We employed the double task paradigm to control spatial extent of visual attention.

Methods

The stimulus display consisted of a center task stimulus and a detection stimulus. The center task stimulus was of two concentric rings subtending 1.6 deg, each of which had four possible gaps. The detection stimulus was a Gabor patch of 1.0 deg diameter. In the double task condition, the observer had to find number of gaps of the rings for the first priority. The second task was to detect the Gabor patch, which was presented either on the right or on the left of the center rings at a distance of 4 deg. In the single task condition, the observer merely detected the Gabor patch without doing the center task.

Results and Discussion

Figure 1 shows contrast sensitivities (CSs) in an achromatic and two chromatic directions for an observer. CSs in the double task condition were found to be the same as or lower than those in the single task condition. It is obvious that large reductions in CSs exist at 4 c/d in the achromatic, 1 and 4 c/d in the y/b and 1 c/d in the r/g directions when visual attention was paid less on the detection area. These characteristics of CS functions indicate that visual attention have selective effects on visual sensitivity depending on the direction in the LMS cone space. This suggests that visual attention may influence lower levels of the visual system.

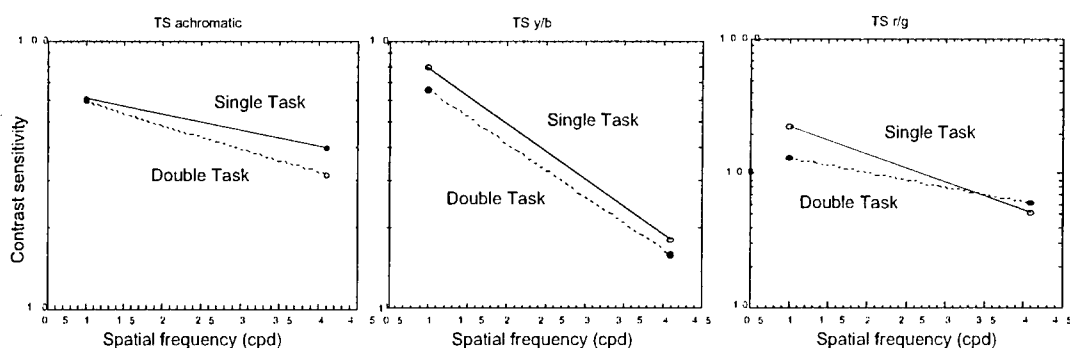


Fig. 1. Contrast sensitivity in the achromatic, y/b and r/g directions in the LMS cone space. Solid lines represent the single task condition and dotted lines represent the double task condition. Observer: TS.

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Effects of eccentricity on temporal phase shifts between L- and M- cone signals

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INTRODUCTION In flicker photometry, temporal counter-phase modulation of a pair of heterochromatic lights can show residual flicker after adjustment to equiluminance. De Lange (1958) observed that, under appropriate conditions, this residual flicker could be cancelled by adjusting the relative physical phase of the two lights. Psychophysical studies estimated the phase shifts between L- and M-cone signals and found a strong effect of the background color (Swanson *et al.*, 1988; Stromeyer *et al.*, 1997; Tsujimura *et al.*, 2000). Physiological studies found substantial phase shifts of retinal ganglion cells in the magnocellular pathway which disappeared if only the center of the receptive field was stimulated, suggesting that the phase shifts are produced by an L-M chromatic input to the surround of the receptive field in the magnocellular pathway (Smith *et al.*, 1992). The aim of this study was to measure the phase shift as a function of spatial frequency at several eccentricities to determine whether the relationship between spatial frequency and phase shift reflects the structure of the receptive field of magnocellular ganglion cells.

METHODS We used an abbreviated method (Tsujimura *et al.*, 2000) to estimate the phase shifts between L- and M- cone signals. At eccentricities of 0, 10, and 20 deg, we measured motion identification thresholds of a drifting sinusoidal grating (Temporal frequency: 10 Hz, Spatial frequency: 0.25, 0.5, 1.0 and 2.0 c/deg) modulated along two vector directions in cone-contrast space with various relative physical phases between L- and M- cone signals. The gratings were presented in circular apertures whose diameters were 5 deg at the fovea, 10 deg at 10-deg eccentricity and 15 deg at 15-deg eccentricity. The background color was orange with a luminance of 34 cd/m² and CIE (x, y) coordinates of (0.55, 0.44). Two-alternative forced-choice staircases were used to determine motion identification thresholds. Ten observers participated in the experiment.

RESULTS & DISCUSSION The results showed that (1) at each eccentricity the phase shifts markedly decreased as spatial frequency increased and (2) at each spatial frequency the phase shifts decreased as eccentricity increased, ranging between -120 deg and +40 deg. When spatial frequency was scaled to the dendritic field size of magnocellular ganglion cells obtained in morphology (Dacey *et al.*, 1992), phase shifts became relatively independent of eccentricity.

CONCLUSION These results are consistent with the hypothesis that the relationship between spatial frequency and phase shifts reflects the structure of the receptive field of magnocellular ganglion cells.

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Color Induction Phenomenon Analyzed in the New Uniform Color Space

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Color induction phenomenon was analyzed in the uniform color space recently proposed by our laboratory. The uniform color space was constructed based on the cone tristimulus values, l , m and s . They underwent compressive nonlinearity, and then added constant noise as follows.

$$\begin{aligned} l_c &= 0.6250 \{ f(l, 10000) + 4 \}, \\ m_c &= 0.3125 \{ f(m, 10000) + 4 \}, \\ s_c &= 0.0625 \{ f(s, 10000) + 4 \}, \end{aligned}$$

where function $f(x, \sigma)$ was defined as follows.

$$f(x, \sigma) = \frac{\sigma}{114} \left[\left\{ 342 \left(\frac{x}{\sigma} \right) + 1 \right\}^{\frac{1}{3}} - 1 \right]$$

Then, three orthogonal axes of the uniform color space were described as follows.

$$\begin{aligned} L^* &= 40 f(l+m, 100) \\ t^* &= 1500 \left\{ f\left(\frac{l_c - m_c + s_c}{l_c + m_c + s_c}, 30\right) - f(0.3750, 30) \right\} \\ s^* &= 1500 \left\{ f(0.0625, 10) - f\left(\frac{s_c}{l_c + m_c + s_c}, 10\right) \right\} \end{aligned}$$

This uniform color space explains threshold color differences such as MacAdam ellipses and supra-threshold color differences such as Munsell color chips fairly well. We thought this uniform color space would be a good tool for analyzing color induction phenomenon that was very complicated when described on the conventional color space such as CIE xy chromaticity coordinates.

Color induction data was collected by the method of color appearance matching under different surround conditions. A reference patch consisted of gray surrounded by white, for example, and a test patch consisted of adjustable central color surrounded by certain color such as red. A subject adjusted the color of the test center so that its appearance became the same as the reference center. Colors of the reference center and the test surround were changed in a large variety.

When the reference center was a dark gray, for example, chromaticity coordinates on the CIE xy diagram of the test center was located on a point shifted from neutral point toward the surround color, and it moved toward desaturated direction as colored test surround became brighter to keep the appearance of the test center the same gray. This is difficult to explain if that means that chromatic induction decreases as colored test surround become brighter. When we plotted the same data on the proposed uniform color space, t^* - s^* coordinates of the test center moved toward saturated direction as colored test surround became brighter. This is because the proposed uniform color space explains the phenomenon that the colorfulness of a stimulus increases as its brightness increases. When the colored test surround become brighter, blackness and complementary color sensation will be increasingly induced in the center. To keep the appearance of the center the same gray, a subject has to increase the brightness of the test center and the colorfulness of the center increases accordingly even without chromaticity change on the CIE xy coordinates. The increase of the colorfulness is enough to compensate complementary color induced by the surround color, and even make the center more saturated. This must be why the CIE xy coordinates of the test center moved toward desaturated direction, while the t^* - s^* coordinates moved toward saturated direction as colored test surround became brighter. To summarize our results, the proposed uniform color space makes the explanation of color induction phenomenon simpler.

Presence of structure dependent system for human color constancy

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[Purpose] We used functional magnetic resonance imaging (fMRI) technique to reveal the mechanisms of human color constancy. In our previous study, we found increased activity in ventro-occipital part of cortex while observer was paying attention to illuminant color change, compared to the activity while paying attention to object color change. However, it could be claimed that observer responded to change in the average color of the stimulus image, without analyzing spatial information contained in the image. Therefore, we conducted the following experiment to test whether the increased activity during illuminant color attended condition was introduced by the change in average color or not.

[Methods] To maintain consistency with the previous experiment, we used identical series of natural scene images used in the previous study, which contains illuminant- and object-color change. We degraded the spatial structure of the images by randomly replacing the locations of a certain percentage of pixels. This method allows no change in the spatial average of the image. The percentages of randomized pixels used for experiment were 0%(original), 85% (partial structure) and 100%(no structure). 10 images for each percentage were presented in the same order with original image sequence. Stimulus subtended 20deg x 15deg and the duration for each image was 2.5s. Whole head BOLD images were taken with T2* weighted protocol at TR=5s. Each voxel size was 3mm x 3mm x 3mm. 6 normal subjects participated in experiment.

[Results] If the observer's visual system were simply responding to the change in average color of the stimulus, no difference should be expected from comparison between different percentages of randomness. However, it was not the case. Figure 1 shows typical result for statistical significance level at $p < 1.0 \times 10^{-4}$. Highlighted areas (a) indicated by arrows are those showing increased response in the illuminant-attended condition (modified from Kuriki, et.al., 2000) and highlighted outlines (b) indicate contours of areas showing difference in activity between three randomization conditions. The area (a) is included in the area (b) means that the activated area while subjects were paying attention to illuminant-color change responded to change in the quality of spatial structure of the scene.

[Conclusion] Human color constancy system, which discriminates illuminant color change from object color change, may use information of spatial structure of the visual scene as a clue to solve the problem.

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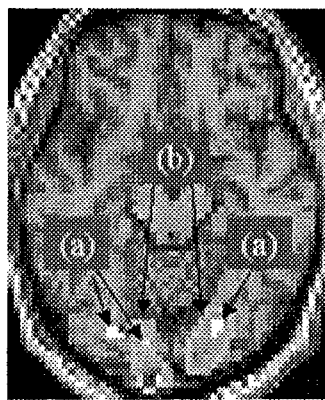
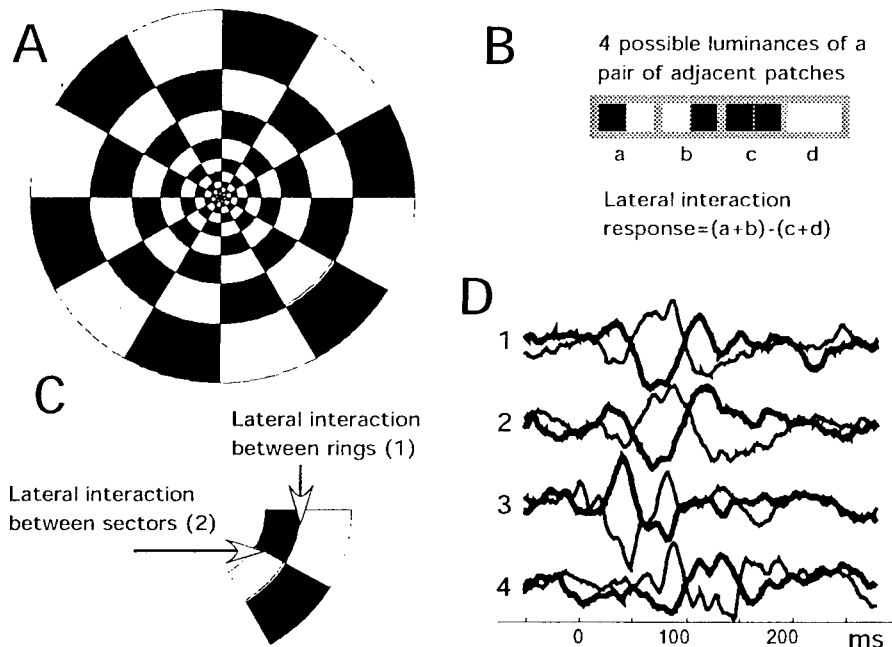


Figure 1

Recording Local Spatial Lateral Interaction with M-Sequences

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Introduction: Lateral interactions are important and ubiquitous features of the nervous system. Although the effects of spatial lateral interactions can be seen with visual evoked potentials (VEP) methods [1, 2], local lateral interaction are difficult to study with traditional VEP methodology. This paper presents a paradigm that allows for the recording of local lateral interaction. The paradigm (Fig. B.) is an extension of the multifocal VEP technique developed by Sutter [3]. An m-sequence is designed to allow for the derivation of the 1st, 2nd order kernels and lateral interaction kernels. A lateral interaction kernel is the product between the m-sequence that modulates one stimulus patch and the m-sequence that modulates one of its adjacent patches.



Stimulus: The stimulus array was a dartboard (Fig A) with 10 rings and 120 sectors, which spanned 40 degree of the central visual fields. The radius of each ring is scaled according to the cortical magnification [3]. The luminances of the black and white were near 0 and 80 cd/M². Each stimulus lasted 4 screen frames (52 ms).

Recording: Monocular VEPs were recorded with high and low pass filters set to 3 and 100 Hz. The active electrode is placed at 4 cm above inion and the reference electrode is placed at inion.

Analysis: The recorded EEG was transformed into the significant kernels with a c++ program.

Result: Lateral kernel responses from a normal subject are shown in Fig. D. Average traces from both the upper (thin) and the lower (thick) hemifields are presented. Trace 1 is the lateral interaction between two rings (Fig C). Trace 2 is the lateral interaction between two sectors. Trace 3 is the on-off reversal and trace 4 is the first order kernel response. The effects of different contrast, width of neutral inset on lateral interaction were also studied.

Conclusion: The lateral interaction response is the largest response in multifocal flash VEP. The onset of the lateral interaction is faster than both the flash response and the 2nd order response. This paradigm allows the study of the local lateral interaction. It may help us understand the neural processes underlying pattern reversal VEPs and lateral inhibition in visual cortex.

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Caspase-3 is activated in the progression in epiretinal membrane of proliferative vitreoretinopathy (PVR)

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Purpose : In human experimental animal models of PVR and PDR, apoptosis has been noted in the epiretinal membrane. Inhibition of cell proliferation and induction of apoptosis have been implicated as potential therapeutic approaches for proliferative diseases. The aims of the present study are to assess activity of cell proliferation and apoptosis and further investigate the potential involvement of apoptotic regulators, such as caspase-3 in patients with PVR.

Methods: Epiretinal membranes were stained from the eyes of eight patients who underwent vitrectomy surgery for PVR. Cell proliferation was evaluated by Ki-67 and PCNA (proliferation cell nuclear antigen) immunostaining. Apoptosis was assessed by TUNEL (terminal deoxynucleotidyl transferase-dUTP-nick end labeling). The expression of caspase-3 and PARP (poly-ADP-ribose-polymerase) was detected using the specific antibodies against activated Caspase-3 and p85 fragment of PARP. To further recognize the apoptotic cell type, cytokeratin (AE1/AE3, Boehringer Mannheim) was used.

Results: Most apoptotic cells were RPE-derived, as assessed by cytokeratin immunostaining. Apoptosis was correlated with the increased expression of activated caspase-3 and the p85 fragment of PARP. Apoptotic nuclei appeared to be presented in more frequent quantities in long standing PVR. The expression of Ki-67 and PCNA was detected in all the patients and appeared to be increased in patients with recent retinal detachment.

Conclusions: This study supports the hypothesis that apoptosis is a key regulatory mechanism of specific cell population of epiretinal membrane in patients with PVR. Induction of apoptotic regulators such as caspase-3 activation may be used as a target for the treatment of PVR.

The flash-lag effect as a spatiotemporal correlation between the moving stimulus and the flash's position judgment

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When a flash is presented adjacent to a continuously moving stimulus, the flash appears to lag behind. As the underlying mechanism of this "flash-lag effect", we have previously proposed the differential latency model, in which the flash's latency is supposed to be longer than the latency for the moving item (Whitney & Murakami, 1998). Accordingly, the moving item and the flash that are physically aligned with each other are not perceived at the same time; by the time the flash is brought onto perception, the moving item has already traveled a bit ahead. This simple framework well accounts for the effect in various situations (Whitney, et al., 2000a, 2000b; Murakami, 2001). In the present study, I offer a novel way of data visualization of the flash-lag effect, showing that this illusion is simply viewed as a correlation structure in spatiotemporal domain.

In a classical flash-lag effect, a flash is presented adjacent to a continuous horizontal motion. The observer's task is to judge whether the flash is to the left or right of the moving item. By collecting the percentage of "to the right" responses at a series of flash positions, we get a sigmoidal psychometric function along the horizontal space. Its 50% point is not located at the physical alignment but biased toward the direction of motion, indicating that the flash has to be shifted this way, this amount, so as to obtain perceptual alignment. Also, the sigmoidal curve appears to be elongated along the horizontal.

However, the same data can be visualized in a different way. Consider a spatiotemporal chart, its abscissa and ordinate indicating the horizontal space axis and the time axis, respectively. Its center corresponds to each instantaneous spatiotemporal position of the moving item, relative to which the flash's spatiotemporal position can be defined. By plotting the percentage of "to the right" responses there, we get a two-dimensional psychometric function. The sigmoidal curve looks elongated along the horizontal as well as the vertical, i.e., the time axis. The question is whether the sigmoid arises from a spatial uncertainty or a temporal one.

This novel analysis was applied to many psychophysical data taken in several different experimental conditions including various speeds of motion and various forms of motion trajectory. It was found that apparently diverse data structures from different situations are reduced to a simple form of first-order spatiotemporal correlation. A large amount of variance in the spatiotemporal psychometric function was attributed to a temporal uncertainty of the flash. Shortly, the data were explained well by assuming that, on average, the flash has a longer latency than the moving item, and that the differential latency between the flash and moving item fluctuates according to a Gaussian-like probability density function. There was no need to introduce other clever mechanisms such as motion extrapolation (Nijhawan, 1994) and postdiction (Eagleman & Sejnowski, 2000).

The present study offers a new methodology to disentangle the apparently confounding nature of the flash-lag effect. It is concluded that the differential latency with probabilistic fluctuation is the most likely explanation of it.

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Where Bottom-Up and Top-Down Processing Meet

G.J. van Tonder and Y. Ejima ¹

We propose an idealized general circuit of the visual system with a fast bottom-up pathway (Thorpe *et al.* 1999), purely top-down path and a mixed pathway where bottom-up and top-down processes meet each other.

The focus of this presentation is to discuss our findings regarding the possible level of visual processing at which bottom-up and top-down processing meet. The famous dalmation image (after R.C. James, figure 1.a) is the main stimulus in our survey. Even Marr concluded that this image clearly demonstrates the limitation of bottom-up visual processing. But look at the dalmation again, especially through the eyes of the naive observer. What are the chances of finding the dog, and what kind of mistakes are typically made when looking at this image for the first time? Does this image contain significant bottom-up features or not?

In our survey 75% of subjects initially found a bulging body which overlaps with the dog, but final top-down percepts were unexpected: nearly all subjects assigned an incorrect head and limbs to the body (figs. 1.b-e). After randomly rotating texture elements overlapping computed features, only 45% of subjects reported a bulging body, with few adding limbs etc. We conclude that the dalmation image must contain many bottom-up features and that a top-down strategy may find "incorrect" targets at the correct target location.

Computational support based on bottom-up 3D surface interpolation from 2D scenes are provided to reinforce our claims. Anisotropic texture compression (Sakai & Finkel, 1995) and affine texture distortion cues (Rosenholtz & Malik, 1997) yield significant clues to the location of the target.

We conclude that bottom-up processing finds probable targets via feed-forward computational strategies, and that attention is guided towards such targets whereupon the top-down pathway applies and tests various hypotheses of shape. The top-down strategy is highly influenced by context and easily makes "mistakes". Subjects who mistook the dalmation for some other animal could nevertheless report that what they saw somehow did not look 'right'. This has deeper philosophical implications for our understanding of top-down processing.

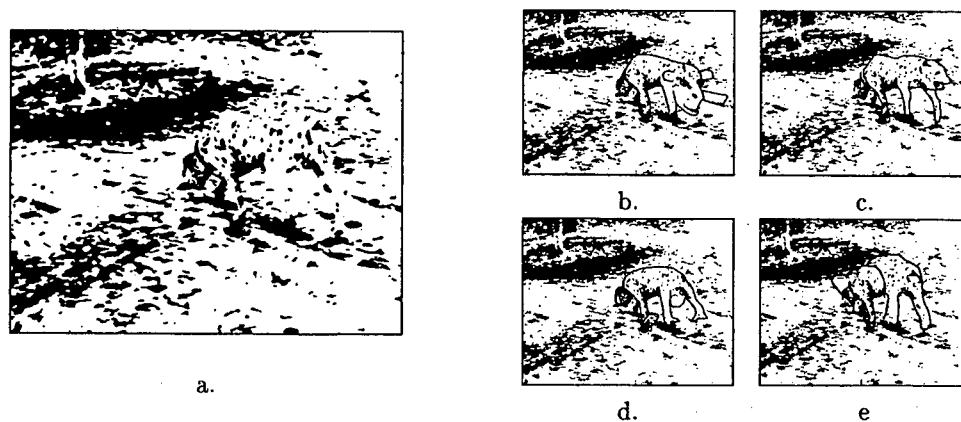


Figure 1: The famous image of the dalmation (a). Figures as seen by subjects (b-e).

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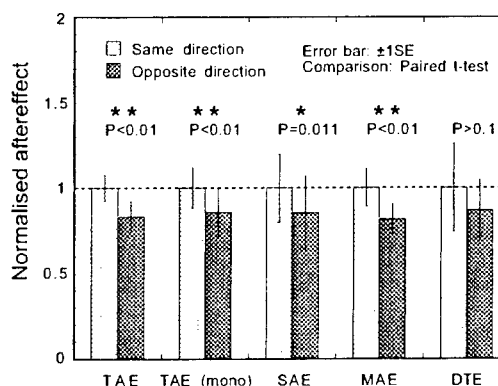
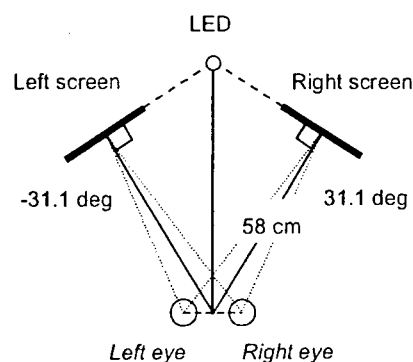
GAZE DIRECTION MODULATES VISUAL AFTEREFFECTS

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PURPOSE: In many cortical areas including V1 (Trotter & Celebrini, 1999), the direction of gaze can modulate the gain of neuronal response to visual stimuli, presumably for the conversion from gaze-dependent (eye-centred) to gaze-independent (e.g., body-centred) coordinates. A potential psychophysical correlate of the neural gaze modulation is the gaze modulation of visual aftereffects, which Mayhew (1973) had anecdotally reported for the motion aftereffect, and we systematically examined in this study. **METHODS:** Using Gabor stimuli, we measured the effects of varying gaze direction between adaptation and test on the tilt aftereffect (TAE), the size aftereffect (SAE), the motion aftereffect (MAE) and post-adaptation detection threshold elevation (DTE). The nulling strength of TAE or SAE, as well as the contrast threshold (for DTE), was measured by using a double random staircase method, top-up adaptation procedure and 2AFC judgement. The strength of MAE was estimated from lasting duration. Subjects always had to keep their head direction straight ahead, hence had to rotate their eyes in the head to gaze directly at a pattern. The adaptation pattern was presented 31.1 deg to the left or to the right. The test was presented pseudo-randomly on the same or opposite side of the midline as the adaptation stimulus. In either case, the subjects had to make a two-step gaze shift from adaptation to test patterns via an LED marker on the midline. To match the retinal position of the image, the subjects were required to align the dot grid pattern presented prior to the test pattern with the afterimage of the adaptation pattern. **RESULTS:** Group data indicated that TAE, SAE and MAE were significantly stronger when measured at the adapted gaze direction than when measured at the non-adapted gaze direction. The gaze modulation however was modest (<20%) and did not always appear in individual data. The gaze modulation of TAE occurred with monocular viewing as well as with binocular viewing, which suggests that the gaze modulation cannot be simply ascribed to binocular artefacts such as changes in vergence angle, vertical disparity and eye dominance. Some subjects indicated the gaze modulation of DTE, but it did not reach statistical significance in group data due to large individual variation. **CONCLUSIONS:** The gaze direction can modulate, though modestly, a wide range of visual aftereffects. The gaze shift paradigm with visual aftereffects may provide a useful psychophysical tool to analyse cortical process for coordinate transformation of visual space.



Ambiguous Contours in Shape-from-Shading

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ABSTRACT

We investigate the nonlinear interactions between contour and shading in the perception of three-dimensional structure. It has been reported that contours give strong influence on the perception of shape-from-shading. For example, we perceive a sphere if a circular contour is given to vertical gradation of grayness, while we see a horizontally placed cylinder if a rectangular contour is given to the same gradation. Here, we examine the perception of 3D structure from shading when contours give ambiguous convex/concaveness.

We developed stimuli whose 3D structure was generated from Gaussian or white-noise so that their saliency of contour was controlled. An example of stimuli generated from white-noise is shown in Figure 1. First, we generated stimuli in which a surface is given by Gaussian functions, and parallel light is projected on to the surface from either above or below. By changing a viewing angle, the ambiguity of contour is controlled. When a surface is viewed from the direction orthogonal to the surface, contours are invisible, while viewed from 45° aside, self-occluding contours appear. When the viewing angle is in between, ambiguous contours appear. Similar gradation of grayness is given for all stimuli, thus shading cue is kept constant. We measured whether human subjects determine correctly the convex/concaveness of the stimuli. The results show that the correct rate is high for stimuli with invisible contours and self-occluding contours, and the correct rate is nearly chance rate for stimuli with ambiguous contours. This suggests that contour cue is significant and override shading cue even if a contour is ambiguous.

Second, we generated stereo stimuli whose 3D shape and lighting were identical to the first experiment. The same procedures were taken, and the correct rate was measured. The results are similar to the first experiment except that the correct rate is substantially lower than chance rate if light is projected from below and contours are invisible (vertically viewed stimulus). This suggests that shading cue dominates stereo cue when contour is not given.

Finally, we compared the correct rate for stimuli with and without varying local contrast that was generated from shading on a randomly bumping (white-noise) surface. Multiple spot lights with vertical attenuation gave the vertical gradation of grayness as shown in Figure 1. The measured correct rate is shown in Figure 2, indicating that the correct rate is higher if white-noise bumps exist. This result suggests that the orderly changes in local contrast due to shading is effective for the perception of global 3D structure, in addition to the monotonic gradation of grayness.

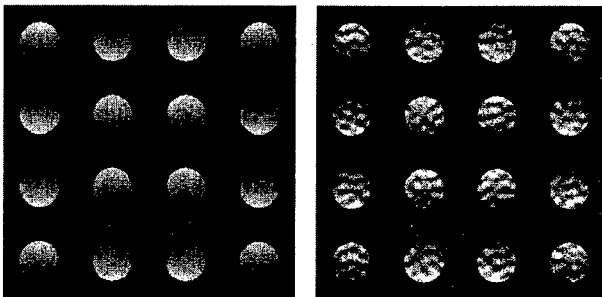


Figure 1: An example of stimuli. Vertically attenuating spot lights are projected on to a flat surface (left) and a surface with bumps generated from white noise (right). Human subjects were asked to judge convex/concaveness of assigned locations.

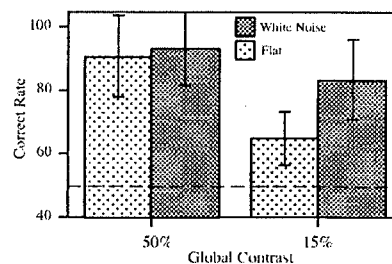


Figure 2: Measured correct rate for flat and bumpy surfaces with high and low contrast. Chance rate is set to 50%. Correct rate is high if small bumps exist in addition to gradation of grayness.

Limiting Factors for Human Gaze Perception

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Several researchers reported that the feeling of "being looked at" occurs when the looker's gaze is directed to the area between the two ears, and this corresponds to an 1-deg shift of edge of pupil. It is not clear, however, whether this limit should be related to acuity limit (absolute amount of angular shift), or to the amount of shift relative to the eye ball size, since measurements in all the past studies have been made with only one viewing distance. To clarify this problem, we measure the characteristics of gaze perception at five different viewing distances with actual-size color photographs of faces with nine gaze directions presented on CRT screen. Subjects discriminated whether stimulus gazes hit their face or miss it either to the left or to the right (3AFC). Results indicated no effect of viewing distance. Hit responses occurred when the gaze was directed within 3 deg range around the nose regardless of the viewing distance. These results clearly indicated that acuity is not the limiting factor.

As the next step to identify the limiting factor, we measured the gaze perception for low-pass filtered images with several different cut-off frequencies by using the method of adjustment. Subjects were asked to match the position of a marker to the perceived gaze line. No effect of low-pass filtering was found. These results, together, indicate that gaze perception is determined by shifts of pupil relative to the eye-ball size rather than absolute angular shifts, and by using mostly low spatial frequency contents.

Toward a Neurophysiologically-based Theory of Eye Movement Control During Reading

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Yang & McConkie (Vision Research, in press) describe the beginnings of a theory of eye movement control during reading, based on a neurophysiological framework of eye movement control proposed by Findlay & Walker (1999, *Brain & Behavior Science*).

This paper will develop the theory more fully, describing, in terms of activation and inhibition within the oculomotor system, the normal operation of eye movement control during reading, possible ways in which eye behavior is modified in response to task and stimulus characteristics, and how the system responds to processing difficulties.

The paper will also report a series of studies related to saccade control in reading, in which the process of saccade preparation is systematically manipulated so as to investigate the interaction between saccadic activity and inhibitory activity within the oculomotor system. Evidence from these studies suggests that saccade preparation in reading is not under direct control of psycholinguistic mechanisms, and that reading difficulties affect the patterns of saccadic eye movements by means of inhibitory signals. The evidence also shows how the effects of lower-level and higher-level factors on saccadic eye movements can be separated based on their effects on measures of oculomotor responses.

Based on the above evidence, the paper will further describe how certain puzzling observations can be explained within this theory (i.e., the many saccades that are uninfluenced by current stimulus characteristics, lack of a relation between fixation duration and whether a word is skipped, relatively flat hazard curve for longer fixation durations). It will also point out issues that arise within the frame of reference of this type of theory, such as the time course of the onset and dissipation of saccade inhibition when processing difficulties are encountered, and how activation and inhibition influence saccade length and direction.

Abstracts (Poster presentations)

Left/right asymmetries in the oculomotor gap effect

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Saccades to a suddenly presented visual target typically have latencies that range from 150 to 250ms. However, if an observer's fixation point is turned off 200-300ms before the target appears, saccadic latencies are significantly reduced. This reduction in saccadic reaction times has been termed the 'gap effect'. Recently, Weber & Fischer (1995)(*Vision Research*, 35, 987-998), using different gap durations and an overlap task (i.e., the fixation point remained on throughout the duration of trial), examined the distribution of saccadic reaction times for left vs. right directed saccades. They found that, in the overlap and the gap=0ms paradigms, the reaction times for the left and right targets were essentially symmetric and no express saccades (with latencies less than 135ms) were obtained. But, if the gap duration was more than 100ms, many express saccades were present toward the right (or left) targets, and the left/right asymmetry was most evident in the gap=200ms condition.

In the present study, I replicated Weber & Fischer's experiment using five gap durations (0, 50, 100, 200 and 500ms) and an overlap paradigm. Six subjects participated in the experiment. On each trial, a LED was turned on as a fixation point, and immediately before (in the overlap paradigm) or after (in the gap paradigm) the offset of the fixation point, a target for saccade (LED) was presented 6deg left or right of the fixation point. Subjects were asked to make a saccade as fast as possible to the target. The position of the subject's right eye was recorded with a scleral-reflectance method.

Four out of the 6 subjects showed an ordinary effect of gap duration similar to the results reported by Saslow (1967)(*J.O.S.A.*, 57, 1030-1033) and no left/right asymmetries were observed. Other 2 subjects (NS and KA) showed marked left/right asymmetries. Subject NS executed saccades more rapidly when a target appeared in the left visual field. An interesting result was obtained from subject KA. In this subject, the saccades towards the left showed an ordinary effect of gap duration, but the latencies of the rightward saccades were very short and fell within the range of express saccades even in the overlap paradigm (Fig. 1).

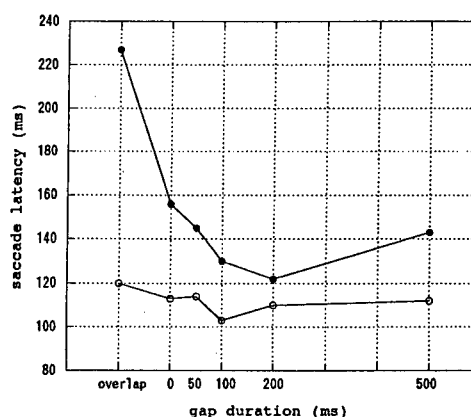


Fig.1. Saccade latencies (ms) shown by subject KA in the overlap and gap paradigms. ●: Leftward saccades, ○: Rightward saccades. Each point represents the average of 20 trials.

Flickering retinal signal induce longer perceived length than continuous retinal signal at about saccades onset

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< Introduction >

When we make a saccade across a flickering light-emitting diode (LED), we perceive an array of dots. Hershberger (1987) and his colleagues (1994) investigated how we perceived the length of array during saccades and how we temporally integrated them. Their studies, however, did not thoroughly investigate what properties of the stimuli affected the perceived length. The purpose of this study was to examine whether the perceived length varied with the properties of the stimuli (continuously-lit / flickering).

< Stimuli >

The stimulus LED was continuously lit (Continuous condition), or was flickered at 200-Hz (Flicker condition) for 31 ms. Subjects perceived a line under Continuous condition, while they perceived an array under Flickering condition.

< Method >

Two male and one female subjects participated in this study. In a completely dark room, subjects were seated 57 cm from the LEDs with the head fixed by a dental bite board and a forehead rest. After 15-minute dark adaptation, subjects were required to make eight-degree rightward horizontal saccades from a fixation point (-4 degree from subject's median plane) to a target point (+4 degree). Stimuli (+2 degree) were presented at various timing from the saccade onset. Subjects were, then, asked to localize the both endpoints of perceived lines (or arrays). Movement of the subject's left eye was monitored by Ober2. The length of the perceived line (or

array) was calculated by subtracting the subject's localization of the left endpoint from that of right endpoint.

< Results >

As Fig. 1 shows, it is revealed that the perceived length under Flicker condition (array) was longer than that under Continuous condition (line). The difference in perceived length between both conditions emerged at about 10 ms before the saccade onset, and they lasted until about 10 ms after the saccade onset. The difference was largest at the saccade onset, which reached to one degree.

< Conclusion >

Subjects evaluated the length of perceived array (Flicker condition) longer than the length of perceived line (Continuous condition), in spite of that the distance between both endpoints on the retinae were physically the same under both conditions. This result suggests that the abrupt appearance of stimuli affects coordinates of spatial locations of objects.

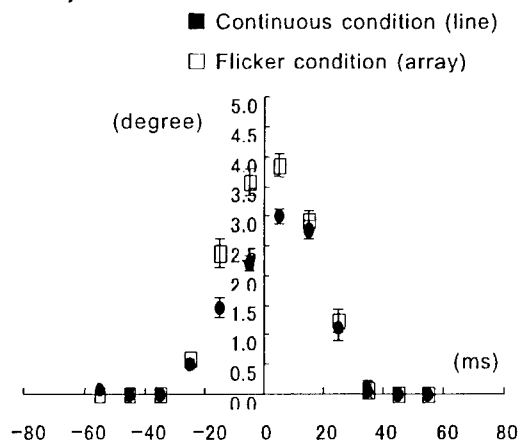


Fig.1. The perceived length under both conditions

Detectability of Stimulus Displacement Across Saccade Depends on the Apparent Direction of Displacement

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Introduction

When we observe the external world we repeat saccades and fixations. Our eyes obtain retinal images of the external world at each fixation. Although images of each fixation are discontinuous, we perceive an unified, continuous visual world. Our visual system integrates these discrete images into a continuous visual world. To investigate characteristics of position integration across saccade we measured thresholds for stimulus displacement^[1] and apparent (perceived) direction of stimulus shift across saccade. Size of visual field is one of the very important factors for space perception, so we studied effects of visual field size in detecting stimulus position change during saccade.

Method

We used a projection system to present a stimulus which covered the whole visual field. A LCD projector, equipped with a fish-eye lens, projected a large visual stimulus on a 180deg hemicylindrical screen. The subject used a bite bar to keep his head steady. The viewing distance was 60cm. The horizontal eye position was monitored by the limbus tracker method.

Stimuli were multi-colored mondrian patterns (mean luminance was 2.3cd/m²). We had two stimulus conditions (whole and 18deg square field of view) to measure the effect of visual field size. The subject made a saccade toward the target which was positioned at 16deg right from the fixation point. The stimulus was shifted during eye movement. To measure threshold, a trial consisted of two presentations. A stimulus shift occurred either in the first or in the second presentation. The subject responded in which presentation the stimulus shifted by 2AFC. To measure apparent direction of displacement, the subject observed a presentation and responded which direction stimulus shifted (left or right).

Results & Discussion

We defined threshold as a size shift that yielded 75% correct response. We also defined apparent stable

point as a size shift at which "right" and "left" response ratio was fifty-fifty. They were estimated by probit analysis.

Our results show that threshold in the same direction as saccade is higher in the small (18deg) visual field, and that in the opposite direction to saccade is higher in whole visual field condition (Figure 1). The apparent stable point for 18deg visual field condition deviates from physical stable point (0deg shift) toward the same direction as saccade.

These results suggest that thresholds for detecting stimulus displacement across saccade depend on the apparent direction of displacement.

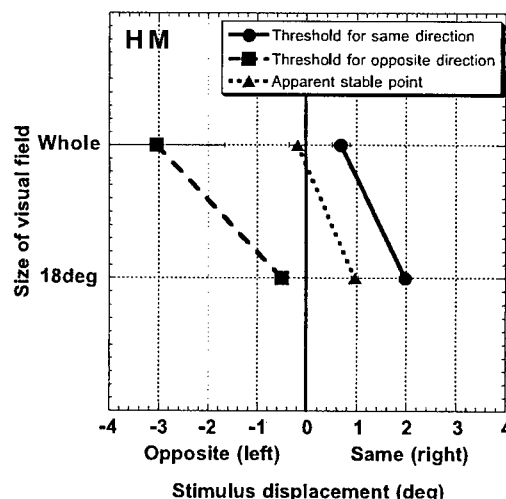


Figure 1. Thresholds for detecting stimulus displacement (●: for the same direction as saccade, ■: for the opposite direction as saccade, respectively) and apparent stable points during saccade (▲). Positive value represents the same direction as saccade (right), negative value represents the opposite direction as saccade (left).

Reference

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The eye-movement responds to the difficulty of a calculation task during a subsequential ocular task

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1. Introduction

The pupil size and act of blinking are evoked by problem solving. Especially, pupil is dilated in respond to the mental activity (Beatty, 1982). The eye-movement is often measured as viewing behavior, but it is unclear the responsibility of eye-movement to the task difficulty. The aim of this paper is to examine the change of eye-movement with difficulty of problem solving as viewer's mental activity during a subsequential ocular task.

2. Experimental procedure

Stimuli: Subjects were asked to follow a symbol(+) which moved in each second on the screen. It moved randomly on the circle whose radius was 5deg in visual angle. The target symbol size was 0.5x0.5 deg. **Oral calculation task:** The tasks were given to the subjects in order to activate mental activity during a subsequential ocular task. This requires an oral answer to the calculation task (Takahashi et al., 2000).

Oculo-motors: Eye-movement was observed by the eye-tracker (NAC:EMR-7), and each movement was divided into saccade and gaze by the speed 40deg/sec. Pupil size was measured by the image processing of an eye image from the tracker. Both sampling rates are 30Hz in NTSC video. Blinking was detected as a smaller pupil size which was removed away.

Procedure: Seven male university students took part in the experiment as subjects. Subjects were required to respond to ten tasks, each in 10sec. intervals. The following stimuli session was also conducted without any instruction as a control session.

3. Results

Pupil size was compared among four response conditions: control, fast correct, slow correct, and incorrect response. Average pupil size increases from control to incorrect response. This shows that pupil size reflects task difficulty. Blinking time increases with response conditions. The source of the condition is significant on both pupil and blinking change in one-way ANOVA (pupil: $F(3,295)=18.5$, $p<0.01$; blinking: $F(3,363)=9.4$, $p<0.01$). This suggests the order of task difficulty can be defined by both changes. According to eye-movement, total gazing time rate

decreases with the response conditions ($F(3,248)=12.3$, $p<0.01$). The rates are compared among the conditions, average rates for both slow correct and incorrect response are significantly lower than the control. When the gazing time decreases, the rest time might be allotted for the saccade.

However, saccade occurrence rate also decrease with the condition ($F(3,244)=10.5$, $p<0.01$). Figure 1 shows the changes of saccade occurrence rate with standard error bar in according to response conditions. The rate for incorrect response is significantly lower than the control and fast correct response ($p<0.05$).

In addition, average length of saccade is shorten by the response conditions. The source of the response condition is also significant ($F(3,242)=6.0$, $p<0.01$). The length for an incorrect response is significantly shorter than the control and fast correct response. There is no significant difference for all indices between the control and fast correct response without pupil size.

Despite gazing time significantly decreased in an incorrect response, saccade occurrence rate was significantly the lowest and saccade length was significantly the shortest. This suggest that the rest time may be allotted to do something which related task difficulty without gazing and saccade. Also this provides the evidence that the task difficulty which reflects the response influences eye-movement.

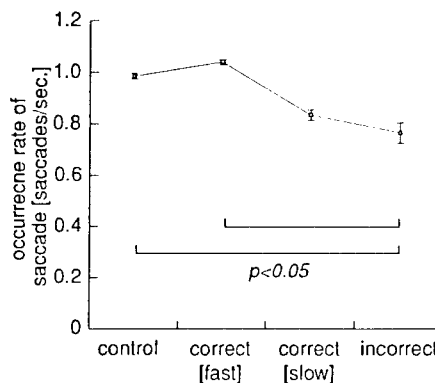


Fig. 1 Changes of occurrence rate of the saccade.

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K. Takahashi et al. (2000) ACM-ETRA Symposium 2000, <http://www.vr.clemson.edu/eyetracking/et-conf/>

Disparity tuning of the transient-vergence system revealed by disparity adaptation

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[Purpose] Based on data from stereo and vergence anomalies, it has been suggested that the transient-disparity vergence system, which processes large disparities to initiate vergence responses, consists of a relatively small number of channels that are sensitive to a broad disparity range (Richards, 1970, 1971; Jones, 1977). In order to examine this further, we investigated the disparity tuning of the transient-disparity vergence system for normal observers, using a sensory adaptation method.

[Methods] The effects of sensory adaptation to binocular disparities on the transient vergence responses were estimated from percentages of vergence responses made in the direction corresponding to the sign of the test disparities and the gain of that vergence response. The test stimulus was a dichoptic pair of two-dimensional Gaussians with the standard deviation of 0.5° . It replaced an initial fixation point and nonius lines for 500 ms and had either 1° , 3° , 5° crossed or uncrossed disparities with respect to the fixation point. The adaptation stimulus with the same stimulus pattern had either 1° or 5° crossed or uncrossed disparities. In order to minimize the adaptation to non-disparity selective processes, the luminance-contrast polarity and the spatial position of the adaptation stimulus were varied during the adaptation period. The adaptation stimulus was presented at one spatial location for 200 ms and after a 200 ms blank interval it reappeared at a new location. It was initially presented for 60 s and for 3 s prior to each trial. The results were compared with those for the control no-adaptation and monocular-adaptation conditions. Four young-adult subjects were tested. In addition, we tested our four subjects on a stereo test which was similar to that used by Richards (1970, 1971) in order to investigate the relationship between the disparity-tuning mechanisms for transient-disparity vergence and depth perception. The discrimination between binocular disparate and double monocular targets was quantified with d' using signal detection theory.

[Results and Discussion] There were substantial individual differences in vergence performance and effects of disparity adaptation. Adaptation to individual disparities caused reduced performance to either broad or narrow ranges of disparity. For example, adapting to 1° uncrossed disparity could reduce performance to the entire 5° range of uncrossed test disparities or for only the 1° uncrossed disparity. The latter example demonstrates that crossed and uncrossed disparities are mediated by numerous channels which have narrow disparity tuning rather than a single broad channel (Richards, 1970, 1971). We also found that adaptation to uncrossed disparities could facilitate the gain of vergence responses to 1° crossed disparity, suggesting an inhibitory interaction between crossed and uncrossed disparity channels.

The subjects showed some asymmetry in vergence performance for crossed and uncrossed directions. The direction of the asymmetric vergence performance was compared with the direction asymmetry for the stereo discrimination task. Three of four observers showed consistent response bias in the two tasks, however, one observer showed an opposite bias. He showed clear convergence responses to crossed disparities and very weak divergence responses to uncrossed disparities. However, his stereo-depth performance was higher for uncrossed than crossed disparities. As opposed to Jones (1977), this suggests that the disparity-processing mechanism for depth perception and vergence initiation are independent. It is possible that a common source of disparity is used by the sensory and motor systems but other independent factors influence the symmetry of the sensory and motor responses to disparity differently.

The apparent displacement of the part of a vertical line viewed monocularly relative to those parts that are viewed binocularly

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Introduction. When a vertical line is viewed with a ring such that the section of the line inside the ring is seen monocularly while the sections outside the ring are seen binocularly, the inside section of line appears displaced with respect to the outside sections of the line. Nakamizo and Kawabata (2000) argued that the apparent displacement of the section of the line viewed monocularly could be accounted for with Wells-Hering's principles of visual direction by assuming misconvergence to the frontoparallel plane on which the line is located. The aim of this experiment was to examine the apparent displacement of the section of the line viewed monocularly as a function of convergence.

Methods. Stimuli were 8 stereograms, each consisting of a vertical line and a ring, presented with a mirror stereoscope (Fig. 1). In seven stereograms, the line and the ring had a disparity of 46 minutes of arc and the ring occluded the central part of the line for the stereogram to the left eye. Convergence error was controlled by a pair of nonius line. The independent variable was the disparity between the nonius line and the vertical line, which were three uncrossed disparities (46', 34.5', and 23'), three crossed disparities of the same sizes, and zero disparity. Observers were asked to report whether the section of the line seen inside the ring appeared displaced from the sections seen outside of the ring or if they appeared aligned. If the center section of the line appeared displaced, they were asked to report the extent of the displacement by a ratio using the width of the line. Five observers including the authors participated in the experiment.

Results. Figure 2 is the results, in which the mean apparent displacements averaged over 5 observers are plotted as a function of the disparity

of the nonius line. The direction of the apparent displacement of the monocular section of the line was consistent with the prediction of the Wells-Hering's principles; Furthermore, the mean apparent displacement was approximately one half of the disparity between the nonius lines and the vertical line

Conclusion. The results of the present experiment confirmed the prediction of the Wells-Hering's principles of visual direction. In conclusion, the apparent displacement of the part of the vertical line occluded to one eye is due to misconvergence to the frontoparallel plane of the line.

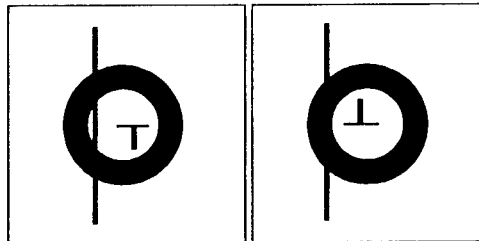


Figure 1. A pair of stereogram used.

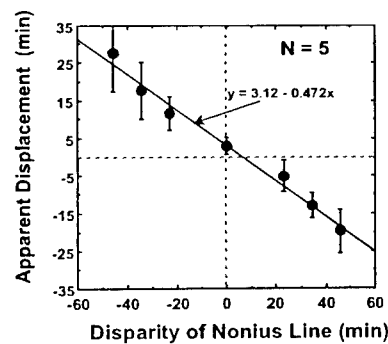


Figure 2. Mean apparent displacement of the monocular line.

Stereo sensitivity to moving stimuli

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Purpose: To investigate the effect of motion on stereopsis, we measured stereo sensitivity to moving gratings with variable spatial and temporal frequencies.

Methods: Stimulus display consisted with four squares filled with sinusoidal gratings arranged in a 2x2 array with gaps to separate them. The gratings in the upper right and the lower left squares had the same disparity that was opposite of those in the other two squares and the observers responded which pair appeared to be closer in depth. Disparity threshold was measured for the depth discrimination in each combination of five spatial frequencies (0.23~3.75c/deg) and five speeds (0.15~10Hz). The stimulus contrast was also varied.

Results: The results showed that the disparity threshold depended little on spatial frequency when stimulus contrast was high (>0.1). When stimulus contrast was low (<0.1), on the other hand, spatial frequency strongly influenced the disparity threshold. The disparity threshold was lowest at a spatial frequency of about 1c/deg independently from stimulus speed. Comparison of the effects of contrast among different conditions showed complex interactions between the contrast and spatiotemporal frequencies. When the spatial frequency of the stimuli was low, threshold with low contrast stimuli did not depend much on stimulus speed while threshold was higher with higher speeds for high contrasts. When the spatial frequency of the stimuli was high, threshold with high contrast stimuli did not depend much on stimulus speed while threshold was higher with higher speeds for low contrasts.

Conclusions: The results indicate that the stereo sensitivity is roughly constant independently on spatial characteristics of the stimulus when contrast is high enough. The effects of spatial frequency with low contrast stimulus possibly reflect the spatial frequency characteristics of the mechanisms detecting contrast modulation, the outputs of which mechanism are used for stereopsis. The effect of contrast was shown to be different among different spatiotemporal frequency conditions. This suggests that more than one underlying mechanisms contribute to stereopsis.

Influence of Object Shape for Depth Difference Perception

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Abstract

Depth perception is one of the indispensable issues for 3-D perception. For investigating the depth perceiving ability, a depth difference discrimination method for two target patterns such as lines or dots, has been used widely. Previously, however, we found that the depth difference discrimination ability was influenced remarkably by the existence of the intermediate surface between the target patterns. We thought that object shape is an important factor for depth difference perception.

In this paper, we investigate the influence of object shape for depth difference discrimination ability by observing the testing target objects and discuss the depth cues for depth difference perception. The depth difference discrimination abilities have been measured by detecting the critical distance at which an observer just could not recognize the test object as curved. We found two significant results from the measurements. One is that the depth difference discrimination distance is specific to each object shape. The other is that the depth difference discrimination ability of concave objects is different from that of convex objects because the depth difference discrimination distances of the concave objects are longer than those of the convex objects on same object shape. These results show that the difference in the depth difference discrimination distance is different for each object shape. Accordingly, we suggest that the object shape is an important factor for depth difference perception.

We also discuss the depth cues for depth difference perception from the above results. There are reversed effects of texture gradient are reversed between the convex objects and the concave objects. Although the effects of texture gradient on the concave objects are weaker than those of the convex objects, the depth difference discrimination distances of the concave objects are longer than those of the convex objects. These results suggest that texture gradient can't be the main depth cues for perceiving the depth of a concave object. In structure, all the concave objects have faced surfaces. Each faced surface can be thought to make the interactive effect affecting the depth difference perceiving ability greatly. It can be expected that depth cues from eye movement such as vergence or accommodation are playing important roles for perceiving the depths of the concave objects. As vergence could saccade on object's surfaces, we think that these depth cues use the faced surfaces and cause the interactive effect of the faced surfaces. This is the perceiving phenomenon that we have newly found.

The effect of haptic learning on the process of depth cue integration for perceptual and motor responses

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It has been assumed that the human visual system integrates the information from several cues for depth perception. A previous study proposed a model for the process of depth cue integration, which stated that perceived depth depends on the weighted sum of the depths specified by the cues¹⁾. In the present study, we investigated whether the process of depth cue integration is plastic. We assumed that the process of depth cue integration is plastic, because the depth cue weights are different from observer to observer²⁾, and because our ability to extract the information from each cue might change with growing and aging. If the integration process is plastic, it could be assumed that the weight of a cue consistent with tactile information would increase gradually. In investigating the effect of the haptic learning, it would be appropriate to distinguish between perceptual and motor responses because the haptic learning would affect motor response only. Therefore, we used both visual and motor responses for investigating the effect of the haptic learning on the cue integration process.

We measured the weights of the cues before and after the haptic learning. Tactile information was presented with a circular paddle, which was placed in front of the subject and could be rotated about the vertical axis by the subject. Visual stimulus was a pair of random-dot stereogram to simulate the circular paddle and was presented with a mirror stereoscope at the same position as the paddle. Binocular disparity and perspective cues in the visual stimulus were manipulated independently. In the learning phase, the subject rotated the paddle freely, while observing the visual stimulus. The slant specified by only one of the visual cues was changing to synchronize with the paddle movement. We used two kinds of weight measurement; visual matching and manual matching. In each trial of visual matching measurement, the test stimulus was presented first, and then a visual display was presented. The subject responded the perceived slant of the test stimulus by adjusting the angle of the white line in the display, which represented the surface angle from the top. In the case of manual matching, after the test stimulus was presented, the subject adjusted the slant of the paddle to represent the perceived slant of the test stimulus.

The result showed that the haptic learning didn't produce consistent changes in the depth cue weights in both visual and manual matching in this experimental condition among the subjects. The result of this study was inconsistent with that of the previous study³⁾. This is probably due to the difference of the stimulus conditions. In the previous study, all of the stimuli were static, while in the present study, the learning stimulus was dynamic and the measuring stimulus was static. The comparison between the results obtained in the previous³⁾ and present studies suggests that the change in the depth cue weight by haptic learning strongly depends on the stimulus properties in the learning and test phases.

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Brain Activity Related to Stereoscopic Perception in Visually Triggered Movement Task: A Magnetoencephalographic Study

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Introduction

Many physiological studies were done about visual cortical neurons that respond to binocular disparity, but it is still not clear what large-scale activity of such neurons detects correspondent regions in both retinæ and calculates amounts of disparity, which is considered to be necessary to perceive stereoscopic image. This study investigated magnetic fields evoked by visual stimuli including binocular disparities to elucidate macroscopic responses of visual cortical neurons in the process of stereoscopic perception by means of a visually triggered movement task.

Methods

Two types of random-dot stereograms (RDS-C and RDS-U) and correlograms (CRG) were used for visual stimuli. RDS-C and RDS-U contained crossed and uncrossed disparities, respectively. Visual stimuli were projected on a screen by an LCD projector as anaglyphs. A floating rectangular bar and a hollow rectangular bar on the right hemifield were perceived in RDS-C and RDS-U, respectively. The stereograms subtended an angle of 40 deg by 30 deg of arc and the rectangular bars an angle of 2 deg by 30 deg of arc. A cross-shaped marker at the center of the figure was displayed as a fixation point. CRG was displayed for 1.5-3.5 s and then either RDS-C or RDS-U was displayed for 0.8 s in one trial. Trigger signals for the MEG measurement were generated at the changes of the images, from CRG to RDS-C or from CRG to RDS-U. Acquisition of MEG responses started 0.2 s before the trigger and lasted for 1 s. All subjects performed a counting task (CNT) and three types of reaction time tasks (M-C, M-U and M-CU). In a task CNT, subjects counted the number of the changes between RDS-C and RDS-U in ten RDS presentations. In a task M-C and a task M-U, subjects were instructed to make a button-press response as soon as a floating bar (a task M-C and a task M-CU) or a hollow bar (a task M-U and a task M-CU) was detected. The evoked magnetic fields were recorded in a magnetically shielded room using a 64-channel, whole-cortex MEG system. EMG signals were simultaneously recorded. The collected data were classified according to stimuli and tasks, and then synchronously averaged. Subjects were six volunteers.

Results

In all classified and averaged MEG responses, obvious activities whose peak values were larger than 50 fT started about 100 ms after RDS presentations and lasted for 200-400 ms. Median reaction times were 200-400 ms under task M-CU conditions and 300-600 ms under task M-C and task M-U conditions. Source estimations of MEG responses under task CNT conditions were conducted by means of a single equivalent current dipole (ECD) method. The estimated ECDs were mainly located around calcarine fissures and the latencies were 100-200 ms. ECDs around parieto-occipital sulci and parietal lobes were also observed in some subjects.

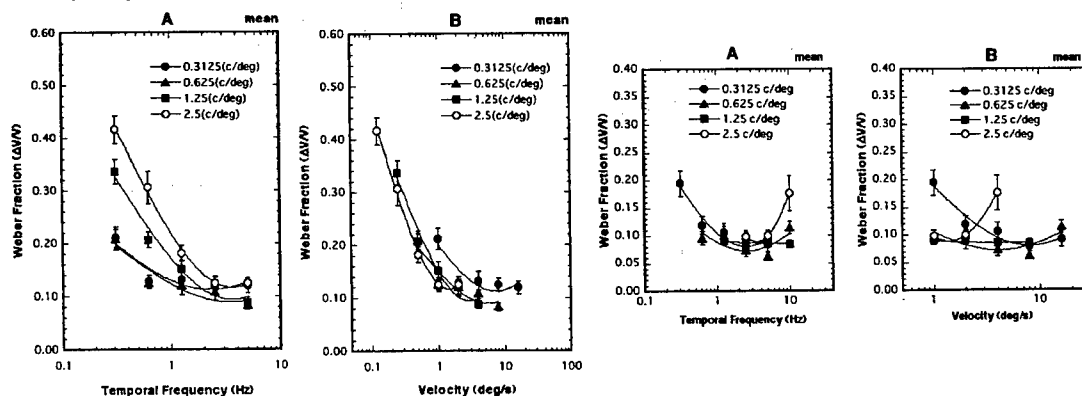
Discussion

To perform a task M-C or a task M-U correctly, Subjects have to judge which disparity the presented RDS has. Solving correspondence problem is indispensable to the judgment. Therefore reaction times in a task M-C and a task M-U can be used as an upper limit of the time when subjects detect the correspondent regions in RDS. A few ECDs were estimated both before and after the median response times from MEG responses of the subject whose median response times were the fastest. While the ECDs before the median response times were around the calcarine fissure, the ECDs after the median response times were found in the region of the cingulate gyrus. This finding indicates the estimated sources were related to the brain activity in the dorsal pathway of visual information processing.

Velocity discrimination of moving gratings with different spatial frequencies

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Purpose: The purpose of this study was to clarify the basis of velocity discrimination: velocity itself or temporal frequency. Some previous studies indicate that velocity discrimination is based on velocity itself, while other studies show that the discrimination is based on temporal frequency or both. The author hypothesizes that in slow velocity conditions, velocity discrimination is based on velocity, but that in fast velocity conditions, it is based on temporal frequency. The following two experiments examined the validity of this hypothesis. **Method:** Stimuli were generated on a monitor controlled by a personal computer. A fixation mark (+) was presented in the center of the monitor. Test and variable patterns were presented to either the left and right sides of the fixation mark or in the opposite positions. The size of each pattern was 3.2 deg x 3.2 deg. Both patterns were sinusoidal gratings and all moving directions were centripetal. The mean luminance of both patterns was 10 cd/m² and the contrast of patterns was fixed at 20%. The observing distance was 80.5 cm. The spatial frequency of variable patterns was the same as that of test patterns. The presentation time was fixed at 800 ms. Subjects were asked to judge which of two patterns was faster by depressing one of two keys. Variable velocity changed with each subject's response. If judgments were correct twice in succession, variable velocity in the next trial was set closer to test velocity by one step (4%). If the judgment was incorrect once, then variable velocity was set further away from test velocity by one step. In theory, this method makes variable velocity converge to 71% (or 29%) threshold of velocity discrimination. In Experiment 1 (four subjects), the spatial frequencies of test patterns were 2.5 ~ 0.3125 c/deg and the temporal frequencies were 0.3125 ~ 5.0 Hz. In Experiment 2 (three subjects), the spatial frequencies of test patterns were the same as for Experiment 1 and the velocities were 1.0 ~ 16 deg/s. The experiments for all conditions were carried out in random order. The upper and lower threshold for each condition was measured four times for each subject. **Results:** The results of Experiment 1 are shown in Figure 1. The mean Weber fractions were plotted as a function of temporal frequency (Figure 1A) and as a function of velocity (Figure 1B). The results indicate that the Weber fractions of the velocity discrimination decreased with an increase of test velocity, irrespective of changes in spatial or temporal frequencies. The results of Experiment 2, shown in Figure 2, are in the same form as Figure 1 results, and display the opposite tendency to Experiment 1. The Weber fractions varied with temporal frequency and the most sensitive frequency was 5.0 Hz. These results showed that velocity discrimination was based on velocity itself in slow velocity conditions, but was based on temporal frequency in fast velocity conditions. **Conclusions:** It is concluded that velocity discrimination was based on velocity itself or temporal frequency, depending on the magnitude of velocity.



Asymmetry of motion perception in the lower and upper visual field with motion-defined motion stimulus.

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Purpose

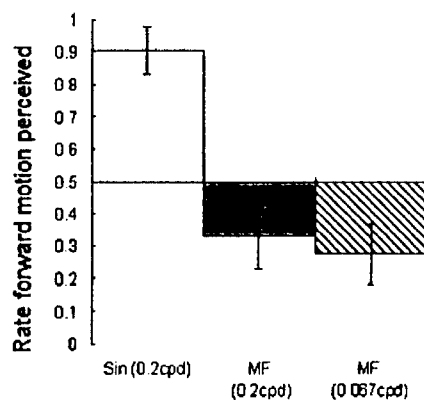
Motion of motion-defined patterns (motion defined motion, MDM) has no luminance motion component in its direction, and thus is considered as second-order motion. Zanker (1993) proposed a two-layer model as a model for detecting motion-defined motion. In this Model, outputs of local (luminance-based) motion detectors on the first layer are processed by second layer detectors that have the same mechanism as local motion detectors. We investigated this hypothesis by using motion-defined-missing-fundamental waves.

Stimulus

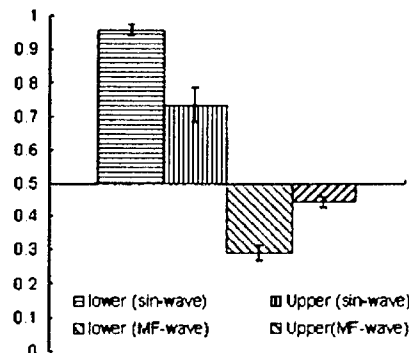
Stimulus was Dynamic Randomdot Kinematograms (size: 4(V) x 10(H) deg), in which dots were displaced to the right or to the left according to the probability modulated with sinusoidal or missing fundamental vertical wave form (spatial frequency: 0.067 or 0.2 c/d). An 8-frames apparent motion stimulus was generated by shifting those modulation wave horizontally with the displacement of 90 deg phase angle. SOA was 320 ms, and ISI was 0 ms. The stimulus was presented in the central or peripheral (10 deg upper or lower) visual field. Task was direction discrimination and a 2AFC method was used.

Results and discussion

Motion was perceived in the direction opposite to the physical shift in the central and peripheral visual field, and this is consistent with the prediction from a two-layer model. However, unexpectedly, response rate for reversed motion was higher in the lower than in the upper visual field for missing fundamental patterns, and response rate for forward motion was higher in the lower than in the upper field for sinusoidal patterns. These results suggest there is a lower visual field superiority in the detection of motion-defined motion based on the pattern's fundamental harmonix. It is difficult to account for this asymmetry in the upper and the lower visual field by the two-layer model. These results suggest contributions of higher-order processes.



<Central Visual Field>



<Peripheral Visual Field>

Color Input to First-order Motion Detectors

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Detecting moving objects is a fundamental function of the visual system. Recent studies have shown that the human visual system contains multiple different kinds of motion mechanisms. The so-called first-order motion mechanism detects simple motions of moving luminance-defined objects, the most common type of motion in nature. Based on anatomical, physiological and psychophysical studies, it has been widely accepted that the magnocellular pathway plays a key role in the detection of luminance motion, while the color-sensitive parvocellular pathway is less involved. Since the neurons in the magnocellular pathway are spectrally broadband and hence are not selective for color, first-order luminance motion mechanisms constructed from such neurons should be largely insensitive to the color of a moving luminance-defined object. We have examined the assumption that the first-order motion mechanism is not selective for color.

Human observers judged the direction of motion (upward or downward) of a drifting luminance grating. As the grating moved, its color alternated between two hues. Each frame of the moving pattern was isochromatic (not isoluminant), but the chromaticity of the pattern changed over time. The temporal frequencies of drift motion and color alternation were manipulated independently. We measured the minimum luminance contrast needed to determine the direction of motion with and without the color alternation. We chose two hues from a color space based on the chromatic tuning characteristics of neurons in the lateral geniculate nucleus (LGN).

The color alternation between 0° (pinkish red) and 180° (greenish blue), corresponding to opposite ends of the LM axis, greatly increased the luminance contrast required for direction discrimination, thus disrupting the ability of observers to analyze the direction of motion (motion interference). When the temporal frequencies of drift motion and color alternation were similar, the luminance contrast required increased by as much as 6x. The strength of motion interference decreased as the temporal frequency difference between drift motion and color alternation increased. This temporal frequency selectivity of motion interference suggests that the time delay of the responses between L- and M-cones is not the cause of the motion interference. Motion interference disappeared when the color alternation was faster than ~16 Hz and thus invisible, which implies that any possible luminance mismatch between the two hues is not the cause of the motion interference, since such a luminance mismatch should be quite

detectable at this temporal frequency. Motion interference was prominent at drift frequencies of 10 and 12 Hz, to which higher-order motion mechanisms do not respond. This indicates that the color alternation affects first-order motion mechanisms. Also, motion interference disappeared in the retinal periphery (15 deg in the temporal retina), where color perception becomes poorer than in the central retina.

Based on these observations, we conclude that color, *per se*, influences the direction discrimination of a luminance-varying moving pattern. When the temporal frequency of grating drift is similar to that of color alternation, the directional information in luminance gratings having the same hue is ambiguous. The temporal frequency selectivity of motion interference suggests that motion integration occurred predominantly across frames having the same hue, causing deterioration in direction discrimination. When motion interference occurred, subjects reported that the alternating pinkish-red and bluish-green gratings appeared to be jittering and their motion directions could not reliably be determined.

Results were quite different when the color alternated between 90° (yellow) and 270° (bluish purple), opposite ends of the S-varying axis, however. Here, only the activation of S-cones varies while the activation of L and M cones is fixed. In this case, color alternation caused no significant increase in direction discrimination contrast thresholds, although the difference between the two hues is perceptually quite salient. Measurements made with several hue pairs showed that the amount of motion interference is directly related to the total contrast of L and M cones, with no contribution from S cone contrast and no simple relationship to either unique hues or perceptual salience.

Our results indicate that first-order motion mechanisms are sensitive to the color of moving objects as coded by the outputs from L and M cones. Directional information is extracted from luminance patterns producing similar L and M cone responses. The amount of motion interference is proportional to the chromatic signal encoded by LM opponent neurons at the level of the LGN. Since the chromatic signal is modified in V1, our results suggest that the parvocellular input to first-order motion detectors derives either from LGN cells or from cells very early in the V1 processing stream.

Contribution of color to motion in depth

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[PURPOSE] There are two binocular depth cues known to be used to see motion in depth. One is that based on disparity change in time and the other is that based on inter-ocular velocity differences. Sensitivity tunings to stimulus variations may be different in the use of the two cues. One of the interesting questions is the sensitivity to color. We examined whether the visual system see motion in depth in isoluminant color stimulus in the condition with isolating either of the two cues.

[METHOD] Stimulus consisted with a pair of Gabor patches (space constant sigma was 1° with the central spatial frequency of 0.3 c/deg) in each eye. Two oriented Gabor patches were placed at 2.5° above or below the center of the display field (5° h x 6.7° w). The two patches moved in the opposite directions to create relative motion, which was necessary to arise motion in depth sensation. The contrast modulation was along either isoluminant red/green direction or isochromatic luminance direction. The orientation of the Gabor patches was $\pm 45^\circ$ from the vertical. In the inter-ocular velocity difference condition, the orientation was in the opposite between the images for the two eyes to remove disparity cues and they moved in the opposite directions. In the disparity change in time condition, the stimulus orientation was the same for the two eyes. To remove monocular coherent motion, the phase of the function varied randomly from frame to frame while disparity changed smoothly in time. We also run the condition with both cues, in which the stimulus orientation was the same and the images move coherently. The observers responded the direction of motion in depth (upper patch approached or went away). The same task was used to find individual isoluminant points in the Gabor patch. Before the experiment, pilot experiments determined the isoluminant point, where we obtained the luminance ratio between red and green that gave the least percentages of correct responses.

[RESULTS] Contrast sensitivity was measurable with color stimulus both in the velocity and disparity cue conditions. The sensitivity in the disparity condition and that in the two cue condition were similar while the sensitivity in the velocity condition was somewhat lower than that in the other two. This pattern of the results was consistent with the results with luminance stimulus. These results suggest that color contributes to perception of motion in depth both through the motion process and the disparity process. An alternative interpretation of the results is that motion in depth seen based on residual luminance signals in the color stimulus, or that generated in the visual system due to the variation of the isoluminant points among the cells concerns. Our additional measurements of temporal frequency characteristics of the sensitivity to color stimulus ruled out this possibility. The sensitivity function for luminance stimulus showed a bandpass characteristics whereas that for color showed a lowpass characteristics, at least in the velocity condition. These results indicate that color inputs both to disparity and motion detection processes. Although the contribution of the color to motion and stereopsis has been reported in many experiments, it is in dispute whether the manner of contribution is the same as luminance. Our results did not show any essential differences between color and luminance stimulus. Both contribute to motion in depth perception in the velocity and disparity conditions and the relative sensitivity among the cue conditions were similar. They are consistent with, although not necessarily support, the notion that color contributes to motion in a similar manner as luminance.

[CONCLUSION] Color contributes to motion in depth perception both through the motion process and the disparity process.

Visual Determination of Equal Color-Difference Contours

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For the practical application of a color-difference evaluation model in industry, the basic issue is how to make the colorimetric magnitude represent the visual one. One of the most important aspects is the relation between metric color differences in a color space and their corresponding perceived scales, which concerns the uniformity representing color-difference of the specific color space or model.

In this study, an experiment for determining the equally perceived color-difference contours in CIELAB color space was carried out to analyze the relationship of Euclidean and visual color differences and to evaluate the color perception uniformity of the color space. The results also can be used to test the existing color-difference formulae and to modify or even to configure a new model.

The experiment was designed based on the psychophysical method of constant stimuli and with the use of CRT-generated color stimuli driven by a VSG (visual stimulus generator) system. The stimulus pattern consisted of a reference color-difference pair (CIE Gray) and a test pair, with a 0.5° separation in between, on a 6° neutral gray background (Munsell N5). The subtended viewing angle of the measured stimuli at the center of the display was about 2.5° , so CIE 1931 Standard Colorimetric Observer was used in data reduction. The pattern was surrounded by a bright border, with a width of 1° visual angle, having a luminance of 100 cd/m^2 and the chromaticity of D65. The border was presented to have the CRT stimuli appear as related colors and to define the white point for the image. The color difference of the reference pair was only the difference of luminance (gray scale). For the test pair the color difference was the selected color distance, predetermined by a pilot experiment, along different directions from CIE color centers. The arrangements of the left and right position for the reference and test pair and of the upper and lower position in the color pairs were all randomized to avoid an eventual bias by the presenting positions. A modified temporal gap condition was used, of which one cycle began with a 200 ms gap and ended at receiving the subject's response. The visual task of the observer is to press one of the 2 keys according to his/her judgment whether the color difference of test pair was greater or less than that of reference pair. During the gap, only reference and test pairs were shut off with black, while the surrounding border and background remained for the subject to maintain the complete adaptation to the white point and background throughout the entire experiment.

The reference scales of color difference were set as 4.0, 8.0, and 12.0 CIELAB ΔE units, corresponding to each of which the equal color-difference contours were determined via the statistical method of probit analysis. The contours of equally perceived color difference could be fitted by symmetrical ellipses, but the fitting accuracies in (a^*, L^*) - and (b^*, L^*) -plane, with the L^* component mixed, was worse than in (a^*, b^*) -plane. This verifies the lack of uniformity for color perception in CIELAB space. Furthermore, the colorimetric magnitudes corresponding to different visual scales were likely linear with the visual ones, but not with a unity proportion, which differed a lot for different directions around a same color center or for the same direction around different color centers.

COLOR DISCRIMINATION UNDER CHROMATIC ADAPTATION BY PRE-PRESENTED EQUILUMINANCE STIMULI.

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INTRODUCTION Chromatic vision has been explained by opponent-color theory, according to which red-green and yellow-blue channels receive input from all three classes of cone photoreceptor, either directly or indirectly through multiple stages of processing. This paper is concerned with an unresolved issue: whether, and to what degree, the red and green components of a red-green channel are independent of each other? We used chromatic adaptation to address this issue and were particularly interested in testing whether there is a unitary red-green channel or whether it represents the combination of "subchannels."

In our previous work (1), we used adaptation stimuli with square-wave chromatic modulation in order to separate the two opponent channels (for example, red and green channels). The color of the adaptation stimuli changed between equal-energy white and a set of highly saturated colors. In the experiments, observers could see only white and one of the basic colors (red, in this example) except for the aftereffect of the adaptation stimulus. We observed increased thresholds for color discrimination under equal-luminance conditions for both opponent-color directions (red and green directions in this example). This result suggests that opponent-color channels are not independent of each other, but consist of one opponent channel. However, because we used square-wave modulation of chromatic adaptation stimuli, it is possible that the results stimulated both the temporal ON- (say red) and the OFF-channels (of the opponent color, green) when the color of stimuli changed from white to the saturated color.

METHOD In this research, we used adaptation stimuli in which chromatic change was varied by a temporal saw-tooth wave as shown in figure 1. We expected that this type of adaptation stimuli would strongly stimulate one opponent color and be less effective in stimulating the temporal-OFF channel of the opponent color. We measured thresholds for color discrimination in different color directions under equal luminance conditions (10 cd/m^2) after the chromatic adaptation. The saw-tooth adapting light was 1 Hz presented as a $13.6^\circ \times 13.6^\circ$ square in 2000 cd/m^2 . Test stimuli for the color discrimination have spatial Gaussian shape (Diameter of $\pm 1 \text{ SD} = 2.3^\circ$). The adaptation light was presented for 5 minutes before all trials after dark adaptation and 6 seconds before each trial. Thresholds were determined by a staircase combined with 4-alternative forced-choice method.

RESULTS Figure 2 shows one example of the threshold of color discrimination plotted in cone excitation coordinates (L-2M vs. S). Crosses denote the threshold with no adaptation. Triangles denote the threshold with the square-wave adaptation stimulus of red-white color change (the direction of the adaptation is shown by an arrow). Squares denote the threshold with the saw-tooth adaptation in the same color direction. Not only thresholds with the square-wave light, but also thresholds with the saw-tooth light increase symmetrically along the color direction of the adaptation light. This result shows that even the saw-tooth adaptation light could not adapt the red channel independently.

DISCUSSION These results demonstrate that the elevation of thresholds in color discrimination in the other opponent-color direction is not caused by the effect of the temporal-OFF channel of the other opponent color, but caused by the interaction between two opponent colors. Thus we expect that psychophysically-measured opponent-color channels are not independent of each other but that they consist of one-opponent color channel, or at least, they have strong interaction in each other.

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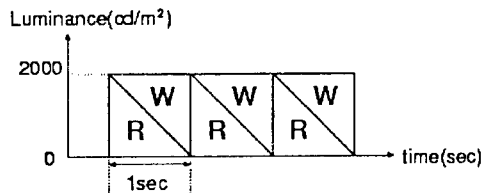


Figure 1

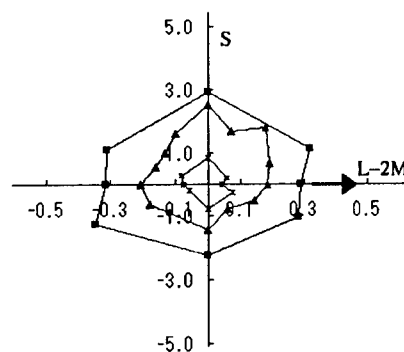


Figure 2

Color Appearance of Chromatic Lights in the Entire Visual Field

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Quantitative measurement of the appearance of colored lights at the different eccentricity is important for both basic and applicative vision science. The purpose of this study is to measure the change of color appearance with the eccentricity and obtain basic data for the establishment of color zone map. In addition, we measured responses of blackness evaluation and categorical color naming in the whole visual field, to investigate relations among these responses and color zone map.

Five stimuli, Red, Yellow1, Yellow2, Green, and Blue, of color LCD were used, and the surround was a gray (about N5). Measurements were done for 8 points, from 10 to 80 degrees with 10 degrees step, for each of the 8 directions. Thus a total of 65 points including 0 degrees were employed as test points. The stimulus field was a circle with a diameter of about 2 degrees. Measurement was carried out by the right eye and the observer evaluated color appearance of test stimulus. The evaluation methods used were an opponent-type color evaluation (saturation and hue judgments), blackness evaluation, and categorical color naming.

Color zone map consists of the change of unique hue component with eccentricity for each the entire visual field. Unique hue component (UHC) is a product of the saturation value and the percentage of the hue measured using an opponent-type color evaluation. UHC was calculated in each test point, and the equal UHC contours in entire visual field were obtained. We call such a contour map as a color zone map.

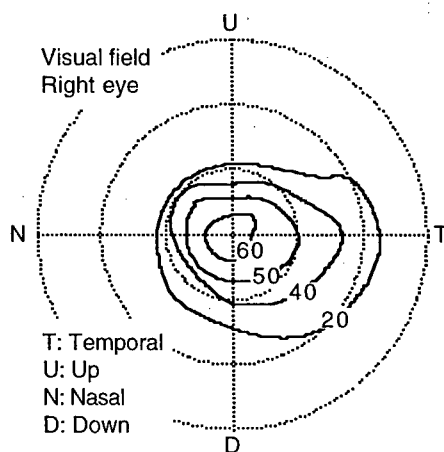


Fig. 1. Color zone map (Green).

Fig. 1. shows the color zone map for Green. This figure is drawn with 5 observers mean of unique green component. A radius indicates the eccentricity in the visual field, the dots line circles of from the most inner side to outer side denote 30, 60, 90 degrees, respectively. The values in this figure indicate the percentage of unique green component. This figure shows that color zone extended to the right and the lower direction. Color zone maps for other unique hues obtained by other stimuli are similar to Fig. 1. Relations among color zone map and responses of categorical color naming and blackness evaluation are discussed.

Color Opponent Is A Dominant Mechanism to Discriminate Inhomogeneous Colors

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In our previous studies, we investigated the influence of size and color distribution width of stimulus patches upon inhomogeneous color discrimination using random patch arrays¹⁾. From these results, we concluded that there were no special mechanisms for inhomogeneous color discrimination. Mechanisms for uniform color discrimination worked, and their criteria were changed according to the size of each patches. It is severally believed that the mechanisms for uniform color discrimination are based on color opponent mechanisms²⁾. In our experiments, however, we did not measure the influence of the color distribution upon the color discrimination along intermediate axes. Therefore, it was not clear whether the color-opponent mechanisms were dominant for the discrimination. There were some studies investigating similar problems^{3,4)} although their color distribution was only used as noise. In this study, we investigated the influence of color distribution upon the discrimination along intermediate axes at various patch sizes in order to reveal mechanisms for inhomogeneous color discrimination.

The stimulus was an array of isoluminant random-patches displayed on a CRT monitor. The MacLeod-Boynton chromaticity diagram was used to express chromaticity coordinates of the stimulus. We changed size of each patch and color distribution of patches. The colors were distributed on the *r* axis while discrimination was carried out along intermediate axes.

The results on the equal energy white (EEW) are shown in the Fig.1. It is shown that the discrimination along the *r* axis is largely affected by the color distribution. The effect is larger when the patch size is larger. However, the discrimination along orthogonal or intermediate direction was hardly affected by the color distribution.

The results of experiment suggest that the mechanisms to perform inhomogeneous color discrimination are color opponents. This supports the idea that there are no special mechanisms for inhomogeneous color discrimination.

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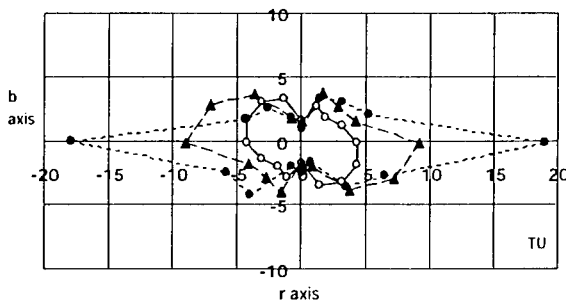


Fig.1 Discrimination thresholds for each direction on EEW; The measured thresholds are plotted as the length between the origin and the symbols. The open circle($\circ$) indicates the threshold of uniform color discrimination. The filled triangle($\blacktriangle$) indicates that the size of each patch was 5.7 min. The filled circle($\bullet$) indicates that the size of each patch was 13.8 min. In all conditions, the color distribution was on the *r* axis and the width of it was 40 times the discrimination threshold at EEW. Data plotted in the third and the fourth quadrants are copies of data in the first and the second quadrants. Each axis is scaled as large as 10^4 times the corresponding axis of MacLeod-Boynton chromaticity diagram.

Influences of Categorical Color Perception on Heterochromatic Visual Search

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We often search targets among heterogeneous and heterochromatic scenes although previous visual search studies used uniform and simple stimuli except a few experiments. The traditional visual search models cannot be applied to these complex visual search paradigms.

To investigate characteristics of heterochromatic visual search we used sets of distractor colors. A set consisted of 13 colors. Each chromaticity of distractors in a set was selected from a certain spherical range of color difference in the OSA uniform color space to keep color difference conditions constant. A target and a total of 63 distractors (4-5 distractors for each 13 colors) were presented at random positions of an 8x8 matrix on the CRT display.

The target chromaticity was located outside of the spherical distribution of distractors. We used 6 conditions of target colors for each distractor distribution. The distance between the target and the center chromaticity of distractors was held constant, so that if search time depended on the color difference alone, it should be equal for all conditions. The position of the set of distractors covered all hues and saturations in the OSA space.

We measured the response time to find a target in two conditions; the explicit condition (the target color was informed before search) and the implicit condition (the target color was not informed), in order to investigate effects of the top-down information. Categorical color naming for all OSA color stimuli was also performed.

Fig.1 shows that the response time depended on the categorical color perception, which should be caused in the higher-order color mechanism. In the conditions that one category occupied large part of distractors, response time for the targets belonging to the category are longer, even if the colors of the targets was informed explicitly. When many categories were contained in distractors, targets of

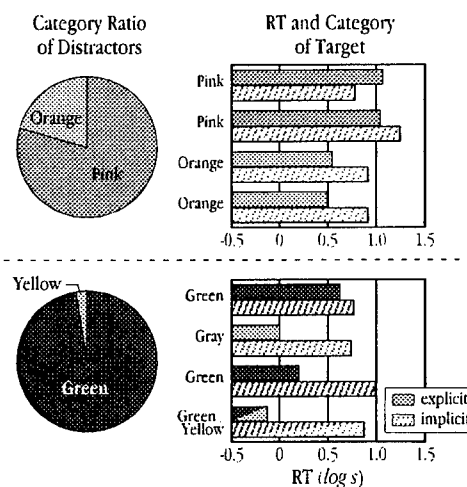


Fig.1 Category ratio of distractors and response time to detect a target among them. 4 conditions of the targets for each distractor set are plotted.

any categories were detectable in short response times in the explicit condition.

We proposed the categorical color search model. In this model, the color visual search process was divided into two stages, the inter-category search and the intra-category search. The model could account for influences of categories of stimulus colors on the visual search. This suggests that the higher-order color mechanism influences the heterochromatic visual search. However, the higher order color perception might be affected by some other color mechanisms, such as color contrast, color constancy, and adaptation. Therefore, in the present study, we also investigated the target appearance among heterochromatic distractors by color naming with heterochromatic background. The relationship between the visual search and the color appearance is also discussed.

Contrast Dependency of Orientation Filling-in

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1. Introduction

When people look at a display in which a small peripheral target is presented on a uniform background, the target becomes invisible within a few seconds and the display appears uniform. This phenomenon, called "perceptual filling-in", occurs in various stimulus dimensions, such as luminance, color and texture (e.g., Ramachandran & Gregory, 1991).

In general, the time for filling-in depends on the feature difference between the target and surround: When the target and surround differ in orientation, for example, filling-in is delayed with a larger orientation difference (Sakaguchi, in press).

The present study explores how the stimulus contrast affects the time for orientation filling-in. The result will be discussed in relation to the neural mechanism of our early vision.

2. Method

Typical stimulus configuration is depicted in Figure 1. A Gabor patch (i.e., target) was presented on a circular surround region. Their spatial frequency and average luminance were 2.5 cpd and 30 cd/m², respectively. The orientation was horizontal for the target, and diagonal for the surround.

Stimuli were displayed on a 17-inch color monitor, and subjects observed the screen at 50 cm distance with their head fixed by a chin rest. The task was to fixate at the central cross and respond when the target became invisible.

Two conditions were prepared. In the first condition, the target contrast was chosen from 0, 16.7, 33.3 and 50% while the surround contrast was fixed to 33.3%. In the second condition, by contrast, the surround contrast was chosen from 0, 16.7, 33.3 and 50% and the target contrast was fixed to 33.3%.

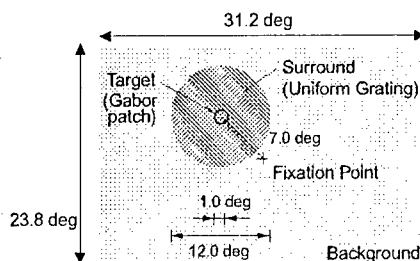


Figure 1. Typical Stimulus Configuration

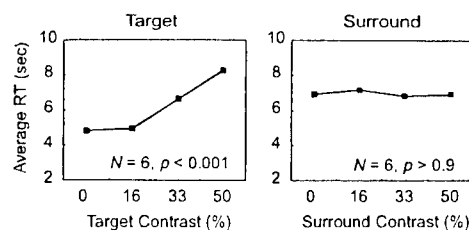


Figure 2. Result

3. Result and Discussion

Figure 2 shows the inter-subject average of median reaction time (RT). The time for filling-in increased significantly with a higher contrast of target while it was almost constant independent of the surround contrast.

The effect of the target contrast can be explained based on the target/surround balance theory (De Weerd, et al., 1995), hypothesizing that the time for filling-in is determined by power relationship between neural activities representing target and surround features. It is plausible that a higher-contrast stimulus brings stronger neural activation in the target region, which would be less likely to be defeated by the activity representing the surround.

However, this view cannot explain why the surround contrast had no effect on the time for filling-in. To explain this result, the author hypothesized that the neural activity representing the surround stimulus might be regulated by the contextual modulation (e.g., Sillito, et al., 1995). In other words, the neural activity representing the surround feature may remain constant independent of the stimulus intensity due to lateral inhibition.

To test this hypothesis, the author ran an supplementary experiment where smaller sizes of surround were adopted. The rationale is that the activity regulation by contextual modulation would be diminished when the surround is small. Unfortunately, preliminary data showed no definitive tendency, partly because perception of filling-in became rather unstable with a smaller surround.

The present results imply that the contextual modulation is an essential factor to determine the time for orientation filling-in. Role of edge adaptation in orientation filling-in may not be so significant as in luminance filling-in.

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Effects of peripheral stimulation on foveal contrast sensitivity

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It has been demonstrated in many studies that appearance of a stimulus is modified by the surrounding stimuli. Spatial interactions between stimuli could be explained by lower processes such as lateral inhibition, and higher processes such as an attentional shift. The object of the present study was to investigate the properties of the spatial interactions between stimuli in the higher level. We investigated whether the presence of surrounding stimuli in the periphery affects the contrast sensitivity for a foveally-viewed grating and whether this effect is dependent on the spatial arrangement of the surrounding stimuli.

We measured detection thresholds for a Gabor patch presented on the fixation while one or four horizontal Gabor patches were simultaneously presented in the peripheral field. The direction of the grating presented in the fovea was tilted plus or minus 45 degrees from the vertical and the subject's task was to respond alternatively the perceived direction of the stimulus, tilted to the right or left. Each of the surrounding patches was presented in the left, right, top or bottom of the foveal patch and one or four surrounding patches were presented at a time. No surround condition was also carried out for a control. The distance between the fixation and each of the surrounding patches was 0.93 degrees. Viewing distance was 114cm and the size of each patch was 0.93 degrees. The background color was set to the average of Gabor patches. A method of constant stimuli was used to determine the threshold.

The results showed that the peripheral stimulation increased the detection threshold for the grating presented in the fovea. Further, this effect was relatively stronger when less stimuli are distributed in the surrounding. These results suggest that the higher process such as an attentional shift affects the foveal contrast sensitivity.

AGE-RELATED CHANGE IN IMPULSE RESPONSE FUNCTIONS FOR A LUMINOUS PULSE

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Impulse response functions (IRFs) for a luminous pulse were measured by a double-pulse method for 56 observers ranging in age from 16 to 81 years. The IRFs were calculated using a model without a minimum phase assumption using the threshold data measured in inter-stimulus intervals from 6.7 to 180 msec. The results show that the duration of the first (excitatory) phase of the IRFs was about 40 to 60 msec and the duration is almost constant with age except for 5 older observers whose durations are more than 70 msec. The peak amplitude of IRFs is nearly constant until about 40 years of age and it decreases gradually with increasing age.

METHOD AND MODEL ANALYSIS We used the double pulse method to measure IRFs. Each pulse was presented in a single frame on a CRT display operating at a 150 Hz frame rate. The pulses had a spatial Gaussian shape (Diameter of $+1$ SD = 2.3 deg.) with a luminance of 10 cd/m² background, having the same chromaticity as the pulse. To control for possible changes of criterion with age, a spatial 4-alternative forced-choice method was combined with a staircase procedure. Each IRF was measured four times, in separate sessions, for each observer. We used a model by Burr and Morrone (1993) to calculate IRFs from the threshold data. This model does not assume a minimum phase. Four parameters in the model equation were changed to find the best fit to the threshold data with a least-squares method.

RESULTS Figure 1 shows examples of IRFs calculated for the best fits to the threshold data on one old observer (60.0 yrs. old; denoted by solid curve) and one young observer (18.8 yrs. old; denoted by thin curve). As shown in these examples, younger observers usually have IRFs with higher amplitudes than elderly observers, but the temporal features of IRFs are quite similar across different ages groups.

IRFs calculated on five older observers (57.9–81.3 years old), however, clearly show that the second (inhibitory) phase in the IRFs is reduced and the IRF is quite slow and long.

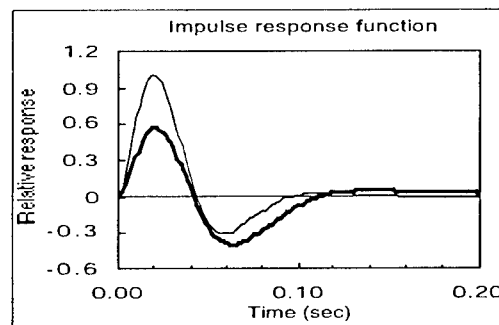


Figure 1

DISCUSSION We analyzed the speed of IRFs with age. Figure 2 shows the duration of the first (positive) phase in the IRFs as a function of age. The horizontal line represents the best fit to the data points. Except for five elderly observers, the results show that the duration of the first (excitatory) phase of the IRFs was about 40 to 60 msec and the duration is constant across age. This indicates that the speed of the response is not reduced with age. Second, we also analyzed the data in terms of a peak value, which directly reflects the strength of temporal response functions. The peak value is almost constant until about 40 years of age, but it decreases gradually after that age. This means that after around 40 years of age, the sensitivity to the luminous pulse is gradually reduced.

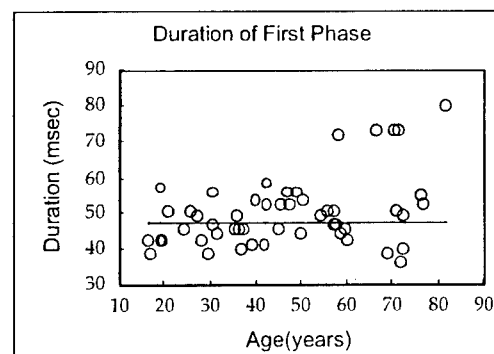


Figure 2

Of course, by the double-pulse method, information about phase is lost and the shape of IRF can be calculated only under certain assumptions. However, our argument is that it is reasonable to expect that the speed of IRFs is not changed with age as long as the IRFs have similar temporal features, which we already observed in the raw data.

We could not find any mechanism of compensation for the reduction of visual signals caused by the age-related change in ocular media, cones, ganglion cells and so on. Instead, the data suggest that the human visual system maintains a stable speed of response to a flash until at least about 80 years of age, even while the response signal level decreases with age.

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Age-related nonlinear compensation in the color vision mechanism

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INTRODUCTION: Visual characteristics of older people can be classified in terms of the aging effects on the ocular system, retina, optic nerve and brain stages. In particular the age-related change of the crystalline lens in the human ocular system produces a modification of the spectral characteristic of the light arriving at the retina of older people. According to previous studies, however, there is no significant difference between young and old subjects in their color appearances. This fact suggests that a compensation mechanism of color vision to keep the same color appearance throughout our lives, operates as we grow older. In the present study, we qualitatively examined the performance of this "color appearance compensation" in the elderly under D65 lights.

METHODS: To compare color appearance as seen by older and young people, we conducted an experiment where the subjects responded to the color appearance of 75 color chips (Toyo-Color-Finder-1050) using a categorical color naming method and an elemental color scaling method. Six elderly subjects (average age = 69.5) and six young subjects (average age = 20.7) participated, all the subjects having normal color vision and no eye defects. The illumination level was set at 500 lx or 50 lx during one session by controlling brightness of the lights. One session consisted of 75 trials for all the color chips, and three sessions were repeated at each illumination level for another three days. The subjects first adapted to the illumination level for 10 minutes. The test color chips were presented on an N5 gray background in random order and the subjects were initially asked to give (i) the ratio of the achromatic and chromatic components in the test color chip, (ii) the ratio of whiteness and blackness in the achromatic components and (iii) the ratio of the four unique-hue components (redness, greenness, yellowness and blueness) in the chromatic components. The subjects were then asked to choose one color name out of 11 basic color terms (RED, GREEN, YELLOW, BLUE, ORANGE, PURPLE, PINK, BROWN, WHITE, BLACK and GRAY) to describe the chip's color.

RESULTS AND DISCUSSION: The results show that categorical color naming between elderly and young subjects is almost the same for most color chips, but there were systematic differences in the elemental color scaling between the two age groups. We analyzed the ratios of unique-hue components (redness, greenness, yellowness and blueness) separately and compared the results of two age groups directly, and found that the response values of redness and greenness components in elderly subjects are slightly lower than those in young subjects and that the response values of yellow component in elderly subjects are lower than those in young subjects. In contrast the response values of the blue component in elderly subjects are slightly higher than those in young subjects when the blue component value is low. These differences in yellow and blue components between elderly and young subjects suggest that the neural mechanism of color vision in elderly people may over perform on constancy of color appearance so as to compensate for the age-related change of the human crystalline lens. Figure 1 shows the age-related change of chromatic components (open lozenge symbols) for 32 chips. The chromatic components in elderly subjects indicate higher values than those in young subjects for low saturation color chips, whereas the chromatic components in elderly subjects indicate lower values than those in young subjects in high saturation color chips. These results indicate that the age-related changes of unique hue components strongly depend on saturation of colors, and suggest that the practical range of color appearance in elderly people is small in comparison with young people. It may be a cause of why color discrimination declines as one ages.

CONCLUSION: Categorical color perception appears to be nearly independent of aging but saturation and hue perception change with age. The age-related changes of elemental color scaling depend on unique-hue components, and the age-related changes of unique-hue components depend on saturation of colors. These nonlinear correlations of color appearance between different ages suggest that the color appearance compensation would progress nonlinearly for each opponent mechanism independently.

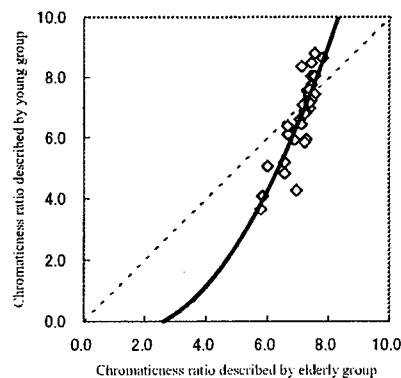


Figure 1 Nonlinear correlation plot of chromatic components between two age groups. ($L^*=30$, 500 lx)

Retinal Mechanism of Color Multi Stage Model

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Introduction

Human color perception model now widely accepted is multi-stage theory_[1], an integrated theory of metamerism and color opponency. Any color perception is determined by three systems_[2,3], L-, M- and S-cones in first stage. Next stage of the visual system has red-green color opponency and yellow-blue color opponency. But the fundamental mechanism how the opponent-color perception is formed was left for a question. Recently, direct imaging of retina by adaptive optics showed the real distributions of the three cones were rather in random arrangement_[4]. The data spurred new arguments because special cone arrangement and indiscriminate connection of midget ganglion cells was thought to cause the color opponency at LGN area. We did a simulation how the ganglion cells sense to color in condition of real retina cone arrangement pattern and two diffuse and midget receptive fields.

Methods

Simulation was done on real retina cone arrangement, by direct imaging of living human retina with adaptive optics, a kind of fundus camera. The locations of the three classes of cones, L-, M- and S-cones were extracted. On the other hand, each ganglion cell has receptive field in its cone layer. The sizes of the receptive field differ whether the ganglion cell is diffuse ganglion or midget ganglion. The midget ganglion cell has excitatory connection with only one cone while the diffuse ganglion cell has rather wide excitatory area. Inhibitory area is determined by the neural connections of horizontal cell, bipolar cell and ganglion cell, and estimated to valid size. The receptive field was estimated as a difference of two Gaussians.

As a conclusion of metamerism, the neural connection cause linear (or very similar to linear) operation at retina, we simulate how the ganglion cell integrates information from the three classes of the L-, M- and S-cones. The receptive field of center-surrounding-opponent weighting field gives linear convolution operation, spatially edge-enhancement. Each ganglion cell integrates L-, M- and S-cone responses differently according to their location. The weighting of the three classes give the color selectivity of ganglion cells. The only three parameters can describe the color selectivity in central vision. We defined this three parametric space as "Color Sensitivity Space" and the color sensitivity can be described by the location in the color sensitivity space. We did similar simulation with artificial cone arrangement pattern, changing the condition how the cones make cluster.

Results

The midget ganglion cell class constructed three clusters of color sensitivity vectors, similar to L-M, M-L and S-(L+M) vectors. The diffuse ganglion cell class constructed one cluster of sensitivity vectors, similar to L+M vector. As the electrophysiologic method on monkey pLGN shows that color tuning direction is L-M, M-L and S-(L+M)_[5], the result of the simulation matches the fact. The result with artificial cone arrangement shows that color selectivity of midget ganglion cell is destroyed when the same classes gather in clusters.

Conclusion

From the simulation we show two simple conditions, random cone arrangement and receptive field of midget and diffuse ganglion cell naturally construct the color opponency of the midget ganglion. Also, we found if the cones make cluster, color opponency of midget ganglion cell would be destroyed.

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Sustained pupillary constriction driven by (L-M) cone-opponent signals

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INTRODUCTION The pupil responds to changes in the chromaticity (in addition to the luminance) of a stimulus field. For instance, the pupil constricts transiently to the offset of chromatic flashes presented on a background (e.g., Kohn & Clynes, 1969; Kimura & Young, 1995). The chromatic pupillary responses reported so far are transient constrictions and investigators have provided evidence that the constrictions are, at least partially, driven by cone-opponent signals (e.g., Kimura & Young, 1996). These findings would require some explanation, because cone-opponency is generally associated with tonic responses in the visual neurons such as P-cells. The present study reports more straightforward properties of the chromatic pupillary response that some chromaticity changes can produce a sustained constriction which is also mediated by cone-opponent signals.

METHOD The test stimulus was presented in a uniform 5° field for 3 seconds at the center of a $19 \times 14^\circ$ white field (28 cd/m^2). Test direction and contrast in the $(\Delta L/L, \Delta M/M)$ plane of cone-contrast space were the main experimental variables. Most of the test directions were selected from the third quadrant of the plane as these stimuli produce luminance decrements as well as chromaticity changes. The test contrast was typically varied from several tenths of a log unit below the psychophysical threshold to the highest contrast available. Observers viewed the stimulus binocularly and pupillary responses were recorded from the left eye using an infrared video pupil tracking system.

RESULTS and DISCUSSION Test stimuli in the third quadrant of the $(\Delta L/L, \Delta M/M)$ plane produced distinct sustained constrictions at higher contrasts (Fig. 1), although apparently transient constrictions to the onset and offset of the stimulus were found at low contrasts. Furthermore, the sensitivity of the sustained (as well as the ON-) constrictions can be accounted for mostly by an (L-M) cone-opponent interaction (Fig. 2). Putting previous and present findings together, the pupillary constriction driven by cone-opponent signals exhibits different temporal waveforms depending upon the stimulus condition. The transient constriction would be found in response to the offset of incremental chromatic flashes presented on a background. In contrast, the response waveform could be sustained when the stimulus change is composed of both a steady-state chromaticity change and luminance decrement. These findings can be explained if the pupil is driven by pairs of chromatically out-of-phase P-cells (e.g., Red-on and Green-on) and by a luminance detector.

ACKNOWLEDGMENTS This study was supported by Nissan Science Foundation and JPSP Grants-in-Aid for Scientific Research (#11410023).

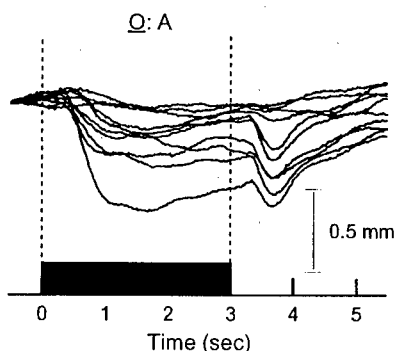


Fig. 1: Pupillary responses evoked by test stimuli of various contrasts. The test direction was 220° in the $(\Delta L/L, \Delta M/M)$ plane.

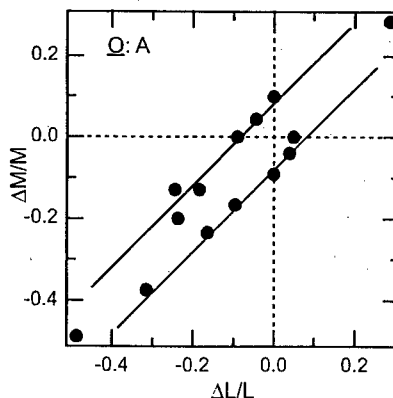


Fig. 2: Test contrasts required to produce sustained constrictions of a criterion amplitude. Most of the results can be fitted by two parallel lines with a positive slope.

Neural representation of surface luminance and brightness in the macaque primary visual cortex (V1)

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Perception of surface brightness depends not only on the surface luminance but also on the luminance of its surround. In the present study, we recorded single and multiple neuron activities from the primary visual cortex (V1) of the monkey to better understand the neural representation of surface brightness. Neural responses were assessed using homogeneous surfaces covering the entire receptive field as stimuli. We investigated the effects of luminance of the surface or its surround on the activities of V1 neurons. We first examined the sensitivity of neurons to variation in surface luminance, while the luminance of the surround was held constant. The activity of a large majority of surface-responsive neurons (103/112) varied monotonically with changes in surface luminance. This monotonic relation between surface luminance and neural activity was more commonly observed in the later period of stimulus presentation. The effect of the luminance of the surround was then assessed in 81 of the surface-responsive neurons by varying the luminance of the surround while keeping the luminance of the surface constant. In one group of neurons (25/81), the activity was unaffected by the luminance of the surround. This type of neuron appears to encode the physical luminance of a surface covering the receptive field. The responses of the other neurons were affected by the luminance of the surround. In 26 of these neurons, the effects of the luminance of the surface and the surround were in the same direction (either increased or decreased). In the remaining 25 neurons, the effects were in opposite directions. The latter group of neurons seemed to exhibit activities that parallel the perceived brightness of the surface, whereas the former seemed to encode the level of illumination. These findings indicate that integration of luminance information across wide area in the visual field takes place in V1 and that not only physical luminance, but also perceived brightness, of a homogeneous surface is represented in V1.

The human V4 complex is more activated by color picture gradually changing in saturation .

-- An fMRI study

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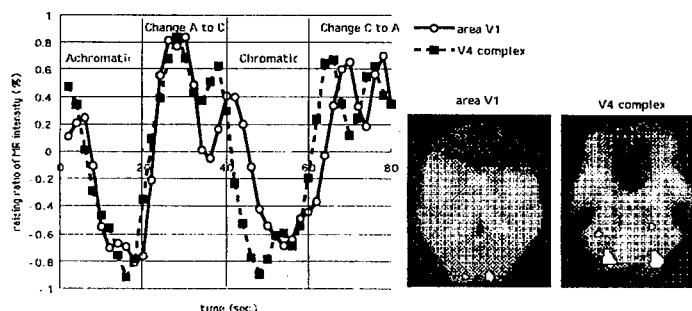
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Color sensitive neurons can be found in V1/V2 and V4 in primates. A number of non-invasive human brain mapping studies using functional MRI (fMRI) and positron emission tomography suggested that the human V4 complex was the color center in the human brain. In our previous report, a continuous pictorial stimulation revealed that the transient signal increase in the V4 complex was similar for both Achromatic to Chromatic and Chromatic to Achromatic transitions. These results suggested that the V4 complex was not directly related to color perception itself, but rather related to color and/or saturation changes of the perceived objects. Here we made an attempt to elucidate by which V4 complex would be more activated; color picture gradually changing in saturation or color picture with constant saturation. Volunteers with normal color vision viewed the following visual stimuli: 1) A fully chromatic picture painted by Matisse (Chromatic condition) ; 2) an achromatic image of the Matisse picture (Achromatic condition) ; 3) a picture changing gradually from Chromatic to Achromatic or from Achromatic to Chromatic (Changing condition) during functional magnetic resonance imaging. We used Siemens Magnetom Vision Plus scanner (1.5Tesla) with standard head coil. Stimulus images were projected on a screen at observer's feet (10 deg. x 12deg.). After identifying the location of V1/V2 (adjacent the calcarine fissure) and the V4 complex (area around the collateral sulcus) by a cross-correlation analysis between the Changing and other conditions, we compared the time course of the MR signal in V1/V2 with that in V4.



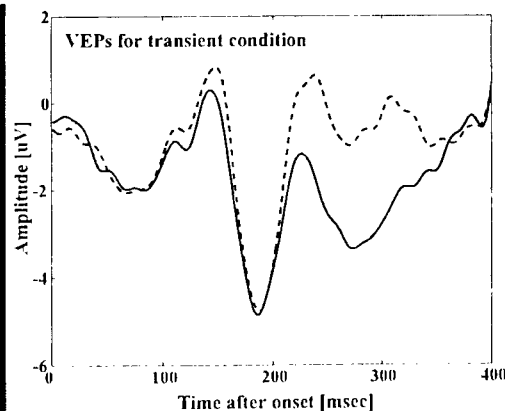
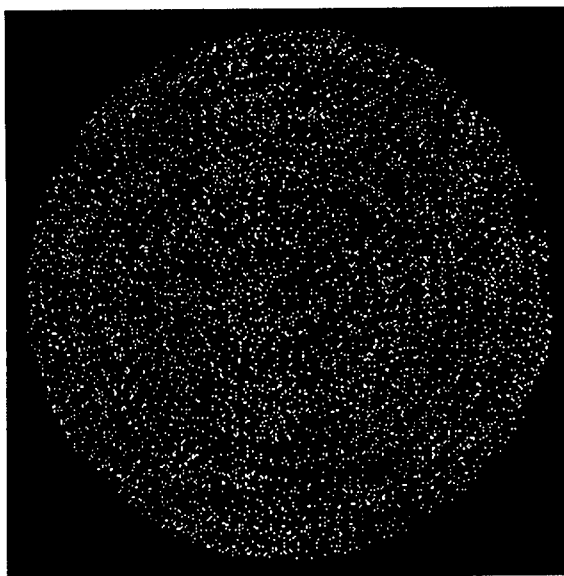
As a result, both the V1/V2 and the V4 complex MR signals increased in the Changing conditions. We think that this fMRI stimulus was very useful for clinical application to detect V4 complex. However, we detected no significant change between Chromatic and Achromatic condition in both the V1/V2 and the V4 complex. Our result may cast a question whether V4 complex is a color center or not.

VEP study on visual processing of global structure

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We examined characteristics of VEP produced by globally defined patterns which were assumed to activate the extrastriate cortex engaging the visual processing of global information (Gallant, Braun & Van Essen, 1993). Three test stimuli (parallel, radial and concentric) were composed of random dots in which pairs of dots were placed such that the orientation of each dot pair was tangent to contours of global form for each stimulus (Glass, 1969; Wilson & Wilkinson, 1998). A pattern of randomly oriented dot pairs was used as a control stimulus, so that the comparison of the VEP to the control with that to the test stimuli enabled us to analyze global process. Two kinds of stimulus presentation were used; steady state and transient conditions. In the steady-state condition, VEP decreased with repeated presentation of the control and test stimuli for the three patterns. The subjects could not perceive the concentric pattern during the repeated presentation (10 seconds). You can observe this effect by prolonged view to the below figure. The concentric pattern will be invisible at around 2-3 seconds after fixation. In the transient condition, VEP patterns around at 230 msec after transition from the control to the test stimulus differed between the concentric pattern and the parallel one (See the plot). Subjects reported pop-out (Treisman & Gelade, 1980) like percept for the concentric pattern under the transient condition. The observed VEP for the concentric pattern was similar to that reported for the visual stimulus causing pop-out percept in existing studies (Luck & Hillyard, 1995). Given the above observations, the underlying physiological correlates may be spike frequency adaptation which is a property of virtually all neocortical excitatory neurons (Lorenzon & Foehring, 1992; Wang, 1998). In psychophysics, Wilson, Krupa and Wilkinson (2000) demonstrated that spike frequency adaptation of V4 neurons accounts well for adaptation of percept for circle pattern. Our VEP results with visual processing of concentricity would thus reveal temporal aspects of transient burst and adaptation with a few seconds.



The left picture shows an example for the concentric pattern. The above plot indicates transient VEPs. The thick line and dotted line represent data for the concentric and parallel pattern after transition.

VISUAL SIZE INDUCTION: AN EFFECT OF ATTENTIONAL ALLOCATION

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ABSTRACT

An effect of attentional allocation on visual size induction was studied using Delboeuf figures, that consist of two concentric circles. The two constituents were varied in diameter; the method of magnitude estimation of each was used under free, binocular viewing. Attentional allocation was modulated by alternative judgment-order instructions - starting estimation with either the inner or outer circle.

In line with previous studies (Morinaga, 1935; Ogasawara, 1952), we found that the induced size of the circle constituents (the strength of the Delboeuf illusion) depended upon the diameter ratio of the inner-to-outer circles. With a range of diameter ratios used in the present study, outer circle was under- and inner circle overestimated indicating a size assimilation. Maximal assimilation was obtained at the ratio 2 : 2.7, that somewhat deviates from the value of 2 : 3 found earlier using comparison-judgment methods of limits or adjustment. In addition, the amount of size assimilation was found to be a non-linear function of absolute diameter difference.

Attentional allocation, as modulated by instructed judgment order, influenced the perceived size of target stimuli: the circle judged initially was estimated more veridically and had, in addition, a stronger assimilative effect on the apparent size of the circle judged subsequently. Moreover, the effect of induction was more salient upon the inner circle than outer.

The results suggest that perceptual mechanisms underlying size induction are intertwined with top-down attentional modulation in the sense of a "biased competition" (Deco & Zihl, 2001). That is, a visually attended stimulus is assumed to be enhanced in spatial resolution due to suppression of processing of distracting counterpart of the configuration and, hence, is perceived more veridically. Further, the stronger assimilative power of the initially attended stimulus is presumably due to a competitive perceptual "win" which provides it with a "reference" mode. Finally, the asymmetry of outer/inner-circle size induction might be essentially accounted for by the spatial span of attentional "zoom" (Eriksen & St. James, 1986): When the outer circle is judged first, the span of attention is larger, so that the inner circle falls in the span and is thus partly processed preattentively (Enns & Rensink, 1991); conversely, when the inner circle is judged initially, the spatial span of attention is too small to take up the outer circle.

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Predominance of shape from global shading in figure and ground segregation.

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Purpose: We perceive the three dimensional (3-D) structure of the world using various clue. Especially, shading is one of the most primitive information to recover the surface of 3-D objects. In present study, we examined figure and ground segregation based on shape from shading as a function of duration of displays.

Method: We composed vase/face Rubin patterns of shaded disks and bipartite disks. There were two conditions on the stimulus. In one condition, *Non-masked condition* (NMC), there were not black thick lines between face and vase region. In the other condition, *masked condition* (MC), there were black thick lines between two regions in order to eliminate the *global* shading generated between two regions. In shaded display (Figure 1 (a) for NMC, and Figure 2 (a) for MC), one region (e.g. face region) was filled with the "convex" disks, and the other region (e.g. vase region) was filled with the "concave" disks. In bipartite display (Figure 1 (b) for NMC and Figure 2(b) for MC), one region was filled with the top-bright disks, and the other region was filled with bottom-bright disks. These displays were presented for 100msec, 300msec, or 500msec. And it was followed by mask. The task of subjects was to decide which region of face or was seen as figure.

Results:

<Non-masked condition> Proportions of responses were calculated as a function of the duration of the display in Figure 3. This graph shows the proportions that the region contained convex disks (or top-bright disks) was perceived as figure. In shaded display condition, subjects reported that the region containing the convex disks was mainly perceived as figure, and in bipartite display, subjects also reported that the region containing the top-bright disks was apt to be perceived as figure of any duration.

<Masked condition> Figure 4 shows the result in masked condition. In shaded disk condition, subjects reported that the region containing the convex disks was mainly perceived as figure at longer exposure, In bipartite disk condition, however, subjects did not report that the region containing the top-bright disks was not perceived as figure mainly of any duration.

Conclusion: From these results, we found that shape from shading made a contribution to figure and ground segregation, and the processing of *global* shading generated between two regions was relatively faster than that of *local* shading in figure and ground segregation.

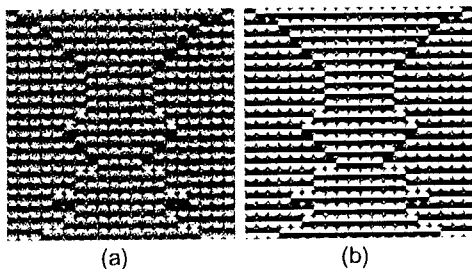


Figure 1.

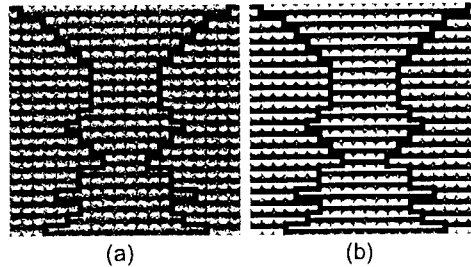


Figure 2.

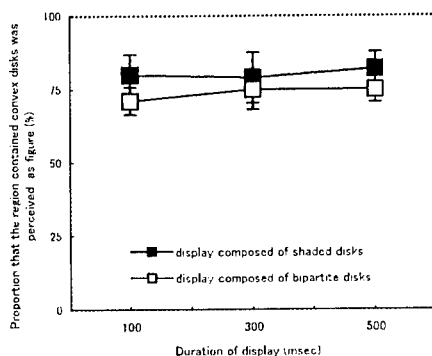


Figure 3.

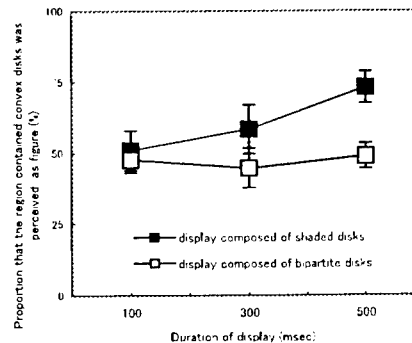


Figure 4.

Extraction of the information about the direction of illumination for shape from shading

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To perceive shape from shading, the information about the direction of illumination is needed. It has been reported that we tend to assume that illumination comes from above for perceiving shape from shading. This is called "light-from-above assumption". This assumption is usually valid because the sun, the primal illuminant source on the earth, is always above. However, after human being invented artificial light, we often face the scene with multiple lights on the ceiling, the wall and the floor. In these cases, we must extract the information about the direction of illumination from the scene and perceive shape from shading properly. In this study, we investigated how visual system extract the information about the direction of illumination from the visual images for perceiving shape from shading.

We measured the area to which the information about the direction of illumination produced by visual stimuli spreads. The stimuli consisted of a test disk with shading at the center and eight surround disks with shading and cast shadow (Fig. 1). The central disk had no information about the direction of illumination so that its perceived shape was ambiguous if it was presented alone. On the other hand, the surround disks had information about the direction of illumination so that their perceived shape was decided definitely to be convex. The observers responded the perceived shape of the test disk, convex or concave, for the stimuli with various distance between the test and surround disks. Using this stimulus, we estimated the limiting distance that the information about the direction of illumination produced by the surround disks expands.

The result is presented in Figure 2. Radial axis indicates the percentage of "convex" response and the direction of the radial axis indicates the shading direction of the test and surround disks. The parameter indicates the radial separation between the test and surround disks. These results show that the information about the direction of illumination produced by the surround disks influenced the perceived shape of the test disk. The effect increased as the distance between the test and surround disks decreased. In addition, the "light-from-above assumption" was also effective even if definite visual information about the direction of illumination produced by the surround disks was available. These results suggest that the direction of illumination for shape from shading is estimated locally depending on both the visual information and the "light-from-above assumption".

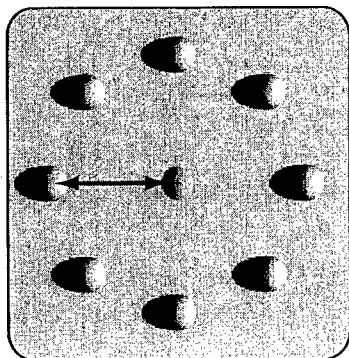


Fig.1 Stimulus configuration

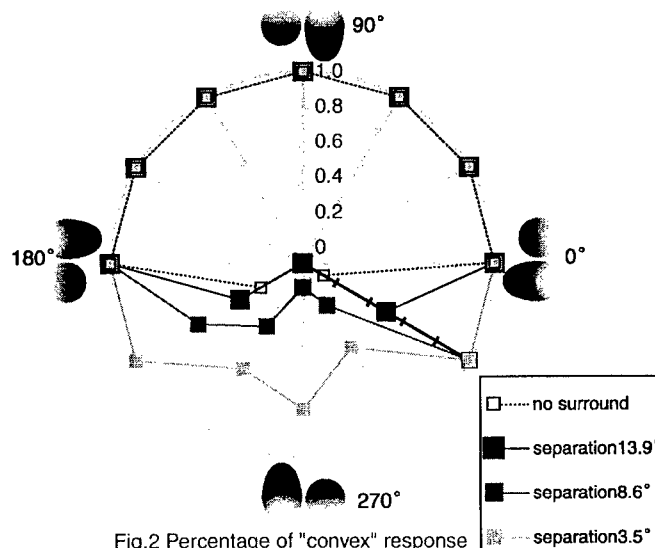


Fig.2 Percentage of "convex" response

Lightness constancy disrupts pop-out visual search

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Introduction

Lightness constancy refers to the phenomenon that we can perceive two (or more) areas as the same reflectance even if the luminances of these areas are different from each other, caused by transmittance, illumination, or orientation changes of surfaces. Does the lightness (perceived reflectance) information affect visual search?

To answer this question, I conducted a task to search for a target defined by a luminance change. In the non-transparent condition, the luminance change was interpreted as a reflectance change of the object: the lightness of the target was different from those of distractors. In the transparent condition, the luminance change was perceived as a transmittance change caused by an illusory transparent filter: the lightness of the target and distractors were the same.

If a search performance is determined by the lightness difference between the target and distractors, search in the transparent condition will be more difficult than that of non-transparent condition.

Methods

Eight naive students participated in this experiment. The subjects searched for a medium-gray square embedded in a horizontal bar among uniform light bars (Figure 1). They were asked to determine the presence or absence of the target as quickly as possible while maintaining 90% accuracy. Set sizes were 1, 6, and 12.

The configuration of items in the non-transparent condition was that upper and lower outlined squares were separated from the horizontal bars (Figure 1A). In this condition, the medium-gray square was perceived as a reflectance change of the horizontal bar, and phenomenal transparency was not perceived. In the transparent condition, although the horizontal bars were the same in the non-transparent condition, outlined squares met the horizontal bars (Figure 1B). In this condition, the medium-gray square of the target was perceived as the intersection of two crossing bars, one of which was phenomenally transparent (Kanizsa, 1979).

Results

In the non-transparent condition (Figure 1A), search was quite easy: the reaction time $\times$ set size

slopes were 4.1 ms/item for target-present trials and 13.2 ms/item for target-absent trials. This suggests that the medium-gray target can be "effortlessly" detected. In the transparent condition (Figure 1B), however, search was difficult: 19.7 ms/item for target-present trials and 45.4 ms/item for target-absent trials. This dramatic slowdown of the search performance indicates that information accessed in visual search is not luminance but lightness. That is, the target and distractors are interpreted as similar each other in the transparent condition because the medium-gray square of the target is the same lightness as the rest of horizontal bar.

Conclusions

I showed that visual search was affected by lightness of objects. This suggests that the monocular cues for transparency are strong enough to produce *preattentive* lightness constancy.

References

Kanizsa, G. (1979). *Organization in Vision*. New York: Praeger.

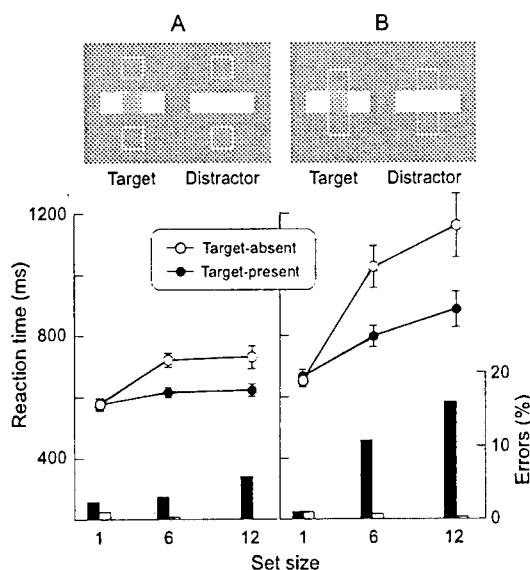


Figure 1. Stimuli and results for Experiment. A: the non-transparent condition. B: the transparent condition. Filled symbols indicate target-present trials, and open symbols indicate target-absent trials. Error bars represent standard errors.

Effects of spatial position and light source direction on visual search asymmetry for viewing direction.

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PURPOSE: Previous studies reported a search asymmetry for the direction with which three-dimensional objects are viewed. This asymmetry is more pronounced in the lower visual hemifield (von Grunau and Dube, 1994, *Perception & Psychophysics*, 56(2), 211-220). We examined whether the search asymmetry might change with the spatial position where stimuli were displayed.

METHOD: Stimulus was an array of cubes displayed on a 3 m * 3 m screen and stereoscopically given. The array of cubes was displayed 60 cm above or below an eye height with 3m in depth (Fig.1). Subjects fixated the center of the stimulus by moving their heads.

RESULTS: When stimuli were line-drawing cubes or shaded cubes whose upper-bottom faces were lighter than side faces (Fig. 2), we found that a bottom-view target among top-view distractors was detected faster than a top-view target among bottom-view distractors. In addition, displaying stimuli in an upper field deteriorated overall performance. On the other hand, the shaded objects whose upper-bottom faces were darker than side faces (Fig. 2) promoted the detection of a top-view target among bottom-view distractors in an upper field. These results indicate that only when the objects' direction and shading information are appropriately situated, the contextual effect of viewing upward is driven.

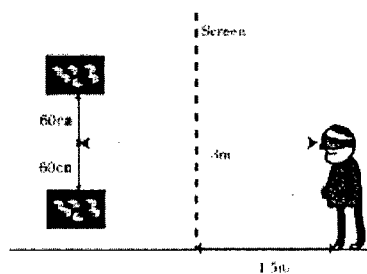


Fig. 1, Experimental setup

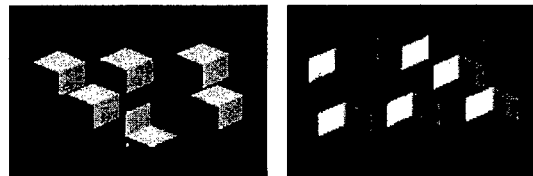


Fig. 2, Examples of stimuli. Left: An array of cubes whose upper-bottom face were lighter. A bottom-view target among top-view distractors. Right: An array of cubes whose upper-bottom face were darker. A top-view target among bottom-view distractors.

Can Inhibitory Tagging Operate on Randomly Moving Objects?

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Inhibitory tagging is a process that prevents focal attention from revisiting previously checked items in inefficient searches, facilitating the search performance (e.g., Klein, 1988). But it is still unclear whether inhibitory tagging operates on moving objects. The purpose of the present study was to investigate a dynamic object-based tagging effect on independently and randomly moving objects.

Method

The participants were asked to search a target in both the efficient- and the inefficient-search condition. The search display consisted of four or eight items that moved in random direction.

After search task, the luminance-detection probe was presented on the search display on 50% of the trials. On half of these probe-present trials, the probe was presented at a distracter location (on-probe). On the remaining trials, the probe was presented in an empty location (off-probe). The participants responded only to the presence of the probe by pressing a button (go/no-go task).

Result

Search Performance. RT increased as the number of items only in the inefficient-search condition.

Probe detection performance. The difference between on- and off-probe RTs were greater in the inefficient- than the efficient-search condition, supporting the hypothesis of inhibitory tagging. Moreover, in the inefficient-search condition, on-off difference in target-absent trial was approximately twice greater than that in target-present trial. This result supports the assumption that half of items, in average, were inhibited in target-present trials, whereas all items were inhibited in target-absent trials.

Conclusion

The present result shows that it is possible to tag, at least, eight independent objects even when those object move randomly and independently.

Our visual environment is highly complex, and the capacity of visual system is limited. Therefore, inhibitory-tagging processes might prevent attentional deployment to already checked objects, facilitating the visual-information process.

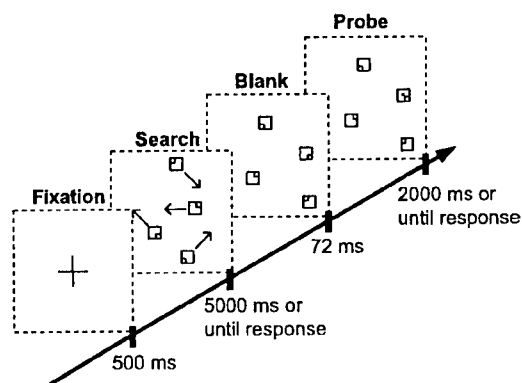


Fig. 1. The sequence of events during trial.

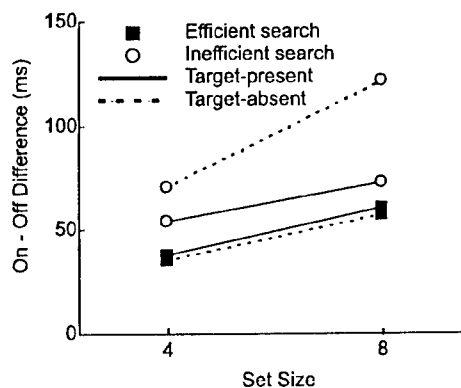


Fig. 2. The on-off probe RT differences as a function of search type and set size.

Targets are facilitated in counting: Evidence from probe detection

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In visual tasks requiring serial deployment of spatial attention, such as serial visual search or counting of visual objects, a process distinguishing previously attended objects from unattended objects is necessary to prevent reallocating of spatial attention to searched or counted objects. In visual search, it is known that the previously attended objects are inhibited relative to the unattended objects (inhibitory tagging, e.g., Takeda & Yagi, 2000, P&P). On the other hand, in counting, there are few studies about the nature of the serial attentional control. In this study, we explored how spatial attention is serially controlled in counting, using a probe detection task.

In Experiment 1, a gray fixation, red bars, and green bars were presented on the display. The number of bars was seven or eight in each color (14-16 bars in total). Twenty participants were required to enumerate the target bars (either red or green) and respond to the number of targets (seven or eight) by pressing one of two keys. In 80 % of trials, in 300 ms after a response for enumeration, a probe was presented on the fixation (60%), one of targets (10%), or one of distractors (10%) by changing of the color of the item into yellow. Then, participants were required to respond to appearance of the probe (go / no-go). A mean RT for a probe on targets (399 ms) was significantly faster than on distractors (418 ms, Figure 1). In Experiment 2, a probe was presented before enumeration responses were elicited (SOA: 150, 300, 600, or 1200 ms). Mean RTs for a probe on targets were again significantly faster than on distractors (Figure 2). Contrary to an inhibitory control of spatial attention in serial visual search, these results suggest a facilitatory component involves in controlling of spatial attention in counting.

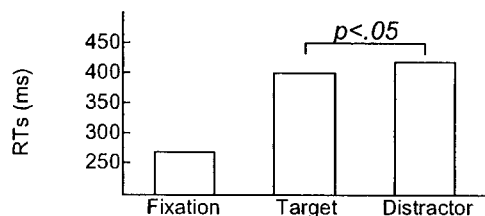


Figure 1. RTs (ms) in Experiment 1

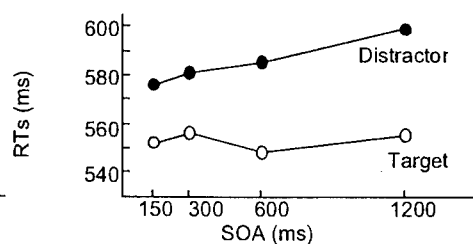


Figure 2. RTs (ms) in Experiment 2

A study on sampling strategy in the figure cognitive procession

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abstract

The figure recognition was an active cognition process, while sampling was the first actual working stage in the cognitive process. The processing strategy had great effects both on the quality and on the speed of information processing. A study was conducted to investigate the sampling strategies for 2 visual materials: 3-dimension cubes-made figures and human face figures. The aim of the research was focused on: (a) the features which were sampled in the cognition process; (b) the order in which the features are sampled; (c) the mental resources distribution when the features were sampled. The research consisted of 6 experiments: a).feature-sampling of 3-dimension cubes-made figures; b).parameter-measuring of 3-dimension cubes-made figures; c).sampling order and mental resource distribution during the sampling processing for the 3-dimension cubes-made figures; d).feature-sampling of human face figures; e).parameter-measuring of human face figures; f).sampling order and mental resource distribution during the sampling processing for the human face figures.

The results showed: (a)The features sampled from both the 3-dimension cubes-made figures and the facial figures could be classified into 3 catalogues: a) basic sampling features; b) supplement sampling features; c) unique sampling features, respectively. (b)For the 3-dimension cubes-made figures material, the first sampling-position was most likely located at the outline parts of the figures, and rarely at the center of the figures; while for the facial figures, the first sampling-position was most likely located at the hair part and the outline parts of the figures, rarely at the corners of the mouth and face cheek. The tendency of first sampling-position was affected by the degree of the task-difficultibility. The lower degree of the task-difficultibility was, the more stable and more concentrating the first sampling-position would be located at. But, in most cases, the first sampling-position had no significant effects on the figures recognition performance. (c)The sampling order of both 3-dimension cubes-made figures and facial figures were arranged by the degree of the difference among the sampled-features. the sampling-features with higher degree of such difference would be prior to those with lower degree in sampling order. (d)The distribution of mental resource in the sampling processing was affected by the degree of the difference of the sampled-features. The sampled-features with higher degree of such difference would be assigned more mental resource than those with lower degree. (e)By optimally assigning the mental resource, the figures recognition performance could be improved in some degree.

A computational model for character recognition based on multi-resolution channels and IAM

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Abstract

A computational model to recognize Korean characters is presented. The model is based on IAM but improves the input processing part. We excluded the assumption that all the characters are of a standard template. Also we incorporated the multi-resolution channel theory so that we can improve the performance. We simulated the model and tried it to real data. The simulation results show that the model has a practical significance and the multi-resolution channels actually improve the performance.

The effect of the mental rotation on the matching task

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1. Introduction

The speed of the mental rotation depends on the axes of the rotation (x-, y- or z-axis) (e.g., Parsons, 1987). Why each direction of the mental rotation caused the difference of the performance? The purpose of the present study was to investigate whether there was the intermediate representation in each direction of the mental rotation with the priming paradigm of Kourtzi & Shiffrar (1999a, b).

2. Methods

2.1. Participants : 20 undergraduate students.

2.2. Apparatus & Materials : Six kinds of objects, which were consisted of 10 blocks and 3 bends, were similar to those used by Shepard & Metzler (1971). They were white line drawings on the black background, and were generated on a color CRT.

2.3. Procedure : Two tasks were performed in one trial. This experiment consisted of 288 trials.

Prime task: Firstly, participants were instructed about the three conditions for the direction of the mental rotation: "rotation about the horizontal axis (x-axis)", "rotation about the vertical axis (y-axis)" or "picture-plane rotation (z-axis)". The two stimuli were sequentially presented with the ISI of 500 ms. The first stimulus (Frame-1) was presented for 3000 ms, and the second stimulus (Frame-2) was presented until participants performed the task. Frame-2 was always a 180° rotated image of Frame-1. Participants were asked to judge whether the Frame-1 and the Frame-2 were identical or not as quickly as possible by a key-press.

Probe task: After the prime task was finished, the probe stimulus was presented which consisted of two objects. Participants were asked to judge whether the two objects simultaneously presented were same or different. Only the correct "same" trials were analyzed. The "same" trials were divided into two categories, "Primed" and "non-Primed". In the "non-Primed" trials, the both objects in the probe stimulus were irrelevant to the stimulus presented in the Prime task. The "Primed" trials comprised four conditions: 1) Probe0: both objects in the probe stimulus are identical to the Frame-1 in the Prime task, 2) Probe180: both objects in the probe stimulus are identical to the Frame-2 in the Prime task, 3) Probe60: both objects in the probe stimulus are identical to the 60° rotated image of the Frame-1, 4) Probe120: both objects in the probe stimulus are identical to the 120° rotated image of the Frame-1.

3. Results

Prime task: The ANOVA of Response (2) $\times$ Direction (3) showed only significant main effect of Image ($F(1, 19) = 10.44$, $p < .01$). RT of the "same" response was faster than that of the "different" response.

Probe task: Fig.1 shows the amount of priming in all rotational directions. The amount of priming was defined as the difference of the reaction time between the "Primed" trials and the "non-Primed" trials. In the horizontal axis condition, the ANOVA of Probe (4) $\times$ Prime (2) showed a significant main effect of Probe ($F(3, 57) = 7.11$, $p < .001$) and Trials ($F(1, 19) = 7.24$, $p < .05$). Fischer's LSD test about Probe factor showed Probe0, Probe60 and Probe120 were significantly less primed than Probe180 ($p < .05$). In the vertical axis and plane rotation condition, the ANOVAs showed no main effect.

4. Conclusion

In the Prime task, the mental rotation was not influenced by the rotational direction. This result did not agree with previous findings. In the Probe task, the present study showed the negative priming occurred in the horizontal axis condition. This result suggested that the process of the mental rotation about the horizontal axis was different from those of the mental rotation about the other axes. However, it was not clear whether there was the intermediate representation in the mental rotation.

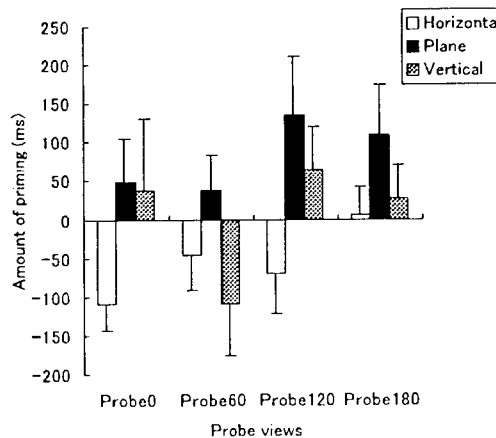


Fig. 1. The amount of priming in each direction of mental rotation.

A patient complained that the right side of the face looked paler and smaller than the left.

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What mechanism is there for adjustment both visual hemifields in our brain? We report a 73-year-old right-handed woman with unilateral dischromatopsia and metamorphopsia caused by metastasis of colon carcinoma in the adjacent splenium of the corpus callosum. The patient visited our clinic on June 30, 1992 and complained that the right side of the face looked paler and smaller than the left. She also had transient prosopagnosia and topographical disorientation. She was alert at the first examination. Visual acuity was 0.5 (1.0) in the right eye and 0.6 (1.0) in the left. We detected no abnormality in the optic media and fundi. Goldmann perimetry showed no abnormality in her visual field but color visual field test with small dim target revealed that she had right hemiachromatopsia. We detected visual recognition abnormality of letters, figures, concrete objects and colors only in the right visual hemifield. Colors in the right hemifield looked paler than those in the left. We used twelve kinds of color plate for the test. We showed her a variety of pairs of color chips and asked her to report which looks paler than the other. Brown exhibited the strongest, and orange did the weakest change in apparent paleness. Order between all colors was as follows: Brown > purple > blue > green > gray > red > black = yellowish green > white = yellow = pink > orange. Enhanced magnetic resonance imaging (MRI) by Gadolinium DTPA showed a small round lesion in the adjacent splenium of the corpus callosum only. In addition, MRI performed after half year revealed secondary degeneration in the fibers of the corpus callosum. The MRI change suggested us that the right hemiachromatopsia in this case was likely caused by disconnection between the left visual center and right color center. However, why the metamorphopsia in the right hemifield happened? Conversely, why we can see consistent sight in the right hemifield and in the left? What mechanism is there for adjustment both visual hemifields in our brain?

Reaction times in a finger-lift and manual aiming tasks at a visual target

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We investigated whether the reaction times of both a finger-lift and a manual aiming at a visual target appearing on a touch-panel monitor were affected by either the spatial location (left, center, or right) of the target or hand (right or left) used.

METHOD

Apparatus & Stimuli. A graphic circular disk was presented as the visual target. The location of the target was manipulated to make it appear at one of three horizontal positions on a touch-panel monitor. A computer mouse button was used as the response key to measure reaction times (RTs) for both the finger-lift and manual aiming.

Procedure. Eight university students participated in this experiment. They were asked to press the mouse button to initiate each trial: then a fixation point appeared at the center of the monitor. After a while, a visual target appeared at one of the three loci (left, center, or right). The participants were then asked to either quickly lift the index finger from the mouse button after the target onset or touch the center of the target by quickly moving the finger from the button after the target onset (see Figure 1). Each participant performed 20 trials in each task.

RESULTS AND DISCUSSION

An ANOVA performed on RTs showed a significant interaction between hand, task, and spatial location factors ($F_{2,14} = 18.92, p < .01$). Figure 2 shows mean RTs for target locations in each hand used, indicating that the finger-lift and aiming RTs appeared significantly shorter for the central target than either the left or right target. This was the case for both hands. Differential RTs were calculated by subtracting the finger-lift RTs from the aiming RTs. The

differential RTs can be thought of as the information-processing time needed for preparing motor action of manual aiming per se, which is an extra action performed in addition to the simple initiation of a finger lift. An ANOVA performed on the differential RTs showed a significant interaction between hand and spatial location ($F_{2,14} = 18.92, p < .01$). Figure 3 shows mean differential RTs for target locations in each hand used. The mean differential RTs in the right hand appeared shorter for the right target than those for either the left or central target, and vice versa in the left hand. Moreover, the mean differential RTs for the left hand were significantly shorter than those for the right hand. The result of the shorter differential RTs for the ipsilateral target than those for contralateral and central targets implies that the preparation of aiming movement is mediated by information processing of the spatial nature of visual targets. Furthermore, the result of the left hand superiority to the right hand in differential RTs suggests the right hemisphere dominance in information processing for the preparation of aiming movements.

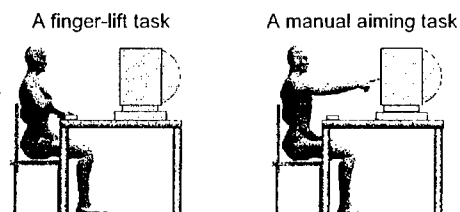


Figure 1. Experimental tasks

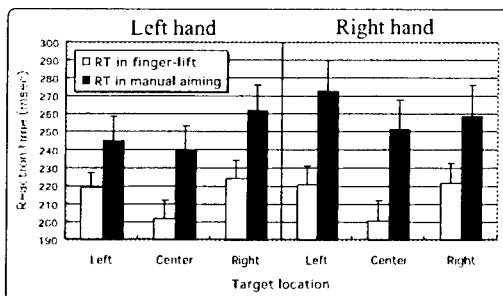


Figure 2. Mean RTs for target locations in each hand used

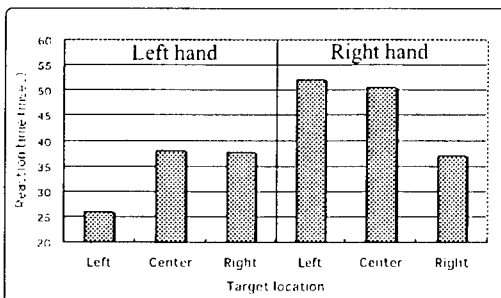


Figure 3. The mean differential RTs for target locations in each hand used

List of 1st ACV participants

A

Akiyama, Kazuo (Tokyo University of Mercantile Marine)

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Asanuma, Tsutomu (Tokyo Institute of Technology)

Ashida, Hiroshi (Kyoto University)

Atsumori, Hirokazu (Tokyo Institute of Technology)

Ayama, Miyoshi (Utsunomiya University)

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(Pohang University of Science and Technology)

C

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Chen, Ai-Hong (University Kebangsaan Malaysia)

Chen, Lin (Chinese University of Science and Technology)

Cheoi, Kyungjoo (Yonsei University)

Chung, Chan Sup (Yonsei University)

E

Eda, Tetsuya (Utsunomiya University)

Emori, Yasuhiro (Tokyo Institute of Technology)

F

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Fukada, Yoshinao (Kochi University of Technology)

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Hanada, Mitsuhiro (Chiba University)

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Harasawa, Kenji (University of Tokyo)

Hayakawa, Tomoe (Communications Research Laboratory)

Hayasaka, Tomohide (Utsunomiya University)

Hayashi, Isao (Hannan University)

Hayashi, Ryusuke (University of Tokyo)

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Inukai, Kumiko (Kyoto University)

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- Kakei, Daisuke (Chiba University)
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- Kaneko, Rika (National Institute of Advanced Industrial
Science and Technology)
- Kano, Yoshinori (Toyohashi University of Technology)
- Kato, Yuichi (Hokkaido University)
- Katoh, Noriyuki (Tokyo Institute of Technology)
- Kawabe, Takahiro (Kyushu University)
- Kawai, Hiroaki (University of Tokyo)
- Kawai, Taka-aki (Tokyo Institute of Technology)
- Kawamoto, Ken-ichiro (Chiba University)
- Kawashima, Eiji (Tokyo Woman's Christian University)
- Kham, Keetaek (Yonsei University)
- Kim, Jeounghoon
(Korea Advanced Institute of Science and Technology)
- Kim, Sang-Ki
(Pohang University of Science and Technology)
- Kimura, Eiji (Osaka Prefecture University)
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- Kitazaki, Mitsuaki (Toyohashi University of Technology)
- Kogure, Masaki (Tokyo Institute of Technology)
- Koida, Kouwa (National Institute for Physiological Sciences)
- Komatsu, Hidehiko
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- Kon, Daisuke (Utsunomiya University)
- Koshimizu, Hiroto (Utsunomiya University)
- Kozawa, Ryo (Chukyo University)
- Kuriki, Ichiro (NTT Communication Science Laboratories)
- Kuriki, Reiko (University of Electro-Communications)
- Kuroki, Yoshihiko (Sony Co.)
- Kuwayama, Taeko (Tokyo Institute of Technology)
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- Lee, Seong-Whan (Korea University)
- Lee, Seungbae (Chiba University)
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- Li, Hyung-Chul O. (Kwangwoon University)
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Umemura, Hiroyuki (National Institute of Advanced Industrial Science and Technology)	Yoshimatsu, Hiroshi (Tokyo Institute of Technology)
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Appendix A (Timetable of Vision society of Japan 2001 summer meeting)

July 31 (Tue)	
	ACV
16:10	Opening Remark
16:30	Poster Session 1
17:30	Poster Session 2
18:30	Dinner
19:30	Topic Discussions 1,2
21:00	

August 31 (Wed)	
8:00	Breakfast
9:00	Topic Discussions 3,4
10:30	
10:50	Invited Lecture
11:40	Business Meeting
11:50	Closing Remark

... coffee breaks & meals

Appendix B (Program of Vision society of Japan 2001 summer meeting)

Invitation: The summer meeting of the Vision Society of Japan will be held from 16:10 on July 31, immediately after the closing of 1st ACV meeting. There are two poster sessions, four topic discussions and one invited talk. Poster presentations are given in the evening of the second day of the 1st ACV meeting (July 31). Primary language for discussions will be Japanese, but most of the posters will provide titles and figure captions in English, and many of the presenters are able to present their posters in English. We would like to invite all attendees of 1st ACV meeting to experience the most exciting meeting in the field of vision science studies in Japan.

July 31 (Tue.)

16:10 Opening remark

H. Kaneko (Tokyo Institute of Technology; VSJ '01 summer meeting chair)

16:30~18:30 Poster sessions (in *FOYER*: see below for detail)

18:30 Dinner

19:30~21:00 Topic discussions

TD1 Information integration processes in visual system (in *AUDITORIUM*)

Organizer: M. Ichikawa (Yamaguchi University)

Panelists:

◇S. Shioiri (Chiba University)

◇M. Sekine (University of Electro-Communications)

◇K. Sekiyama (Future University Hakodate)

TD2 Color and surface perceptions (in *6th meeting room*)

Organizer: I. Kuriki (NTT Communication Science Laboratories)

Panelists:

◇S. Nakauchi (Toyohashi University of Technology)

◇S. Tsujimura (State University of New York)

◇I. Kuriki (NTT CS Laboratories)

August 1 (Wed.)

9:00~10:30 Topic discussions

TD3 Functional brain imaging studies with fMRI and MEG techniques (in *AUDITORIUM*)

Organizer: Y. Ohtani (Kyoto Institute of Technology)

Panelists (*)

◇H. Yamamoto*, M. Fukunaga, S. Takahashi, N. Goda, C. Tanaka, Y. Ejima

(Kyoto University, Meiji University of Oriental Medicine, Kyoto City University of Arts, ATR)

◇S. Okamura*, T. Shibasaki, Y. Ohtani, Y. Ejima

(Shimadzu, Co., Kyoto Institute of Technology, Kyoto University)

◇T. Hayakawa*, N. Fujmaki, M. Kato, T. Imaruoka, S. Miyauchi (Communications Research Laboratory)

TD4 Variations in human vision (in *2nd meeting room*)

Organizer: K. Shinomori (Kochi University of Technology)

Panelists (*):

◇M. Ayama* (Utsunomiya University)

◇K. Okajima* (National Defense Academy)

◇H. Ujike*, K. Sagawa (National Institute of Advanced Industrial Science and Technology)

10:30~10:50 Break

10:50~11:40 Invited lecture

Chair: M. Ohmi (Kanazawa Institute of Technology)

Body image and spatial cognition

K. Sekiyama (Future University Hakodate)

11:40~11:50 Vision Society of Japan business meeting

11:50~12:00 Closing remark

T. Maeda (University of Tokyo; VSJ '02 winter meeting chair)

Poster presentations

Posters should be placed on July 31st, from 13:10 to 16:30. Authors should attend in front of their own poster on July 31st, from 16:30 to 17:30 (even number posters) or from 17:30 to 18:30 (odd number posters). Posters should be removed on August 1st, from 10:30 to 12:00.

- PJ-1 Probabilistic atlas of human retinotopic areas
M. Fukunaga, H. Yamamoto, S. Takahashi, C. Tanaka, T. Ebisu, M. Umeda, Y. Ejima
(Meiji University of Oriental Medicine, Kyoto University, Kyoto City University of Arts)
- PJ-2 Response property of human visual areas under visual masking
K. Maeda, T. Matsuno, M. Fukunaga, H. Yamamoto, C. Tanaka, T. Ebisu, M. Umeda, Y. Ejima
(Kyoto University, Meiji University of Oriental Medicine)
- PJ-3 Perceptual filling-in of a motion stimulus presented around a blind spot
M. Fujiwara, Y. Sakaguchi (University of Electro-Communications)
- PJ-4 Motion aftereffect induced by unconscious adaptation
R. Hayashi, T. Maeda, S. Tachi (University of Tokyo)
- PJ-5 Apparent motion with isoluminant stimuli
K. Sakata (Joshibi University)
- PJ-6 Attempt on separation between SOA and fullframe duration of multi-partite subframes
R. Kuriki (University of Electro-Communications)
- PJ-7 Quantitatively Estimate Spatial Extent of Motion Detector with Velocity Thresholds and S/N Thresholds
T. Mihashi, K. Sato, S. Shioiri, H. Yaguchi (Topcon Co., Chiba University)
- PJ-8 Relative versus uniform motion: Roles of motion energy and position tracking
S. Tsujimura, Q. Zaidi (State University of New York)
- PJ-9 Bilateral and unilateral motion stimuli activate different areas in MT+
Y. Narita, M. Fukunaga, H. Yamamoto, C. Tanaka, T. Ebisu, M. Umeda, Y. Ejima
(Kyoto University, Meiji University of Oriental Medicine)
- PJ-10 Analysis of spatial integration processes in visual motion perception: an fMRI study
K. Yamamoto, M. Fukunaga, H. Yamamoto, C. Tanaka, T. Ebisu, M. Umeda, Y. Ejima
(Kyoto University, Meiji University of Oriental Medicine)
- PJ-11 Feedback processing for perception of motion-defined figure: The inference from VEP study.
Y. Kato, T. Morotomi (Hokkaido University)
- PJ-12 The late VEP components and figure-ground processes: modulatory effects by focal attention
Y. Miyawaki, R. Hayashi, T. Maeda, S. Tachi
(Institute for Physical and Chemical Research, University of Tokyo)
- PJ-13 Vertical disparity and the solution to the aperture problem for stereo
N. Asakura, M. Ohmi (Kanazawa Institute of Technology)

- PJ-14 Parallax depth perception with unrestricted head movement
H. Watanabe, M. Ichikawa (Yamaguchi University)
- PJ-15 Disparity distribution in the peripheral visual field and Perceived distance
H. Anzawa, H. Kaneko (Tokyo Institute of Technology)
- PJ-16 Depth distortion from coma aberration when gazed stimulus eccentrically located in stereoscopic display
H. Yoshimatsu, H. Kaneko (Tokyo Institute of Technology)
- PJ-17 Compensation for the distortion in the perception of slanted pictures
Y. Ishizaka, M. Hanada (Chiba University)
- PJ-18 Speed perception of self-motion from optic flow in central and peripheral vision
K. Segawa, H. Ujike, K. Okajima, S. Saida
(National Institute of Advanced Industrial Science and Technology, National Defense Academy)
- PJ-19 Changes of vection magnitude and centroid position with stimulus size
H. Sato, K. Uchikawa, H. Kaneko (Tokyo Institute of Technology)
- PJ-20 Influence of visual motion on walking velocity
N. Kato, H. Kaneko (Tokyo Institute of Technology)
- PJ-21 Effect of changes in position and size of retinal images on smooth pursuit vergence eye movements
R. Kozawa, H. Ujike, S. Saida (National Institute of Advanced Industrial Science and Technology)
- PJ-22 Image quality evaluation based on human vision, and distribution of point of gaze
H. Koshimizu, T. Hayasaka, M. Ayama (Utsunomiya University)
- PJ-23 Simulation of image appearance for various viewing conditions
Y. Nomura, H. Yaguchi, S. Shioiri (Chiba University)
- PJ-24 Individual differences in contrast sensitivity functions and the image quality evaluation
T. Hayasaka, H. Koshimizu, M. Ayama, M. Aoyama, S. Sugita (Utsunomiya University)
- PJ-25 Measurements of the contrast sensitivity function in suppression phase of binocular rivalry — comparison between normal and strabismic observers —
M. Yanagisawa, K. Uchikawa (Tokyo Institute of Technology)
- PJ-26 An examination of central and peripheral vision in patients with schizophrenia
Y. Matsuda, N. Ebihara, M. Matsui, Y. Tonoya, M. Kurachi (Toyama University)
- PJ-27 Study on difference among individual color appearance maps in peripheral visual field
M. Takase, Y. Takeuchi, K. Okajima (National Defense Academy)
- PJ-28 Visual-field- and individual-difference of MEG response to chromatic and achromatic stimuli
T. Shibasaki, Y. Ohtani, Y. Ejima (Kyoto Institute of Technology, Kyoto University)

- PJ-29 Eccentricity dependency of color processing in human visual areas measured with functional magnetic resonance imaging
Y. Taniuchi, H. Yamamoto, M. Fukunaga, N. Goda, C. Tanaka, T. Ebisu, M. Umeda, Y. Ejima
(Kyoto University, Meiji University of Oriental Medicine)
- PJ-30 A new illusion of color: 'Chromatic' White's effect A. Kitaoka (Ritsumeikan University)
- PJ-31 Achromatic/chromatic mechanisms mediating perceptual color transparency
K. Nagasawa, S. Nakauchi, S. Usui (Toyohashi University of Technology)
- PJ-32 Color coding mechanisms mediating visual search for a color target
K. Nagata, S. Nakauchi, S. Usui (Toyohashi University of Technology)
- PJ-33 Color memory matching with multi-color stimulus M. Kigure, K. Uchikawa (Tokyo Institute of Technology)
- PJ-34 Influence of environmental colors on activities of daily living of aged people
S. Tajima, Y. Yamashita, S. Sunaga (Kyushu Institute of Design)
- PJ-35 Contrast sensitivity function under sudden change in the condition of adaptation
Y. Tsukada, Y. Toyofuku, Y. Aoki (National Traffic Safety and Environment Laboratory)
- PJ-36 Color discrimination property change under different visual environments
N. Matsuki, T. Ito, S. Shioiri, H. Yaguchi (Chiba University)
- PJ-37 The effect of background color on color discrimination
T. Inamura, K. Kawamoto, H. Yaguchi, S. Shioiri (Chiba University)
- PJ-38 Measurement of temporal effects of visual attention on increment luminance threshold
T. Toyooka, K. Uchikawa (Tokyo Institute of Technology)
- PJ-39 Effects of visual attention on increment threshold of chromatic stimuli
H. Atsumori, K. Uchikawa (Tokyo Institute of Technology)
- PJ-40 Individual differences in the spatial contrast sensitivity varied by visual attention
T. Kawai, K. Uchikawa (Tokyo Institute of Technology)
- PJ-41 Effect of attention to color explored by rapid serial visual presentation task
K. Kano, S. Nakauchi, S. Usui (Toyohashi University of Technology)
- PJ-42 The speed of attentional shift adjusted to the speed of tracking object
Y. Kageyama, K. Yamamoto, S. Shioiri, H. Yaguchi (Chiba University)
- PJ-43 Eleven or twelve characters per line? Does difference in line length affect reading of newspaper?
K. Oda, I. Kamada (Tokyo Woman's Christian University, Japan Women's University)
- PJ-44 The effect of size on recognition of facial expression
E. Kawashima, K. Oda, T. Yotsukura, S. Morishima (Tokyo Woman's Christian University, Seikei University)
- PJ-45 Effects of edge components of images for viewpoint dependency in 3-D object recognition
T. Ohnishi, T. Hayasaka, S. Nakauchi, S. Usui (Toyohashi University of Technology)

(End of list)

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