

国際研究集会

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認知神経科学の先端「意識の脳内メカニズム」

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代表：松元健二（玉川大学 脳科学研究所）

所内対応者：伊佐 正（生理学研究所 認知行動発達研究部門）

オーガナイザー：吉田正俊（生理学研究所 認知行動発達研究部門）

オーガナイザー：土谷尚嗣（カリフォルニア工科大学）

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【参加者名】

Tetsuo Kida (National Institute for Physiological Sciences),
Xiaohong Wan (Lab. for Cognitive Brain Mapping, RIKEN),
Fumi Okuyama (Nara Institute of Science and Technology,
Graduate School of Biological Sciences), Atsushi Fujimoto
(Graduate School of Medicine, Kyoto University), Etsuo Kato
(Nara Institute of Science and Technology, Graduate School
of Biological Sciences), Hiroki Terashima (Department of
Complexity and Engineering, The University of Tokyo),

Tetsuo Matsui (Department of Physics, Kinki University),
Ryosuke Soga (Department of Cognitive Neuroscience,
Graduate School of Medicine, The University of Tokyo),
Yuki Aoki (Integrative Brain Science, Graduate School of
Medicine, Kyoto University), Hiroki Ora (Tokyo Institute of
Technology), Yoshito Masamizu (National Center of
Neurology and Psychiatry), Jeroen J.A. van Boxtel (Caltech),
Yumiko Yosihda (NIPS), Kengo Okitsu (Computational

Intelligence and System Science Dept. of Interdisciplinary Graduate School of Science and Engineering Tokyo Institute of Technology Miyake Lab.), Aleksandra Izabela Mroczko (Johannes Gutenberg University, Department of Philosophy, 55099 Mainz), YungHao Yang (National Taiwan University), Koji Fujita (The University of Tokushima), Shohei Yoshida (Department of Computational Intelligence and Systems Science, Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology), Tetsuya Sasaki (National Institute of Basic Biology), Daisuke Yamada (Department of Degenerative Neurological Diseases, National Institute of Neuroscience, National Center of Neurology and Psychiatry, NCNP), Yuki Sakai (Department of Psychiatry, Graduate School of Medical Science, Kyoto Prefectural University of Medicine), Masanori Yokoyama (Tokyo Institute of Technology), Mikio Inagaki (Graduate School of Frontier Biosciences, Osaka University), Heather Ayn Berlin (Mount Sinai School of Medicine), Noritaka Ichinohe (Lab for Neuroanatomy, Cell Biology and Histology, Hirosaki University, School of Medicine), Liang Qi (The University of Tokyo), Maito Tauchi (Grad. Sch. of Human & Environ. Std., Kyoto Univ, Kyoto), Eiji Hoshi (Tamagawa University Brain Science Institute), Gouki Okazawa (NIPS), Daisuke Shimaoka (Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo), Masaki Kanetaka (Tokyo Institute of Technology), Masato Kawaguchi (Tokyo Institute of Technology), Satoshi Eifuku (Univ Toyama, Grad Sch Med Pharm Sci, Dept Intgr Neurosci), Chihiro Imai (Graduate School of Information Science and Technology, The University of Tokyo), Shigeyuki Kan (National Institute of Information and Communications Technology), Ken Kihara (National Institute of Advanced Industrial Science and Technology), Waka Fujisaki (National Institute of Advanced Industrial Science and Technology (AIST)), Satoshi Tajima (The University of Tokyo), Masaru Kuwabara (RIKEN), Manoj Kumar Eradath (RIKEN BSI), Tomoaki Nakazono (Grad. Sch. of Letters, Kyoto Univ.), Hirokata Fukushima (Keio University, JSPS), Kei Nishina (Tokyo Institute of Technology), Koretaka Ogata (Tokyo Institute of Technology), Yukihiro Nobuhara (The University of Tokyo), Hiromasa Takemura (Department of Life Sciences, The University of Tokyo), Minoru Fujiki

(Department of Neurosurgery, School of Medicine, Oita University), Nazli Emadi (School of Cognitive Sciences (SCS), Institute for Research in Fundamental Sciences (IPM)), Sachio Otsuka (Department of Psychology, Nagoya University), Kun Qian (Graduate School of Human-Environment Studies, Kyushu University), Chai-Youn Kim (Korea University), Shiau-Hua Liu (Department of Counseling and Clinical Psychology, National Dong-Hwa University, Hua-Lien, Taiwan), Suhkyung Kim (Graduate Student), Yuki Yamada (Kyushu University), Kentaro Yamamoto (Graduate School of Human-Environment Studies, Kyushu University), Sohei Wakisaka (RIKEN BSI), Takahiro Kawabe (Faculty of Human-Environment Studies, Kyushu University), Françoise Nguyen (Osaka University), Yoshiyuki Kashiwase (Graduate School of Information Sciences, Tohoku University), Keiko Ihaya (Kyushu University Venture Business Laboratory), Osamu Masuda (Department of Information Engineering, Mie University), Seiichiro Amemiya (Graduate School of Human Health Sciences, Tokyo Metropolitan University), Koji Ota (Department of Philosophy, Kyoto University), Tomomitsu Herai (Tokyo Institute of Technology/Sony Computer Science Laboratories/JSPS Research Fellow), Takayuki Hosokawa (Tokyo Metropolitan Institute for Neuroscience), Wataru Sato (Kyoto University), Makoto Suzuki (Nanzan University Institute for Social Ethics), Keiichi Kitajo (Laboratory for Dynamics of Emergent Intelligence, RIKEN Brain Science Institute), Kowa Koida (NIPS), Tomoharu Oide (Takeda Lab., Department of Complexity of Science and Engineering, Faculty of Frontier Science, Tokyo University), Hironori Kumano (Juntendo University School of Medicine), Takanori Uka (Juntendo University), Isamu Motoyoshi (NTT CS Labs), Yoshiyuki Kaneko (Graduate School of Medicine, the University of Tokyo), Hiroaki Mano (AIST), Masaki Ogino (JST ERATO Asada Synergistic Intelligence Project), Hiroyuki Sakai (Toyota Central R&D Labs., Inc.), Sotaro Shimada (Meiji University), Akira Murata (Department of Physiology, Kinki University, School of Medicine), Nobuyuki Yamawaki (Kinki University), Masahiko Terao (The University of Tokyo), Takahiro Doi (Graduate School of Frontier Biosciences, Osaka University), Motohide Miyahara (University of Otago/National Institute of Physiological

Sciences), Tatsuto Takeuchi (NTT Communication Science Laboratories), Haruaki Fukuda (University of Tokyo), Masamichi Hayashi (National Institute for Physiological Sciences), Jun Uchida (Faculty of Engineering, Tamagawa University), Masayuki Kouno (Department of Systems Science, Graduate School of Informatics, Kyoto University), Katsuko Morigiwa (Soiken, Inc), Yasuko Kitano (Hosei University), Ryuzaburo Nakata (University of Toyama, Graduate School of Medicine and Pharmaceutical Science), Yoshiyuki Nishio (Department of Behavioral Neurology and Cognitive Neuroscience, Tohoku Univ), Kenji Matsumoto (Tamagawa University Brain Science Institute), Keise Izuma (Brain Science Institute, Tamagawa University), Michel Vidal-NAquet (Riken - BSI), Takeshi Aikawa (University of Tsukuba Graduate School of Comprehensive Human Sciences), Yoshihiro Morioka (Technology Planning and Development Center, AVC Networks Company, Panasonic), Sayako Masuda (Keio University), Ai Sakano (Tokyo University of Science, SUWA), Shunji Shimizu (Tokyo University of Science, SUWA), Hiroaki Inoue (Tokyo University of Science, SUWA), Kazuhiko Kume (Kumamoto University), Osamu Araki (Tokyo University of Science, Department of Applied Physics), Kiyoshi Nakahara (Institute of Neuroscience, NCNP), Yuichi Ito (Nagoya University, School of Informatics and Sciences), Ryuta Aoki (Department of Arts and Sciences, The University of Tokyo), Alex Pitti (JST ERATO Asada Synergistic Intelligence Project), Takeharu Seno (Kyushu University), Jun Kawaguchi (Department of Psychology, Nagoya University), Shinobu Kuroki (The University of Tokyo), Kyoko Suzuki (Department of Clinical Neuroscience, Yamagata University Graduate School of Medicine), Noriko Katsumata (RIKEN Brain Science Institute, Integrative Neural Systems), Takaki Watanabe (Graduate School of Science, Nagoya University), Hiroyuki Kato (The University of Tokyo), Makoto Wada (National Rehabilitation Center for Persons with Disabilities), Ryusuke Hayashi (RIKEN Brain Science Institute), Atsushi Nagaike (Kyushu University Graduate School of Medical Sciences), Shinichi Nozawa (Tokyo Institute of Technology), Igor Kagan (Caltech), Jun Kitazono (Department of Complexity Science and Engineering, Graduate School of Frontier Sciences, The University of Tokyo), Daisuke H

Tanaka (Keio University School of Medicine), Tomoyoshi Seto (Department of Anesthesiology, Shiga University of Medical Science), Yoshiaki Ajioka (Ecchandes Inc.), Penphimon Phongphanphanee (National Institute for Physiological Sciences, Okazaki), Kaoru Amemiya (Dept. Sensory Motor Neuroscience, Univ of Tokyo), Kenji Aoki (Tokyo Institute of Technology), Yousuke Ogata (National Institute for Physiological Sciences, Division of Cerebral Integration), Shigeaki Nishina (Honda Research Institute Japan), Kimiya Narikiyo (Kyushu Institute of Technology), Masanori Kanazu (Graduate School of Human and Environmental Studies, Kyoto University), Junya Hirokawa (National Institute for Basic Biology), Batu Keceli (NIPS Neurobiology Biophysics), Akira Masuda (Kyushu Institute of Technology, Fukuoka, Kitakyushu), Takeshi Kohama (Faculty of Biology-Oriented Science and Technology, Kinki University), Asaki Nishikawa (RIKEN), Takashi Owaki (Toyota Central R&D Labs., Inc.), Daisuke Narushima (Takeda Lab Graduate School of Frontier Sciences, The University of Tokyo), Toru Yanagawa (RIKEN BSI), Keisuke Suzuki (RIKEN BSI Lab. for Adaptive Intelligence), Nakao Iwata (Fujita Health University School of Medicine), Sumru Keceli (Ankara Education and Research Hospital), Minami Ito (NIPS), Kaoru Amano (The University of Tokyo), Tomoo Inubushi (University of Tokyo), Yoshinori Yamakawa (Kyoto University), Yoshinobu Eto (Laboratory of Cognitive Neuroscience, Department of Frontier Health Science, Division of Human Health Science, Graduate School of Tokyo Metropolitan University), Shogo Soma (Laboratory of Cognitive and Behavioral Neuroscience Graduate School of Medicine Osaka University), Kazuki Iijima (Dept. Basic Science, Graduate School of Arts and Sciences, Univ of Tokyo), Manabu Tanifuji (RIKEN Brain Science Institute), Masashi Nakatani (Shiseido Co., Ltd. / Keio Univ.), Yoko Mano (Department of Functional Brain Imaging, Institute of Development, Aging and Cancer (IDAC), Tohoku University), 伊佐 正 (生理研 認知行動発達部門), 池田琢朗 (生理研 認知行動発達部門), 高浦加奈 (生理研 認知行動発達部門), Asako Mitsuto (Department of Cognitive Neuroscience, Graduate School of Medicine, The University of Tokyo), 渡邊正孝 (東京都神経研), Hiroki Tanabe (Division of Cerebral Integration, National Institute

for Physiological Sciences), Hirofumi Hayakawa (Tamagawa University), Yasushi Onuki (Tamagawa University), Hiroyuki Hattori (Nanzan University), Fumitaka Nakahara (Nagoya university), 糸原重美 (理化学研究所 脳センター), 宇野 裕 (東京大学 大学院), 小松丈洋 (関西学院大学), 宮内 哲 (情報通信研究機構), 木村晃大 (大阪大学大学院 医学系研究科), David Cyranoski (Nature), 松林淳子 (NICT パイオ ICT), 野口泰基 (神戸大学), 高橋英之 (玉川大学 脳科学研究所), 小林憲史 (東京大学), 小泉 愛 (東京大学), 丸谷和史 (NTT-CS 研), 栗木一郎 (東北大学), 速水則行 (豊田中研), 吉田 誠 (東工大), Sumru Keceli (Ankara Education and Reserch Hospital), 祢占雅史 (霊長研), 石川直樹 (霊長研), 小野敬治 (霊長研), 定金 理 (基生研), 松田尚人 (生理研 生体膜), 芦田 宏 (京都大学), 呉 佳珍 (東華大学), 竹中一仁 (東京大学), 石川哲郎 (東京工業大学), 永井裕崇 (名

古屋大学), 中根俊樹 (名古屋大学), 小松英彦 (生理研), 岡本悠子 (生理研), 加藤利佳子 (生理研), Adam Ponzi (OIST), 原田卓弥 (生理研), 水谷有希 (名古屋大学), Ralph Adolphs (California Institute for Technology), Ned Block (New York University), Olivia Carter (University of Melbourne), John Dylan Haynes (Humboldt University Berlin), Ryota Kanai (University Colledge London), Christof Koch (California Institute for Technology), Shinya Nishida (NTT Communication Science Laboratories), Hakwan Lau (Columbia University), Naotsugu Tsuchiya (California Institute for Technology), Melanie Wilke (California Institute for Technology, National Institute for Mental Health), Takamitsu Yamamoto (Nihon University School of Medicine), Masatoshi Yoshida (National Institute for Physiological Sciences) (合計 206 名)

【概要】

人間の心の仕組みを、脳を起点にして明らかにすることを目指す認知神経科学は、神経生理学、心理物理学、脳機能イメージング、計算論的神経科学といったさまざまな discipline からなる学際的領域である。このような学際的領域を発展させるためには 1) 専門分野を超えた共同研究 (情報交換) の促進と 2) 研究者の層の厚みを増すことが不可欠である。これらの目的のためには、認知神経科学における特定のトピックに関して、関連するさまざまな研究領域から人選を行い、各発表では分野ごとのイントロダクションに重点を置き、議論の時間を多く取ることによって、そのトピックについて様々な角度から議論を深めるという形式のワークショップを行うことが有効であると考えられる。このようなコンセプトに基づいて、平成 19 年、20 年と生理研研究会として「注意と意思決定」「動機づけと社会性」というトピックで研究会を開催して好評を得た。そこで本年度は「意識」

というトピックを選んで、国際研究集会として開催した。

名古屋で開催された日本神経科学大会では「意識の脳科学の最前線」というテーマでの企画シンポジウムが行われた。本国際研究集会の日程をこの神経科学大会の開催日の直後に設定して、そこで招待される外国人研究者を岡崎にも招き、最前線の業績に関して、シンポジウムの時間では充分尽くせない部分まで議論を深めることに重点を置いてプログラムを作成した。日本国内で「意識」について「科学的に」アプローチする者が集まって十分に時間を取って議論するというのはこれがほぼ初めての試みであった。集会は講演者 12 名 (そのうち海外からの招待者 9 名), ポスター 40 枚 (そのうち海外からの応募者 6 名), 参加者 206 名 (事前参加申し込み 173 名) という巨大な規模で行われ、活発な議論が行われた。また、集会終了後のアンケート結果からも好意的な感想が多く寄せられた。

口演

(1) On the Relationship between the Consciousness and Attention

Christof Koch (Division of Biology and Division of Engineering and Applied Sciences,
California Institute of Technology)

The relationship between attention and consciousness is a close one, leading many scholars to conflate the two. My talk summarizes psychophysical evidence arguing that top-down attention and consciousness are distinct phenomena that need not occur together and that can be manipulated using distinct paradigms (Koch & Tsuchiya 2007; Tsuchiya & Koch 2008). Subjects can become conscious of an isolated object, or the gist of the scene in the near absence of top-down attention. Conversely, subjects can attend to perceptually invisible objects. In particular, I will describe a full factorial study of the influences of attention and consciousness (as assayed by visibility) on afterimage formation (van Boxtel, Tsuchiya & Koch 2009). We investigated the duration of the afterimage

for all four combinations of an attended/unattended and visible/invisible grating and demonstrated that selective attention and visual consciousness have opposite effects: paying attention to the grating decreases the duration of its afterimage, while consciously seeing the grating increases afterimage duration. These data provide clear evidence for distinctive influence of attention and consciousness on visual perception. Such dissociations between attention and consciousness become easier to understand when considering the different functions of these two processes. Untangling their tight relationship is a necessary step in the scientific elucidation of consciousness and its material substrate.

(2) Thalamo-cortical interactions underlying spatial awareness and decision making

M. Wilke, I. Kagan, R.A. Andersen (California Institute of Technology)

(3) How do neurotransmitters help decide what we see?

Olivia Carter (The University of Melbourne)

One pervading mystery in neuroscience is the question of how the brain is able to generate an “internal” perceptual experience from the available “external” sensory information. Ambiguous stimuli, like binocular rivalry and the Necker cube, offer a unique means to investigate this process experimentally because observers generally experience changes between multiple perceptual states without corresponding changes in the stimulus. I will present results obtained using a variety of methods including pharmacology (hallucinogens), pupillometry and basic psychophysics. The data relates primarily to vision, but I will also describe recent studies looking at auditory and tactile rivalry. Together the

results suggest that the cycle of perceptual switching characteristic of rivalry may reflect a generalized mechanism that allows the brain to decide between multiple valid alternatives, without becoming stuck on a non-optimal decision. While the exact mechanisms are unknown, my data, and research from other groups, suggest that the process may depend heavily on the coordinated activity of diffuse neurotransmitter systems like serotonin and noradrenaline. Because I wish to claim that this mechanism is common to the domains of perception, attention and action, I will conclude by briefly discussing my results in relation to current theories of behavioral decision making.

(4) Neurostructural correlates of individual difference in the switch rate of perceptual rivalry

Ryota Kanai, Bahador Bahrami, Geraint Rees (University College London)

When the visual system is confronted with ambiguous stimuli, the perceptual interpretation spontaneously alternates between competing interpretations. It has been known that the rate of perceptual switch varies considerably across individuals. Although numerous studies have examined the neural substrates involved in spontaneous perceptual switches, the origin of the individual difference in switch rate has not yet been established. Here, we investigated neurostructural markers of individual's switch rate by examining how cortical thickness, local gray matter volume and fractional anisotropy (FA) correlate with individual's switch rate for a bistable, rotating structure-from-motion sphere. Our analysis revealed that cortical thickness of the left intraparietal sulcus (IPS) and the volume of bilateral IPS positively correlate with

individual's switch rate. Furthermore, we found that the FA values of the white matter tracts providing connections to and from the bilateral IPS correlate positively with individual's switch rate. In order to establish that the neurostructural correlates in the IPS plays a causal role in perceptual switch, we modulated the activity of the IPS using transcranial direct current stimulation (tDCS) and compared changes in the switch rate before and after the tDCS. The results showed that suppression of IPS slows perceptual switch rates, confirming the causal involvement of IPS in perceptual switches. Taken together, these results demonstrate a direct relationship between neurostructure of the IPS and individual's switch rate.

(5) Cerebrospinal stimulations therapy for the treatment of vegetative state and minimally conscious state

Takamitsu Yamamoto, Chikashi Fukaya, Yoichi Katayama
(Department of Neurological Surgery, Nihon University School of Medicine)

【Introduction】 The Multi-Society Task Force on PVS (1994) summarized the medical aspects of the vegetative state. They provided a statement that the VS is a clinical condition of complete unawareness of the self and the environment, accompanied by sleep-wake cycles, with either complete or partial preservation of hypothalamic and brainstem autonomic function. However, there are various grades of severity and various stages leading to various outcomes, even if the patient displays neurological signs identical to the VS. The definition of the minimally conscious state (MCS) is characterized by inconsistent but clearly discernible behavioral evidence of consciousness and can be distinguished from coma and the VS by documenting the presence of specific behavioral features. We evaluated patients in the VS and MCS by an electrophysiological approach, and compared with the results of cerebrospinal stimulation therapy.

【Methods】 Forty-one cases of a vegetative state (VS) caused

by various kinds of brain damage were evaluated neurologically and electrophysiologically at 3 months after brain injury. These cases were treated by deep brain stimulation (DBS) therapy or spinal cord stimulation (SCS), and followed up for over 10 years. The mesencephalic reticular formation was selected as a target in 2 cases, and the thalamic centre median-parafascicular (CM-pf) complex was selected as a target in the other 19 cases. SCS was applied in other 20 cases.

【Results】 Ten of the 41 patients emerged from the VS, and became able to obey verbal commands. In the 10 cases that emerged from the VS, the Vth wave of the ABR and N20 of the SEP were recorded even with a prolonged latency; continuous EEG frequency analysis demonstrated a desynchronization pattern or slight desynchronization pattern; and the pain-related P250 was recorded with an amplitude of over 0.007mV. However, they remained in a bedridden state

except for 1 case. On the other hand, DBS and SCS achieved consistent discernible behavioral evidence of consciousness, and emergence from the bedridden state in 10 of 12 minimally conscious state (MCS) patients.

【Conclusion】 Cerebrospinal stimulation therapy can be a useful method for the treatment of prolonged coma patients, if candidates are correctly selected with electrophysiological evaluation.

(6) The Amygdala's Role in Consciousness of Emotions

Ralph Adolphs (California Institute of Technology)

The amygdala has long been highlighted as a structure intimately involved in emotion, specifically fear. In particular, it has been thought to be involved in two components of emotion processing: (1) very rapid, automatic, non-conscious emotional processing, such as detection of fearful facial expressions; (2) expression and experience of emotions. Building on an emerging literature on the connectivity and electrophysiology of the amygdala, and presenting new data

from our own laboratory, I will argue that these views need to be modified. Point (1) is not correct as originally conceived, since complete lesions of the amygdala in humans still preserve many aspects of non-conscious emotion processing. Point (2) needs to be modified as well; I will argue that the amygdala may trigger many components of an emotional response, but that it is not likely to be a necessary part of the neural correlate of the conscious experience of emotions.

(7) Neuronal activity in area MT during perceptual stabilization of ambiguous structure-from-motion

Naotsugu Tsuchiya (California Institute of Technology)

While viewing an ambiguous stimulus, such as binocular rivalry, perception spontaneously alternates between two alternatives. Ambiguous stimuli are powerful tools to study the neuronal correlates of consciousness as they allow us to study the neuronal activity that fluctuates along with conscious percept while physical inputs remain the same. Despite prior studies using ambiguous stimuli, little has been known as to what kind of neuronal activity supports perceptual switches and maintains one perceptual interpretation for a sustained time. Perceptual alternation can be greatly slowed down if the stimulus is periodically removed from view, a phenomenon called “perceptual stabilization” (Leopold et al NatNeuro 2002): a handy model for studying the detailed dynamics of perceptual switches and

perceptual memory. Here, we presented ambiguous structure-from-motion stimuli to awake monkeys and recorded neuronal activity from area MT with multiple (>10) electrodes under two conditions differing in the strength of perceptual stabilization. Using multivariate decoding techniques (Tsuchiya et al PLoS ONE 2008), we could decode the percept during stimulus presentation (~70% correct) but we could not predict upcoming percepts before stimulus presentation in both conditions. Most notably, the latency of MT decoding was much faster in the condition with strong stabilization. Our results suggest that MT is responsible for “encoding” of perceptual memory, but it is not actively involved in its “maintenance”. MT primed during stabilization, resulting in faster latency.

(8) Psychophysical approach to the measurement of perceptual latency

Shin'ya Nishida^{1,2,3}

¹Human and Information Science Lab, NTT Communication Science Labs, NTT Corporation,

²Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology,

³Center for Multidisciplinary Brain Research, National Institute for Physiological Sciences)

There is always a time lag between detection of physical signals by a sense organ (e.g., photoreceptors on the retina) and establishment of the corresponding perceptual representation (or perceptual awareness) in the observer's brain. Despite past extensive investigation, our current understanding of the perceptual latency is far from complete.

One cannot easily specify the perceptual latency in the time course of evoked neural activity without knowing the neural correlate of perception. Since perception is a subjective experience, one might expect that perceptual latency should be best estimated from the observer's subjective judgment on apparent timing, such as simultaneity and temporal order. However, subjective temporal judgments should be considered as the brain's interpretation of the time course of the physical events that does not faithfully reflect of the neural latency for perception [1]. Several findings suggest the existence of the mechanisms in the brain that make subjective time judgments veridical (e.g., temporal judgments based on time markers [2], and adaptive recalibration of simultaneity

[3]).

A more promising index of perceptual latency is the behavioral response latency for a perceptual decision, since it gives objectively measurable time that surely includes the latency of the observer's brain to reach a certain perceptual decision. In addition, when successfully correlated with simultaneously measured neural response, the behavioral latency could suggest when and where in the brain the perceptual decision is made [4,5].

To psychophysically investigate how perceptual latency is determined, we measured behavioral reaction time to judge perception of bistable stimuli. Our results suggest that perceptual ambiguity has little effects on perceptual latency [6], and that a predictive/postdictive modulating stimulus alters the perceptual latency in a timing-dependent manner [7]. A coherent account of the obtained data can be given by an independent race model in which the perceptual evidence is independently accumulated for alternative perceptual interpretations.

(9) The dynamic threshold hypothesis for sensory awareness

Hakwan Lau (Columbia University)

Most theories assume that sensory awareness happens when the relevant neural signal passes a certain threshold; weak signals are subliminal and strong signals yield conscious percepts. The key contention here is that such threshold is not fixed. Rather, the brain adjusts this threshold dynamically in order to achieve statistical optimality. Therefore, the same signal strength can actually lead to awareness or unawareness, depending on whether the threshold is low or high respectively. This prediction has been confirmed in clinical cases of blindsight, as well as by psychophysical experiments

in normal volunteers. Behaviorally, signal strength can be estimated by forced-choice task performance index d' . When d' was matched across conditions in an fMRI experiment, awareness was reflected by activity in the prefrontal cortex, but not by the early visual areas. In another experiment, transcranial magnetic stimulation applied to the prefrontal cortex changed the subjective reports of awareness without changing forced-choice task performance. Computational analysis suggests that reports of awareness depend on a late-stage of information processing in a hierarchy, rather than

a special “conscious” channel. Activity in the prefrontal cortex is likely to reflect processing at this late stage. Finally, in psychophysics experiments we showed that top-down spatial attention changed both the signal strength for a visual stimuli as well as its threshold. Therefore, in some cases, the lack of attention could paradoxically lower task performance but boost awareness. This may explain why we seem to have

an inflated sense of phenomenology for unattended objects at the periphery. Taken together, these results suggest that, despite common research practice, forced-choice task performance may not reflect the most interesting aspects of sensory awareness, as it could be systematically decoupled from subjective reports of conscious experience.

(10) What-it-is-like of monkey with blindsight

Masatoshi Yoshida, Kana Takaura, Tadashi Isa

(Department of Developmental Physiology, National Institute for Physiological Sciences, Japan)

We examined awareness in monkeys with unilateral V1 lesions and sought neural activity specific to blindsight. First, we examined whether the monkeys are able to maintain short-term memory of the stimuli presented in their contralateral (‘affected’) hemifield. The monkeys were tested with a memory-guided saccade task with a 2 sec-delay. The success ratio was over 80%, significantly higher than chance. Then we recorded the neuronal activity from the superior colliculus (SC) during the memory-guided saccade task. We found that a majority of the neurons recorded from the ipsilesional SC showed a sustained activity selective for spatial locations of targets. These results suggest that the monkeys with V1 lesion retain a certain level of visual awareness and that it was represented in the SC. Then we examined their visual awareness more directly using comparison between the performance of a forced-choice (FC)

task, in which localization of target positions was required, and that of a yes-no (YN) task, in which detection of the targets was required. The performance of the YN task indicates residual detection in the affected hemifield. Single-unit recording from the SC revealed that, in the ipsilesional SC, the neural response to the visual stimuli in the affected hemifield was larger when the monkeys successfully detect the targets than when the monkeys missed them. Finally, we examined decision process of these monkeys using a forced-choice (FC) task. We modeled the distribution of saccadic reaction times by a modified diffusion model and obtained evidence that the decision threshold in the affected hemifield was lower than that in the normal hemifield. These results suggest that V1 lesion affect awareness and decision and that neural activity in the SC is a neural correlate of reduced awareness.

(11) Decoding consciousness

John-Dylan Haynes (Humboldt-University Berlin)

Despite many years of research on the neural correlates of consciousness (NCCs), it is still unclear how the detailed contents of consciousness are represented in the human brain. It is often assumed that specific contents of consciousness are encoded in dedicated core NCCs - one for each different aspect of conscious experience. Due to their low spatial and

temporal resolution conventional approaches to human neuroimaging are severely limited in their ability to reveal such content-selective mechanisms. Now, the approach of multivariate decoding provides a powerful framework for studying the relationship between consciousness and content-selective processing in more detail. This approach

makes it possible to assess how conscious experience is encoded in the brain, and how the encoding of sensory

information is affected when it enters awareness.

(12) Three Theories of Consciousness

Ned Block (New York University)

Comparison of the three major theories of consciousness taken seriously by neuroscientists, the global workspace theory, the higher order theory and the biological theory. Clarifies what the difference is between these theories and describes the advantages and disadvantages of each. Considers both conceptual and empirical arguments for and

against the major theories argues that the biological approach is better able to handle the “explanatory gap”, the fact that nothing that is now known allows us to understand why the neural basis of an experience is the neural basis of that particular type of experience rather than another type of experience or, instead, a non-experiential state.

ポスター

(P-01) Attention and consciousness have different afterimage formation

J.J.A. van Boxtel, C. Koch (Division of Biology, California Institute of Technology, Pasadena, CA, USA)

Attention and consciousness are reported to have opposite effects on negative afterimage formation. Attention weakens and shortens afterimages, while consciousness (i.e. visibility) strengthens and lengthens afterimages. However, no study has investigated these effects parametrically in a single study. We employed gratings, presented monocularly, and peripherally during a 4-sec adaptation phase. A uniform average-luminance field followed this phase, and observers used button presses to indicate how long an afterimage was visible. During adaptation, attention was modulated by having the observers perform (or not perform) an attention-absorbing Rapid Serial Visual Presentation (RSVP) letter counting task at fixation. Visibility was modulated by presenting (or not presenting) a strong variant of binocular rivalry, continuous flash suppression (CFS; Tsuchiya & Koch 2005), in the eye

contra-lateral to the adaptor. We found that increased attention to the stimulus reduced afterimage duration (Wilcoxon signed-rank test $p < 0.01$; see also Suzuki & Grabowecky 2003; Lou 2001), while increased visibility (i.e. the absence of CFS) of the stimulus increased afterimage duration (Wilcoxon signed-rank test $p < 0.01$). The attention effects are visible over the whole range of CFS contrasts, while visibility was only strongly affected at high contrasts.

Moreover, when changing the inducer contrast, we found that visibility influences were strongest at low-to-intermediate contrasts (~13% contrast), while attentional effects were strongest at high contrasts (~100%) contrast. These findings show that attention and conscious perception are dissociable processes with potentially opposing effects on stimulus processing.

(P-02) Multiplicity in unity: the unity of consciousness and synesthesia

Aleksandra Mroczko (Philosophy Department, Johannes Gutenberg University Mainz)

In the scientific study of consciousness there is some skepticism concerning the existence of one of the main and most pervasive features of the human mind - the unity of consciousness. Especially in certain pathological conditions, this unity has been claimed to break down. However, such an apparent break down may simply be one extreme on the continuum of the unity of consciousness, where various forms of unity are integrated in a different degree. Here, I review experimental studies on the phenomenon of synesthesia - mirroring the other side of this continuum, where the conscious experience seems to be maximally integrated. Synesthesia is often described as a “union of the senses”,

where the senses normally experienced separately can be joined together involuntarily, automatically and consistently throughout the lifetime. There is not only a multitude of senses subsumed into a unified synesthetic percept, but the phenomenon also combines both semantic and perceptual processing levels (e.g. Mroczko et al. 2009, under review). By means of these studies I discuss some of the conceptual issues for philosophical understanding the unity of consciousness and aim to support the hypothesis that the unity of consciousness can be seen as a functional and graded property.

(P-03) Neurocognition and Temperament in Depersonalization Disorder

Heather A. Berlin (Ph.D., MPH, Holly Hamilton, B.A., Daphne Simeon, M.D. Department of Psychiatry, Mount Sinai School of Medicine, New York, NY)

【Background】 Dissociation is a disruption in the usually integrated functions of consciousness, memory, identity, or perception. Depersonalization Disorder (DPD) is a dissociative disorder characterized by a persistent or recurrent feeling of being detached from one’s mental processes or body, accompanied by intact reality testing. Their alterations in consciousness center around a sense of unfamiliarity/unreality and hypo-emotionality.

【Objective】 Explore the neurocognitive and temperament profile of DPD patients to better understand their underlying neurobiology and to gain insights into the neural basis of dissociation.

【Methods】 19 DPD patients and 22 matched healthy controls (HCs) were given a comprehensive neuropsychological battery (CANTAB), the Iowa Gambling Task, a time perception task, and questionnaires of impulsivity, temperament, emotion, and frontal behavior (measures orbitofrontal cortex (OFC) dysfunction).

【Results】 Compared to HCs, DPD patients performed

significantly better on the Intra-Extra Dimensional Set Shift task (IED) (an analogue of the Wisconsin Card Sorting test) and did no worse on any other cognitive task. However, they did have a significantly faster subjective sense of time (overestimated and underproduced 10-90 seconds time intervals), and their long-term time estimation positively correlated with their attentional impulsivity. DPD patients experienced more childhood trauma (physical and emotional abuse and neglect), negative emotions, and dissociation, and were more impulsive, neurotic, and harm avoidant and less extraverted, agreeable, conscientiousness, and self-directed. DPD patients also had more frontal behaviors which positively correlated with their emotionality, neuroticism, and childhood trauma.

【Conclusions】 Dorsolateral prefrontal cortex (DLPFC) hyperactivation may explain DPD patients’ enhanced IED performance, a task sensitive to DLPFC function. Memory suppression and emotional regulation has been associated with increased DLPFC and reduced limbic activation. DLFC

inhibition of limbic structures may mediate DPD patients' ability to dissociate and their hypo-emotionality. However, OFC dysfunction (measured by frontal behaviors) appears to be related to their other problems, such as their time perception deficits, negative emotions, neuroticism, impulsivity, and childhood trauma. Further investigation is

needed to determine how this "splitting of consciousness" relates to the NCC. Integration of various cortical and subcortical areas may be necessary for cohesive conscious experience. Dissociation may involve disruption of cortico-cortical, thalamo-cortical, or limbic-cortical connectivity.

(P-05) Predictive and postdictive mechanisms jointly contribute to visual awareness

Ryosuke Soga, Rei Akaishi, Katsuyuki Sakai

(Department of Cognitive Neuroscience, Graduate School of Medicine, The University of Tokyo)

One of the fundamental issues in visual awareness is how we are able to perceive the scene in front of our eyes on time despite the delay in processing visual information. The prediction theory postulates that our visual system predicts the future to compensate for such delays. On the other hand, the postdiction theory postulates that our visual awareness is inevitably a delayed product. In the present study we used

flash-lag paradigms in motion and color domains and examined how the perception of visual information at the time of flash is influenced by prior and subsequent visual events. We found that both types of event additively influence the perception of the present visual image, suggesting that our visual awareness results from joint contribution of predictive and postdictive mechanisms.

(P-06) Separate temporal limits of cross-attribute processing revealed by binding and synchrony judgments

Waka Fujisaki¹, Shin'ya Nishida²

(¹National Institute of Advanced Industrial Science and Technology (AIST),

²NTT Communication Science Laboratories, NTT Corporation)

Human brain processes different aspects of surrounding environment through multiple sensory modalities, and each modality can be subdivided into multiple attribute-specific channels. When the brain re-binds sensory signals across different channels, temporal coincidence provides a critical clue, but how the brain binds synchronous attributes remains poorly understood. In a series of human psychophysical experiments, we examined how the combination of visual (color, luminance, orientation), auditory (pitch), and tactile (left and right finger stimulations) attributes affected two types of phase discrimination task, each judging binding and

synchrony. The results indicated that the upper temporal limit of cross-attribute binding was fairly low (2-3 Hz) and surprisingly similar for any combinations of visual, auditory, and tactile attributes. This is not the limit of judging synchrony, since the temporal limit of cross-attribute synchrony judgment was higher (4-9 Hz), and varied with the modality combinations. These findings suggest a novel functional structure of cross-attribute temporal binding process, in which 'when' properties and 'what' properties of a multi-attribute event are once processed separately, and recombined by a common central process.

(P-07) Top-down and stimulus-driven influences in the attentional blink:
Evidence from transcranial magnetic stimulation

Ken Kihara¹, Takashi Ikeda¹, Daisuke Matsuyoshi¹, Nobuyuki Hirose¹,
Tatsuya Mima², Hidenao Fukuyama², Naoyuki Osaka¹

(¹Department of Psychology, Graduate School of Letters, Kyoto University,

²Human Brain Research Center, Graduate School of Medicine, Kyoto University)

When two targets (T1 and T2) are to be identified in rapid serial visual presentation, the response to T1 induces impairment of T2 report when T2 appears within 500 ms after T1 (attentional blink: AB). AB is thought to reflect temporal limitations in the formation process of visual awareness. Several cognitive neuroscience literatures have suggested that the role of the intraparietal sulcus (IPS) is top-down attentional control, while the inferior parietal lobe (IPL) is involved in stimulus-driven orienting of attention. We investigated how the attentional functions of the IPS and IPL

are associated with the AB using transcranial magnetic stimulation (TMS). The results showed that the magnitude of the AB deficit decreased when triple-pulse TMS induced a transient interruption of the right IPS activity after T1 onset, while there was an increasing effect when TMS pulses were delivered over the right IPS or IPL after T2 onset. These findings indicate that top-down attentional control in the IPS is related to the processing of RSVP targets, while stimulus-driven orienting of attention in the IPL contribute to identify T2 presented during the AB period.

(P-08) Implicit association between interoception and mentalizing is indicated
by heartbeat-evoked brain potential

Hirokata Fukushima^{1,2*}, Yuri Terasawa^{1,2}, Satoshi Umeda¹

(¹Department of Psychology, Faculty of Letters, Keio University, Tokyo, Japan,

²Japan Society for Promotion of Sciences, Tokyo, Japan)

Interoception is a processing of physiological and visceral bodily states, and considered to be a basis of our emotion, and maybe consciousness. Here we report a preliminary study showing interoceptive processing in the brain may be associated with explicit mental state processing. Being measured EEG and ECG (i.e. brain wave and heart beat), twenty-one healthy adults participated the experiment where they attended to either the mental or physical aspects of a series of photographs showing the eyes of other people.

Participants' brain potential, which is synchronized to their own heart-beat (termed heartbeat-evoked potential; HEP) was calculated and compared between the tasks. As a result, HEPs showed enhanced amplitude in the period of mentalizing trials compared to non-mentalizing trials. Furthermore, this effect showed weak correlation with a score of empathy questionnaire. This study propose a novel approach to grab the neural activity reflecting the interaction between implicit viscleral processing and explicit cognitive functions.

(P-09) Shared circuits for representing self and others' actions, agency and space

Alex Pitti¹, Ph.D., Yasuo Kuniyoshi^{1,2}, professor(¹ERATO Synergistic Intelligence Project, JST,²ISI laboratory, The University of Tokyo)

A large body of literature in neuroscience emphasizes the role of embodiment for intelligence, many important cognitive skills arise just from the simple structuring of the sensorimotor information flow to form dynamic, cross-modal and shared neural representations; e.g., for representing actions performed by oneself and others (the mirror neurons system), for representing our own body image along with the peripersonal space (visual receptive fields), or to sense our own agency (the feeling that I am the cause or author of the movement) and the perceptual presence of others (in the parietal cortex). These features are assumed to be a determinant bootstrap for babies to acquire later on higher cognitive skills such as self-awareness and attention to others. Neuropsychological evidences suggest that they are built from the temporal extent of our sensorimotor skills (e.g. synchrony, contingency detection) and can modulate the perceptual

experiences with the environment depending on their coordinations at the neural level. We propose that the biological mechanism of spike-timing-dependent synaptic plasticity, discovered to regulate the neural dynamics synchronization at the millisecond order in many parts of the central nervous system, could underlie the computational mechanism for modeling such functional integration in sensorimotor networks: the coherence or the dissonance in the sensorimotor information flow would impart then the neural representations. In three robotic experiments using proprioceptive, tactile or visual feedback information we simulate how low level action representation, agency, spatial representation could arise in sensorimotor networks of spiking neurons [1-2]. This suggests a basic stage representing the self in relation to others at a very raw level in line with Gallese's embodied simulation theory of shared circuits.

(P-10) Neuronal population decoding explains the change in motion detection sensitivity caused by task-irrelevant motion induction

Satohiro Tajima¹, Hiromasa Takemura^{2,3}, Ikuya Murakami², Masato Okada^{1,4}(¹Department of Complexity Science and Engineering, The University of Tokyo,²Department of Life Sciences, The University of Tokyo,³Research Fellow of the Japan Society for the Promotion of Science,⁴Brain Science Institute, RIKEN)

Motion in the surround is known to cause a repulsive bias in the perception of a central target motion (induced motion). It is recently reported that the detection sensitivity to the target motion can be enhanced (or degraded) by adding a slow (or fast) surrounding motion in an orthogonal direction, even though here the illusory motion component caused by the surround is not relevant to the task (Takemura & Murakami, VSS, 2008). Here we present a parsimonious model that explains how task-irrelevant illusory motion modulates the

detection sensitivity. We modeled the neural population responses in a higher visual cortex; individual model neurons were tuned to different directions, and their response gains were modulated by surrounding stimulus motion. We found that the performance of the optimal decoder, which estimates the target motion direction from noisy response, was enhanced or degraded by surrounding motion, as seen in human subjects. This means that the enhancement and degradation found in detection sensitivity can be understood

as consequences of the noisy neural encoding that limits the processing pathway.
resolution of information transmission in the cortical visual

(P-11) Color contributes to natural scene categorization when peripherally presented

Sachio Otsuka, Jun Kawaguchi (Department of Psychology, Nagoya University)

This study examined whether color and greyscale natural scenes presented peripherally and ignored were categorized, using a negative priming (NP) paradigm. We set up low and high attention-load conditions, based on the set size of the prime display (one and five). Participants were required to detect and categorize target object in natural scenes (central visual search task), ignoring peripheral natural images both at the prime and probe displays. The results showed that

irrespective of attention load, NP was observed for color scenes, but not for greyscale scenes. In addition, we did not observe any effect of color information in central visual search where participants directly responded to natural scenes. These results indicate that the color information is critical to object categorization in natural scenes which participants indirectly process, but when scenes are processed directly, color information does not contribute to categorization.

(P-12) Role of default mode network in the understanding of subjectivity of desires

Francoise Nguyen (Osaka University)

Theory of mind is considered a cognitive ability that belongs only to humans, and particularly over-4-year-olds. But before they can pass the Sally and Anne test, children can already begin to understand other people's mind. Repacholi & Gopnik [1997] have shown that infants can understand the subjectivity of desire from the age of 18 months, while they can not at the age of 14 months. During this age therefore, a development in the ability of mentalizing, the attribution of mental states to the other, based on one's self knowledge, takes place. It also happens that this period is strongly characterized by the acquisition of self-consciousness, which indicates that mentalizing and self-consciousness are strongly correlated both in respect to time, and in respect to their

processes. The third correlation is their neural substrates. Both self-referential thoughts and mentalizing tasks activate default network regions. The default-network, first observed in adults, has recently been investigated in younger infants. Whereas the default network in 2-year-olds resembles that of adults, the 1-year-olds' primitive default network activates a large number of regions and connectivity. Therefore, we make the hypothesis that the symbiotic development of the mentalizing ability and self-consciousness makes a big leap around 18 months of age. We introduce a model where the default network, through mentalizing tasks, grows more specialized and enables infants to realize that the other may have likes and dislikes different from them.

(P-13) Spontaneous activity in the visual system can "overcome" stimulus-driven activity

Sohei Wakisaka (Laboratory for Dynamics of Emergent Intelligence, RIKEN Brain Science Institute)

Recently we found two different types of visual illusion. One occurs during binocular rivalry between visual noise and

a grating. When visual noise is perceptually dominant, the noise forms mesh-like pattern that runs diagonally to the given grating. This is called “Diagonal Mesh Pattern (DMP).” One of the most significant characteristic of DMP is that one can perceive dense line segments (i.e., mesh) that are not embedded in the grating itself. Another illusion is similar to DMP but occurs during non-dichoptic viewing condition.

Tentatively called as “Virtual Line”, this is also a perception of orientation which differs from the embedded orientation in the stimulus. We suggest that a common mechanism underlies both DMP and Virtual Line: that is, the mutual interaction between spontaneous activity and stimulus-driven activity in the early visual cortex. This idea gives novel insight into the role of spontaneous activity in brain.

(P-14) Implicit and explicit resilience

Ihaya, K., Yamada, Y., Kawabe, T., Nakamura, T. (Kyushu University)

Resilience is a mental capacity of people to cope with harmful events such as abuse, disaster, and so forth. So far, resilience has been investigated by mainly using self-report questionnaires and hence, the explanation by past findings is limited to the explicit aspect of resilience. The present study aimed at investigating the relationship between implicit and explicit aspects of resilience. As an explicit measure, we used self-report questionnaire consisted of four types of resilience scales (Ihaya & Nakamura, 2008) that can assess understanding/utilization of the own personal/environmental resources. Meanwhile, as an implicit measure, we employed

an implicit association test that disclosed an automatic evaluation for closely-related people of each observer: it was hypothesized that the availability for closely-related people would be positively related with one of explicit aspects of resilience (i.e. utilization of the environmental resources of resilience). Fourteen adult men and women took part in the experiment which consisted of both the implicit and explicit tests. As a result, there was a significant correlation between the scale scores and implicit association scores for the utilization of the environmental resources. The results suggest that at least a part of the resilience mechanism is implicit.

(P-15) How Not to Find the Boundary of NCC

Koji Ota (Department of Philosophy, Kyoto University)

Neural correlates of consciousness (NCC), especially of visual consciousness, have been increasingly explored by psychological and neuroscientific techniques. The basic assumption in the discussion of visual NCC is that there must be a neural condition which constitutes the determinate boundary between conscious and unconscious vision - that was called ‘Cartesian Materialism’ and criticized by Dennett (1991). According to him, the distributed neural architecture

composed of many functionally specialized circuits implies the collapse of the boundary between conscious and unconscious neural representation. I would like to show that the argument raised by him is viable in the case of the contemporary studies of NCC. I will develop his argument especially to focus on how the confounding factors in the measures of consciousness are involved in hypothesizing NCC.

(P-16) Effect of numeric order on perceived duration of following stimulus

Tomomitsu Herai^{1,2,3}, Ken Mogi^{1,2}

(¹Tokyo Institute of Technology, ²Sony Computer Science Laboratories, ³JSPS Research Fellow)

The subjective sense of time is an integral part of perception in general. The nature of its neural mechanism is still unclear. Duration estimations of presented stimuli are affected by various factors. For example, the perceived durations of visual stimuli are underestimated if the subject can predict the next stimuli, as in the presentation of successive integers in order. As regards this particular stimulus category, different impressions are created by ascending and descending integers. Here we study the effect of the presentation of ascending and descending integers on duration estimations. The subjects watched the ascending, descending, or randomly ordered integers and were instructed to discriminate the duration of a square stimulus presented just after the numerical presentation. In all conditions,

subjects overestimated the duration of the target stimuli. The point of subjective equity (PSE) was smaller in the ascending condition than in the descending condition. On the other hand, the just noticeable difference (JND) was not different significantly. These results suggest that the overestimation of the target duration was larger in the ascending condition compared to the descending condition. The performances of the subjects were not significantly different when a single integer was presented just before the target stimuli. Thus, a series of integers presented in a particular order has a significant effect in the temporal processing of following visual stimuli. We conclude that the preceding contexts like the ascending and descending integers affects the subsequent perception of time.

(P-17) Instrumental conditioning with subliminal facial expressions

Yuki Yamada, Takahiro Kawabe (Kyushu University)

It is well known that subliminal as well as supraliminal cues form instrumental conditioning in human. The present study tested whether facial expressions which were subliminally presented as cues affected the instrumental conditioning. We used grayscale photographic portraits with three facial expressions (happy, angry, and neutral). The happy and angry faces were associated with reward and punishment, respectively, and otherwise, though the neutral face always linked to no financial outcomes. On each trial, a face was presented for 10 msec, temporally interleaved between two sequential random-dot patterns reducing the

visibility of the face. Within 3 sec after the second random-dot pattern disappearance, observers had to press a key to bet on the cue, or release it not to bet. When the happy (and angry) faces were associated with reward (and punishment), the betting rate for the happy face was significantly higher than for the angry face in the last 10 of 40 trials. However, when the happy (and angry) faces were associated with punishment (and reward), no difference in the betting rates between expressions was found. These results suggest the involvement of unconscious emotional processing in human instrumental conditioning.

(P-18) The effect of the sense of speed on time perception using static images

Kentaro Yamamoto¹, Kayo Miura²

(¹Graduate School of Human-Environment Studies, Kyushu University,

²Faculty of Human-Environment Studies, Kyushu University)

It is widely known that stimulus motion lengthen perceived time. Current research indicates that this illusion depends on stimulus speed rather than temporal frequency or spatial frequency (Kaneko & Murakami, 2009). However it is still unclear whether this illusion depends on physical speed or perceived speed. In the present study, we examined whether the sense of speed from static images lengthen perceived time.

We conducted a temporal bisection task (Droit-Volet, 2008) with an anchor duration pair (0.1s vs. 0.4s) to measure the perceived time. The result showed that perceived duration was longer when subjects observed running and walking posture of human character than they observed standing posture of it. This result indicates that perceived speed is critical in time dilation caused by stimulus motion.

(P-19) Grid illusions require continuous grids

Kun Qian^a, Yuki Yamada^{a,b}, Takahiro Kawabe^a, Kayo Miura^a

(^aKyushu University, Japan, ^bJapan Society for the Promotion of Science)

Hermann grid illusion and scintillating grid illusion are so-called grid illusions where illusory smudges and spots are perceived on the intersections of the grids. A previous study showed that curved grids reduced vanishing-disk illusion (Levie & McAnany, 2008), indicating a possibility that spatial characteristics of grids also influence on grid illusions. In this study, we examined the role of grid length on the two types of grid illusions. Specifically, the length of grids from each intersection was manipulated. The task of observers was to rate the strength of illusion using a five-point scale

(Experiment 1) or to judge the presence/absence of illusion in a yes-or-no form (Experiment 2). The results in both experiments showed that a critical length of the grids was required for the occurrence of the illusions. The results indicate that continuous grids are necessary for both Hermann grid illusion and scintillating grid illusion to occur. The present study also provides new evidence that the two types of grid illusions share some common factors about the requirement of continuous grids.

(P-20) Predictive and postdictive processing in audiovisual interaction

Takahiro Kawabe (Kyushu University)

Observers were asked to discriminate two stimulus intervals, where one interval had two flashes that were simultaneously exposed for 10 ms at the left and right visual peripheries, and the other interval had three sequential flashes presented at the left, right, and left visual peripheries in order, or vice versa, with the SOA of 20 ms. In half of the trials, the

flashes in both intervals were accompanied with auditory motion of noise bursts. The noise bursts were presented from the left, right, and left loudspeakers in order, or vice versa. The first and third noise bursts respectively preceded and followed the two flashes in one interval or the second flash in the other interval with the SOA of 100 ms. The second noise

bursts were synchronized with the two flashes or the second flash. The discrimination performance for two intervals was impaired when the flashes were accompanied with auditory motion in comparison with when they were not, indicating that auditory motion of noise bursts caused illusory visual motion of flashes (Experiment 1). When the flashes were presented in the upper and lower visual peripheries, however,

there was no reduction in discrimination performance irrespective of the presence of noise bursts (Experiment 2). These results indicate that auditory motion of noise bursts predictively and postdictively causes illusory visual motion of flashes only when noise bursts and flashes are spatially concordant with each other.

(P-21) Quantification of the Induced Emotional Effect by Visual Spatial Attention

Shiau-hua Liu*, Bo-huei Jheng, Huei-cyu Wei, Yu-jhe Shih, Wei-jin Yu

(Department of Counseling and Clinical Psychology, National Dong-Hwa University, Hua-Lien, Taiwan)

Emotions can affect cognitive performance in many tasks (Fredrickson, 2001; Levine and Burgess, 1997). Attention-plus-external-noise paradigm (Doshier & Lu, 2000) has been developed and employed to investigate the mechanisms of visual spatial attention and to quantify the attention effect size. How much the induced emotion affect attention is unknown. This study aims to quantify the induced emotional effect by visual spatial attention paradigm after watching emotional/neutral video clips. Four positive, 4 negative emotion video clips and 8 neutral ones were selected from 30 short video clips by 40 observers participated in the self-report evaluation procedure after watching. In the formal experiments, 4 observers were asked to watch video clips (three emotion conditions were counterbalanced by session, by day and by subject) and then make 2-Alternative-Forced-Choice orientation judgments on oriented Gabor patches. The experiment design varied 7 contrast levels, 2 cueing conditions (5/8 valid & 3/8 invalid central cueing), 2 noise conditions, and 4 locations, which

allowed fitting psychometric function curves for each observer. Each session consisted of two sub-sessions and each sub-session had 448 trials. Every observer participated in 9 experimental sessions. The first session was for practice and then discarded. The psychometric function curves were similar in both the positive and negative emotion conditions. Therefore, we combined these two emotion conditions to compare with neutral condition. The results showed the attention effect occurred in high noise conditions for both emotion and neutral conditions, but not or small in no-noise conditions. This confirmed the major mechanism of visual spatial attention was external noise exclusion. The attention effect was bigger in induced emotion condition than in neutral condition. The magnitude of the attentional difference could be presented as the threshold contrast differences at the 75% correct. Therefore, the induced emotion effect occurred by watching emotional video clips and affected visual spatial attention.

(P-22) Effects of electrical microstimulation of the inferior temporal cortex of the monkey in color perception

Kowa Koida, Hidehiko Komatsu (Natl Inst for Physiol Sci.)

To examine causal relationship between the activities in the color selective patch in the anterior inferior temporal cortex

(area TE) of the monkey and color perception, we applied electrical microstimulation (20 & μ ; A biphasic 200 Hz)

through the microelectrode inserted in or around the color selective patch while the monkeys were performing a fine color judgment task. We tested the effects of microstimulation on color judgments along both hue and saturation directions. In some sites, when microstimulation was applied during sample color presentation, color judgement was significantly biased and this resulted in horizontal shift of psychometric function. The effects were mainly observed in a restricted area

that coincides with the distribution of color selective neurons. Direction of the perceptual bias in the color space was dominated along blue-yellow axis. Surprisingly, direction of the bias was opposite to the color preference of the neuron activity at the stimulated site. Possible explanation on the perceptual bias resulting from microstimulation will be discussed.

(P-23) Effects of stimulus size on spatial frequency tuning of face-responsive neurons in the temporal visual cortex and the amygdale

Mikio Inagaki, Ichiro Fujita (Lab Cogn Neurosci, Grad Sch Frontier Biosciences, Osaka Univ, Osaka, Japan)

Psychophysical performance of face discrimination in human subjects depends on spatial frequencies (SFs) of face images. Changes in image size, which accompany changes in retina-based SFs (cycles/deg), only minimally influence face discrimination performance. Face discrimination depends more on relative SFs normalized by image size or image-based SFs (cycles/image). We reasoned therefore that if neurons in a brain area contribute to face discrimination, they should be tuned to image-based SFs rather than

retina-based SFs. Here, we examined whether face-responsive neurons in the temporal visual cortex and the amygdala of monkeys are tuned to image-based SFs or retina-based SFs by assessing effects of image size on SF tuning. Most neurons in the temporal cortex and only a few neurons in the amygdala were tuned to image-based SFs, demonstrating a difference in face representations between the two areas. Properties of temporal cortex neurons are more consistent with face discrimination abilities than are those of amygdala neurons.

(P-24) Spatial resolution of direction discrimination: comparison of MT neurons and behavior

Hironori Kumano, Takanori Uka (Department of Physiology¹, Juntendo University, Tokyo, Japan)

Observers have difficulty in identifying a target in the presence of surrounding distracters. To understand the neuronal mechanisms underlying this phenomenon, known as ‘crowding’, we recorded activities of single MT neurons from a monkey performing direction discrimination in a bipartite center/surround motion display. The monkey was required to discriminate direction of the center patch of moving random dots, of which parameters were tailored to selectivity of the neuron under study, and to ignore the surrounding noise of varying diameter. Psychophysical threshold first increased

then decreased as the noise diameter increased, suggesting an improvement of spatial resolution of direction discrimination at the large noise condition (‘anti-crowding’). Neuronal threshold of MT neurons also first increased then decreased with increasing surround size. The increased sensitivity with a large surround is due to increased differences of mean responses, not reduced variability. The results suggest that changes of sensitivities in MT neurons underlie the changes of sensitivities observed psychophysically.

(P-25) The effect of temporal discrepancy between visual and tactile stimulations
on rubber hand illusion

Sotaro Shimada (Meiji University)

Rubber hand illusion (RHI), which is an illusion of the self-ownership of a rubber hand, occurs when the rubber hand was touched synchronously with the subject's hand. However, the minimum temporal discrepancy of these two events for attenuation of RHI has not been examined. In this study, various temporal discrepancies between visual and tactile stimulations were introduced by using a visual feedback delay

experimental setup, and RHI effects in each temporal discrepancy condition were systematically tested. The results showed that subjects felt significantly greater RHI effects with temporal discrepancies of less than 300 ms compared with longer temporal discrepancies. We suggest that the time window of less than 300 ms is critical for multi-sensory integration processes constituting the self-body image.

(P-26) Other's body representation referred to self body in the parietal cortex of the monkey

Akira Murata, *Hiroaki Ishida, Kastumi Nakajima, Masahiko Inase
(Department of Physiology, Kinki University, School of Medicine,

*Dipartimento di Neuroscienze Sezione di Fisiologia Università di Parma)

Neurons in the parietal and premotor cortices of the monkey show visuo-tactile bimodal properties that may contribute to mapping of one's own body parts. Furthermore, as revealed by mirror neurons, the brain represents others' action in the motor control system. We expected that a population of visuo-tactile neurons in the parietal cortex would concern to mapping other's body parts onto one's own body representation. In the current experiment, we recorded visuo-tactile bimodal neurons from area VIP and 7b while the

monkey was observing visual or tactile stimuli on other's body that. Some bimodal neurons of those receptive fields anchored on the monkey's body showed visual response on the corresponding body parts of other within approximately 30cm from the body surface. These results were the first evidences of sensory mirror neuron. We suggest the existence of self-other body parts matching system in the parietal bimodal area, in which self body image is available as reference for perception of others' body parts.

(P-27) Smooth pursuit eye movements affect motion correspondence

Masahiko Terao^{1,2}, Masaharu Kato^{2,3}, Ikuya Murakami¹, Shin'ya Nishida¹

(¹Department of Life Science, The University of Tokyo,

²NTT Communication Science laboratories, NTT Corporation,

³Center for Baby Science, Doshisha University)

When multiple elements are included in successive images of apparent motion, the visual system should solve a motion correspondence problem. An important determinant of correspondence matching is proximity. It has been believed

that proximity is defined with respect to retinal coordinates. Here, we report not only the retinal proximity but also the proximity in the environmental coordinates also affects motion correspondence during smooth pursuits. Our finding

suggests that pursuit eye movements affect motion correspondence, a processing stage much earlier than the integration of retinal velocity with extra retinal signals.

Motion correspondence based on environmental coordinates may be a novel mechanism for visual world stabilization despite retinal image motions during eye movements.

(P-28) Disparity computations and temporal frequency channels in stereopsis

Takahiro Doi, Maki Takano, Keiko Abe, Ichiro Fujita

(Lab for Cognitive Neuroscience, Grad Sch of Frontier Biosciences, Osaka Univ.)

The primate visual cortex encodes binocular disparity by using interocular cross-correlation (correlation computation) and by detecting matched patterns in the two eyes (matching computation). We hypothesized that the two computations differently contribute to stereopsis between slowly and rapidly changing images. For rapidly changing random-dot patterns, subjects' performance in a depth discrimination task was consistent with interocular correlation; the performance was below chance (less than 50%) with binocularly opposite-contrast stereograms, and became equivalent to chance when half of the dots were contrast-matched. When the pattern refresh rate was

decreased, the performance became dependent on binocular match; the performance was chance for opposite-contrast stereograms, and improved with the proportion of contrast-matched dots. The data were explained by a model in which band-pass and low-pass temporal frequency channels feed inputs to the correlation and the matching computations, respectively. We suggest that stereopsis differently recruits the correlation and the matching computations according to the refresh rate of monocular images. The different means of recruitment by the two computations is explained by a specific relationship between disparity computations and temporal frequency channels.

(P-29) With which word can people tell threat in faces more accurately, dangerous or trustworthy?

Miyahara, M.^{1,2}, Harada, T.^{1,3}, Ruffman, T.², Sadato, N., Iidaka, T.³

(¹National Institute of Physiological Sciences, Japan,

²University of Otago, New Zealand, ³Nagoya University, Japan)

The degree of threat in faces was asked in term of how dangerous or trustworthy they were. A total of 107 university undergraduate students (51 females, 56 males), with a mean age of 20.57 ± 1.26 years, rated dangerousness or trustworthiness of 60 faces (30 murders, 30 controls) on a 4

point Likert scale. The result indicated that people distinguished murders from controls more accurately when they rated dangerousness of the faces. This study revealed that conscious awareness of threat in faces differed as a function of word to which people pay attention while rating faces.

(P-30) Autonomic responses to learning of visual search

Tatsuto Takeuchi, Théodore Puntous (NTT Communication Science Laboratories)

Perceptual learning refers to the improvement of perceptual

sensitivity and performance with training. In this study, we

examined whether a learning process is accompanied by a release from the dependence of performance on mental effort, leading to an automatization of the task. For the purpose, subjects conducted a visual search task in which the target was defined by orientation while two autonomic response measures, pupil size and skin conductance level (SCL), were monitored. We found that both pupil size and SCL gradually

increased as the learning proceeds. Positive correlation between SCL and behavioral performance was found at the last phase of learning. This result does not support the simple automatization hypothesis, and suggests that the activation of the sympathetic nerve system is enhanced to effectively distribute attentional resources.

(P-31) Subjective color induced by unperceivable surrounding color

Haruaki Fukuda (Department of General System Studies, the University of Tokyo)

We found a subjective color illusion induced by a rotating disk; when the white disk that has a colored sector and a black arc just in the sector rotates, the ring traced-out by the black arc appears colored. We carried out color matching tasks changing the sector color. The results showed that subjective color induced in the ring was the complementary color of the sector color. We also investigated at what speed of rotation subjective color was induced. We found that subjective color was induced when the rotating speed was so rapid that the sector color was mixed with the white background. In addition, we rotated the disk that has three sectors with different color and three arcs located at different radial distances just in each sector. Three different complementary

colors of each sector to which each arc belongs could be also observed in three concentric rings, although the each sector color was consciously unperceivable. Next, we made a particular disk by Land's two color projections. The perceived colors of sectors in this disk were not related to the wavelengths of light. Using this disk, we investigated whether the subjective color in the induced color depended upon the wavelength of light coming from sector or upon perceived color of sector. Result showed that the subjective colors were not the complementary colors of the colors corresponding to their wavelengths but that of the perceived colors. This suggests that our conscious color perception is independent of whether our visual system could process the stimuli.

(P-32) Which process is dominant for the decision-making in the gambling task, unconscious or conscious feedback evaluation?

Jun Uchida¹, Hideyuki Takahashi², Hiroyuki Okada¹

(¹Faculty of Engineering, Tamagawa University, ²Brain Science Institute, Tamagawa University)

It is important for us to switch a choice of action depending on various situations. This change of selection was thought to be processed by the combination of conscious and unconscious processes. From previous studies, it is known that individuals were more likely to switch their choices following negative feedback (i.e. lose feedback) in a gambling task. Error-related negativity (ERN), a negative event related potential, is elicited by the negative feedback. However, it has

not yet been known that whether the influence of ERN to the decision-making was caused by consciousness process or not. In this research, the manner of how ERN affected decision-making in the gambling task when ERN occurred at the "win" outcome was examined. Subjects were presented with "win" feedback immediately after momentary "lose" feedback. This result was compared with the data of simple "win" or "lose" condition. The probability of action switching

under the “fake lose” condition was approximately same level with the “win” condition, and both were less than that of the “lose” condition. This result showed that ERN didn’t affect directly the following decision-making, and the processes

after ERN caused the switch of the action choice. It suggested that action choices were affected by following conscious processes more strongly than earlier unconscious processes.

(P-33) State-dependent cortical synchronization networks in humans revealed by TMS-EEG recordings

Keiichi Kitajo¹, Ryohei Miyota¹, Masanori Shimono², Kentaro Yamanaka^{1,3}, Yoko Yamaguchi¹

(¹Laboratory for Dynamics of Emergent Intelligence, RIKEN Brain Science Institute,

²Neuroscience Research Institute, Advanced Industrial Science and Technology (AIST),

³Department of Health Design, Showa Women’s University)

Transcranial magnetic stimulation (TMS) can noninvasively modulate cortical ongoing activity in the human brain. We investigated frequency-specific and state-dependent cortical networks by analyzing how modulation of cortical ongoing activity at one cortical area (motor cortex or visual cortex) is propagated to the rest of the brain by TMS-EEG recordings in humans. We found state-dependent changes in propagation of TMS-evoked phase

resetting of cortical ongoing activity at some frequency ranges in the open eye condition and closed eye condition. We discussed the functional significance of state-dependent synchronization networks. Our study suggests that TMS-EEG measurement is a good tool for investigating dynamical cortical synchronization networks associated with human perception and cognition.

(P-34) The neural substrate of audio-tactile frequency discrimination in human: a functional MRI study

Masamichi J. Hayashi^{1,2}, Hiroki C. Tanabe^{1,2}, Norihiro Sadato^{1,2,3,4}

(¹NIPS, Okazaki, JAPAN, ²The Graduate University for Advanced Studies, Okazaki, JAPAN,

³JST, Kawaguchi, JAPAN, ⁴University of Fukui, Fukui, JAPAN)

Some sensory attributes such as color, pitch or temperature can be accessed exclusively by vision, audition and touch, respectively. On the other hand, temporal frequency is an attribute which is accessible across different sensory modalities. According to previous psychological experiments, flutter stimuli, defined as the number of repetitions of tactile pulses or sound waveforms range of 4-40 Hz, are comparable within tactile / auditory and even across sensory modalities. Previous physiological studies have investigated the neural mechanism of frequency comparison within sensory modality. However, the crossmodal aspect is unknown. Here, we

conducted an fMRI study to investigate whether the crossmodal (auditory-tactile) frequency comparison task causes shared / distinct neural activation in contrast with that of unimodal (tactile-tactile) one. Our results showed that the encoding of stimulus involved dedicated timing system, including pre-SMA, left IFG and right cerebellum, independent of stimulus modality. In the comparison process, right front-parietal network, basal ganglia, thalamus, left IPL and left cerebellum were commonly activated. These results indicated that temporal frequency is dealt as a modality-independent “general attribute” which does not

require any additional interpretation processes. This supramodal nature may be supported by the similarity of

neural codes between tactile and acoustic flutter.

(P-35) Spatial working memory after V1 lesion

Kana Takaura, Masatoshi Yoshida, Tadashi Isa

(Department of Developmental Physiology, National Institute for Physiological Sciences, Japan)

Blindsight is a phenomenon in which patients with damages to the primary visual cortex (V1) exhibit residual ability of visuomotor transformation without visual awareness. Visual awareness has been proposed to be tightly linked to working memory. Previously we reported that monkeys with unilateral V1 lesion, which have been used as an animal model of the blindsight, can retain spatial memory of cues briefly presented for at least 2 seconds. To investigate neural mechanisms for spatial memory in the visual field affected by lesion, we recorded neuronal activities in the

superior colliculus (SC). We found that most of the neurons in the ipsilesional SC exhibited sustained activities throughout the delay period when cues were presented inside the receptive fields. In naive brain, such kind of activity has been reported in the cerebral cortex. Our results are challenging to the currently prevailing hypothesis about the relationship between visual awareness and working memory, and indicate that the SC could compensate for some functional roles of the cerebral cortices after cerebral damages.

(P-36) Estimation of the time course of attentional “disengagement” and “reengagement” with steady-state visual evoked potential

Yoshiyuki Kashiwase¹, Kazumichi Matsumiya^{1,2}, Ichiro Kuriki^{1,2}, Satoshi Shioiri^{1,2}

(¹Graduate School of Information Sciences, Tohoku University,

²Research Institute of Electrical Communication, Tohoku University)

It has been assumed that there are three serial processes involved in an attentional shift: “disengagement” from the previous location, “movement”, and “reengagement” on a new location. We attempted to estimate the latencies of “disengagement” and “reengagement” of attention from steady-state visual evoked potential (SSVEP) as an index of the attentional focus. In this study, we recorded SSVEPs for two stimuli flickered at different frequencies which were presented on the left or right of the center of the display. Subjects were, after attending to the either stimulus, instructed (1) to stay their attentional focus on the same location, or (2) to shift attention toward the other stimulus. We estimated the latency of “disengagement” from the difference in the time

course of SSVEP modulation between the condition where attention is kept on the stimulus throughout the trial and the condition where attention is shifted away at a certain time during the trial. We also estimated the latency of “reengagement” from the difference in the time course between the condition where attention is directed toward the stimulus from elsewhere at a certain time and the condition where attention is never directed throughout the trial. Results show that the latency for starting “reengagement” is shorter than that for starting “disengagement”, suggesting that processes related to the attentional shift are executed in parallel in the human brain.

(P-37) Conscious awareness of inducing stimulus is necessary for synesthetic color perception

Chai-Youn Kim, Suhkyung Kim (Department of Psychology, Korea University)

【Background】 People with color-graphemic synesthesia experience vivid colors when viewing achromatic alphanumeric characters. The question of whether an inducing character should be consciously perceived for synesthetes to experience synesthetic color has been examined extensively, but experimental results to date have been providing a mixed picture (Mattingley et al., 2001; Ramachandran & Hubbard, 2001; Rich & Mattingley 2005; Smilek et al., 2005; Wagar et al., 2002). We performed a couple of experiments to investigate the role of conscious visual awareness in synesthetic color experiences.

【Experiment 1】 We manipulated the visibility of a character by exploiting a psychophysical technique called continuous flash suppression (CFS, Tsuchiya & Koch, 2005). A full contrast dynamic CFS display was used to suppress a target character (actually colored non-inducing character or achromatic inducing letter) presented to the other eye for a few seconds. Observers performed two kinds of 2-AFC tasks; on some trials, observers were asked which color they saw and on other trials, they were asked which character they saw. Synesthetes' performance on both color & character was near perfect when the color was real but was at chance when the color was synesthetic. This result suggests that the letter was

not able to induce synesthetic color when that letter was presented outside of awareness.

【Experiment 2】 We further examined whether conscious recognition of an inducing character should precede synesthetic color perception by utilizing pairs of alphanumeric characters of which forms look ambiguous when rotated (e.g., W/M or 6/9). On each trial, an achromatic target character in one of 12 different angles (30, 60, 90, 120, 150 degrees clockwise or counter-clockwise, in addition to 0, and 180 degrees) was presented briefly (100msec), which was followed by a pattern mask. Observers performed two kinds of 2-AFC tasks; on some trials, observers were asked which color they saw and on other trials, they were asked which character they saw. Synesthetes' RT performance showed that it took longer time for them to judge color than to judge character, as the ambiguity of the character increased. This result suggests that additional processing time is required for synesthetic color experience after an inducing character is recognized.

【Conclusion】 Results from Experiment 1 & 2 indicate the necessity of conscious awareness of inducing stimulus for synesthetic color experiences.

(P-38) Temporal dynamics in representation of visual saliency in the macaque posterior parietal cortex

Tomohiro Tanaka, Atsushi Fujimoto, Tadashi Ogawa (Graduate School of Medicine, Kyoto University)

A salient stimulus (for example, a red target among green distractors) can automatically attract our attention. To examine neural representation of visual saliency, we trained monkeys to perform a visual search task in which a singleton target was different from distractors in color. We manipulated the degree of visual saliency of the target by independently changing 'target-distractor color contrast' and 'stimulus-background luminance contrast'. For the estimation of the

degree of visual saliency, we measured saccade latency. Both contrasts can modulate saccade latency (when one of the contrasts larger, saccade latency became shorter). We found that these two contrasts differentially modulated neuronal activity in the posterior parietal cortex (PPC). Target-distractor color contrast modulated the late-period (about 120 ms- after array presentation) activity, whereas stimulus-background luminance contrast modulated the

early-period (50-100 ms after array presentation) activity. Thus, these results suggest that the degree of visual saliency derived from the different types of stimulus contrast is

represented with different temporal dynamics in the activity of PPC neurons.

(P-39) On phenomenal concepts: from a functional point of view

Yasuko Kitano (Hosei University)

Many philosophers think that humans (and higher animals) use phenomenal (recognition) concepts of color, taste, sound, hunger, pain, desires, emotions, etc. (Loar 1990/1997; Carruthers 2004; Balog 2006; Papineau 2006), which are often thought as neural models of the properties of objects and

the internal states. However, Jesse Prinz (2007), whose focus is on the project of empirically informed theory of phenomenal knowledge, claims that there is no such thing as phenomenal concept. I present a functional approach that makes it possible to reconcile these two views.

(P-40) Squirrel monkey (*Saimiri sciureus*) can perceive Thatcher Illusion

Ryuzaburo Nakata*, Yoshihisa Osada**,***

(*Toyama University, **Rikkyo University, ***Rikkyo Amusement Research Centre)

We examined whether the squirrel monkey can perceive Thompson's Thatcher illusion. Thatcher illusion is a phenomenon where it becomes difficult to detect changes of local features in an inverted face, despite changes being obvious in an upright face (Thompson, 1980). This illusion is thought to be due to the face configural processing. In the experiment, the monkey was required to discriminate a target face from three kinds of distractor stimuli whose particular facial features were different from those of the target. Because

both faces were tilted at angles of either 45, 135, 225, or 315 degrees, there were four combinations of upright and inverted face presentations. The results revealed that when both faces were inverted and the eyes of the distractor face were reversed from the target face, the monkey's discrimination learning was obstructed more than under other conditions. Thus, these results suggest that the squirrel monkey can perceive the Thatcher illusion. It seems reasonable to suppose that the monkey can utilize information about facial configuration.