Gaze
Bias
Learning II

Linking neuroscience, computational modeling, and cognitive development

Tokyo, Japan

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Tamagawa University
Research & Management Building
Meeting room 507

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Workshop schedule

10:00	Organizer's introduction - Rachel Wu
10:05	Masamichi Sakagami
10:40	Jan Lauwereyns
11:15	*Break*
11:30	Shinsuke Shimojo
12:05	*Lunch*
13:30	Rachel Wu
14:05	Shohei Hidaka
14:40	*Break*
14:55	Hideyuki Takahashi
15:30	Takashi Omori
16:05	Discussion
16:45	Closing
18:00	*Dinner*

Masamichi Sakagami

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Multiple neural circuits in value-based decision-making

Valuation is an essential process and function in decision-making. The variety and organization of such valuation systems characterize the decision-making of animals. To understand the nature of the distinct neural systems used in such valuation, we performed monkey single-unit recording experiments together with a human fMRI experiment using (1) a perceptual discrimination task with asymmetric reward, and (2) a reward inference task. The results suggest that both the primate and human brain have, at least, two distinct valuation systems: one in the nigro-striatal circuit (here, referred to as the “stimulus-based valuation system”) and the other in the PFC circuit (here, referred to as the “knowledge-based valuation system”). We believe that the nigro-striatal circuit calculates values based on the empirical and probabilistic relation between an event and its outcome. The PFC circuit, on the other hand, generates values by further extension of directly-experienced association through categorical processes and rules, thereby enabling animals to predict the outcome of an inexperienced event. Also we will discuss how the distinct decision systems may modulate the process for gaze control.

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Jan Lauwereyns

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Eye movements and the intrinsic attraction of information

Eye movements are a type of observer behavior intrinsically devoted to the acquisition of real-world information. Yet, our eye movements perform the task of information gathering in a decidedly biased fashion: not random, not systematic or machine-like, but chaotic, exhibiting a form of "bounded unpredictability." Here, the concept of informativeness will be introduced as a key player in the attractor dynamics of perception. The brain is organized in such a way as to facilitate pervasive interaction between various polarities in perception, including center and surround, figure and ground, object and context, fovea and parafovea, and ventral and dorsal processing. The polarities entail components of bias and sensitivity that determine the effort, speed, and accuracy of information processing. The biases and sensitivities determine the economy of perception in the critical currency of information value, implying different levels of priority for different types of information. Value-rich information, here, may be considered as an intrinsic attractor; that is, curiosity and exploration would be oriented to such information as a goal in itself. In line with this view, I will present a series of five studies that chart the active boundaries of semantic influences on overt and covert attention. In all of these cases, we can trace the intrinsic attraction of certain types of information that are irrelevant to the task at hand. The data call for a unifying framework that connects the concept of informativeness and its intrinsic attraction to formal models of the observer's knowledge of "things as they are."

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Gaze and Visual Preference/Attractiveness

I will summarize our latest findings on the relationship between gaze and visual preference/attractiveness. First, a gaze bias precedes conscious decision of preference choice in the two-alternative, forced-choice task (the "gaze cascade effect"). Second, by manipulating people's gaze, we can bias their preference decisions. The manipulation effect is not solely due to the "mere exposure effect", thus taken as evidence for spontaneous gaze as an implicit, somatic precursor of conscious preference. Third, memory-related factors, such as familiarity and novelty, affects both initial gaze selection as well as the final preference choice. However, familiarity and novelty have different roles across object categories: with repeated experiences, familiar faces, but novel natural scenes, acquire more attractiveness. Fourth, attractiveness of unattended(, either overtly or covertly,) objects nonetheless affect that of the attended object (the "Attractiveness Is Leaky" effect). Fifth, people have a strong tendency to gaze at the eyes in a face, even when prohibited to look at them. However, this tendency (i.e. an unavoidable tendency to look at the eyes) is negatively correlated with AQ (Autism Quotient) even among the neurotypical population. That is, people with an autistic tendency have no problem following the instruction (not to look at the eyes). Functional dynamics and neural mechanisms underlying these phenomena will be discussed.

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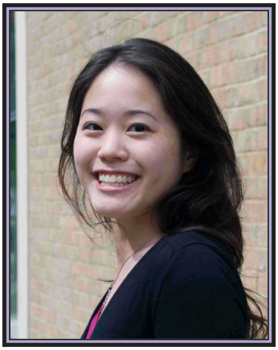

Visual Search for the Familiar and Novel:
ERP correlates of matching items and matching categories

A hallmark of visual search tasks is top-down attentional selection: in order to search for a target you must have a template that specifies the goal of the search process. In the natural environment, however, visual search is often under-specified. For example, rather than looking for a particular item (e.g., a specific key), the goal may be to find a category (e.g., a price tag). Little is known about how search for one object and many related objects differ, and how observers learn what to look for. The present ERP study investigated how known or newly learned perceptual categories affect spatially selective processing in perception (N2pc component) and working memory (SPCN component). Adult participants had to select targets among distracters in a familiar (digits and letters) and a novel context (Chinese characters – numbers and non-numbers). The main findings are that search guided by physical features is more efficient than that by category membership, and that search guided by category templates affect early stages of attentional selectivity, which contradicts current theories of attentional template capacity. Moreover, search for familiar and novel objects and categories follow similar patterns. Our study provides new insights into the dynamics of top-down attentional selection guided by physically or categorically defined attentional templates, and into the acquisition of new perceptual categories.

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Shohei Hidaka

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Characterizing Attention and Learning from Infant Eye Movements

The study of cognitive development hinges, largely, on the analysis of infant looking. But analyses of eye gaze data require the adoption of linking hypotheses: assumptions about the relationship between observed eye movements and underlying cognitive processes. We develop a general framework for constructing, testing, and comparing these hypotheses and thus to produce new insights into early cognitive development. We first introduce the general framework applicable to any infant gaze experiment and then demonstrate its utility by analyzing data from three studies (Wu & Kirkham, 2010) investigating the role of attentional cues in infant learning. Finally, we discuss general implications for construction and testing of quantitative linking hypotheses.

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Hideyuki Takahashi

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The estimation of the sense of agency in infancy from eye movement

We can manipulate an external object which separated from own body, such as a mouse courser, with a sense of manipulating the object as if it is a part of own body. This kind of senses is often called “sense of agency” (SoA). There are a number of studies that try to reveal the computation and neural correlates of the SoA in adults. However there are few tasks that enable to measure the SoA in young infants because of infant’s unstable body movement.
To measure the SoA in young infants, we developed “Eye scratch task” that enables to measure the SoA in young infants. Eye scratch task is a task using a display integrated eye tracker. In the beginning of each trial, participants were presented with a picture fully covered with a black layer. Participants can scratch a part of the black layer where they look by own eye movement and the corresponding area of the picture appears. In this task, we defined the SoA as the state which a participant can be aware of the contingency between change of stimuli and their own eye movement. To control difficulty of contingency detection, we controlled the presence of cursor. In the with gaze point (WGP) condition, a red cursor was continuously presented on the display where participants looked. In the no gaze point (NGP) condition, the cursor was not presented. Our results suggest 8-month-olds can feel the SoA in the scratching of the black layer especially in the WGP condition.

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Computational modeling of gaze direction decision while driving

Driving is a well known behavior with well defined purpose of eye movement, the safety assurance. When we drive a car, we observe environment to detect possible hazard and to decide action for a safer car moving trajectory. So when we observe the gaze direction of a driver, we can somewhat estimate how the driver is perceiving the environment and is planning to do next. Then, the construction of driving behavior model is an important step for realizing a model based prediction of driver's behavior in real driving situation. For the purpose, we constructed a computational model of hazard perception while driving assuming a hazard as a possibility of contact with other objects. We formalized two types of hazard, an explicit hazard and an implicit hazard based on the position probability distribution of object. The eye moves toward an object that caused the hazard perception to acquire mode precise information of the object and to reduce ambiguity the spread of the probability distribution. By comparing the model behavior and the reconstructed eye movement by the model, we evaluated the model in a computational way.

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