DIVISION OF NEUROPHYSIOLOGY

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In order to interact successfully with the environment, animals must deduce their surroundings based on sensory information. The visual system plays a particularly critical role in such interactions with the environment.

"Why can we see?" This question is fundamental for a thorough understanding of vision-dependent animals, including human beings. In order to better understand the sensory systems of animals, we moved ahead to research of the visual system, though we had previously been researching the salt-sensing system.

I. Psychobiological study of Medaka fish

One of our major subjects is the psychobiological study of medaka (*Oryzias latipes*). Medaka, as well as zebrafish, have many advantages for behavioral work. First, genetic examination of medaka is progressing at a rapid pace, like that of the mouse, opening up new approaches to the understanding of genetic control of behavior. Second, although the central nervous system of medaka is relatively simple, its basic structure is the same as that in mammals; it is composed of the spinal cord, brainstem, cerebellum, and cerebrum. Thirdly, because they are fish, they provide invaluable comparative material for work on mammals. Examination of such a relatively simple yet vertebrate system should thus aid in the determination of the basic mechanisms of how genes affect behavior.

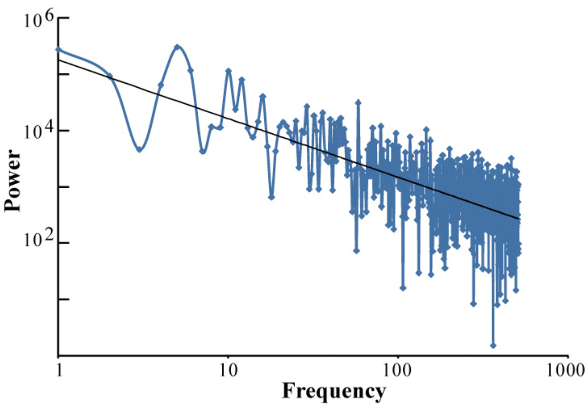

Figure 1. Typical pink noise. Pink noise or 1/f noise is a signal or process with a frequency spectrum such that the power spectral density is inversely proportional to the frequency.

This year, we examined a prey-predator interaction using medaka and the water flea (*Daphnia Magna*), and found that medaka was attracted to pink-noise motion (Figure 1) created by the water flea. These results suggest that the medaka brain includes a mathematical model of the water flea.

II. Psychophysical study of Human vision

Another of our major subjects is the psychophysical study of the visual system of human beings (*Homo sapiens*).

In order to interact successfully with the environment, animals must know the accurate positions of objects in space, though those positions frequently change. Neural processing, however, requires considerable time. By the time a conclusion is reached about location, the moving object has moved on to a new position in the actual world. Does our visual system compensate for this difference?

One recent focus of this debate is the flash-lag effect, in which a moving object is perceived to lead a flashed object when both objects are aligned in actual physical space. The discoverer of this phenomenon, Dr. Nijhawan, has proposed that the human visual system uses motion signals to extrapolate the position of a moving object. The differential latencies hypothesis proposes that the flash-lag effect occurs simply because the visual system responds with a shorter latency to moving objects than to flash stimuli. Besides these two major models, various modified models have been proposed. The problem, however, has not yet been solved, and the debate continues. How does our brain decide the position of a moving object? This year, we proposed a simple conceptual model explaining the flash-lag effect (Delta model, Figure 2; Watanabe *et al*., 2010).

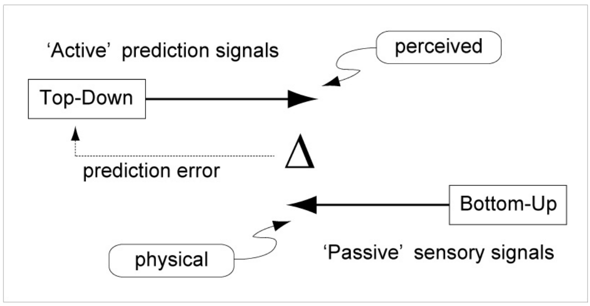

Figure 2. Delta model. Two types of signals (top-down and bottom-up) are assumed in this model. Top-down signals are hypothesized to be derived from a higher level of the visual system and represent the predictive visual information. Bottom-up signals are hypothesized to be derived from a lower level of the visual system and represent the original sensory information. Subtraction occurs between the two signals; the resultant prediction error (Δ) is input to a higher level of the visual system that operates the top-down signal to minimize the prediction error.

Publication List

〔Original papers〕

● Hiyama, T.Y., Matsuda, S., Fujikawa, A., Matsumoto, M., Watanabe, E., Kajiwara, H., Niimura, F., and Noda, M. (2010). Autoimmunity to the sodium-level sensor in the brain causes essential hypernatremia. Neuron *66*, 508-522.

● Matsunaga, W., and Watanabe, E. (2010). Habituation of medaka (*Oryzias latipes*) demonstrated by open-field testing. Behav. Processes *85*, 142-150.

● Watanabe, E., Matsunaga, W., and Kitaoka, A. (2010). Motion signals deflect relative positions of moving objects. Vision Res. *50*, 2381-2390.