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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 visual system of animals, we are researching animal behaviors through psychophysical and computational methods.

I. Psychophysical study of Medaka fish

One of our major subjects is the psychophysical and computational study of medaka (*Oryzias latipes*). Recently, we made progress in studies of prey-predator interaction using medaka and zooplankton. Visual motion cues are one of the most important factors for eliciting animal behavior, including predator-prey interactions in aquatic environments. To understand the elements of motion that cause such selective predation behavior, we used a virtual plankton system where the predation behavior in response to computer-generated prey was analyzed. Virtual prey models were programmed on a computer and presented to medaka, which served as predatory fish. Medaka exhibited predation behavior against several characteristic virtual plankton movements, particularly against a swimming pattern that could be characterized as pink noise motion. Analyzing prey-predator interactions via pink noise motion will be an interesting research field in the future (Matsunaga & Watanabe, 2012).

In recent years, we have made progress in studies of the schooling behaviors of medaka. Many fish species are known to live in groups. Visual cues have been shown to play a crucial role in the formation of shoals. Using biological motion stimuli, depicting a moving creature by means of just a few isolated points, we examined whether physical motion information is involved in the induction of shoaling behavior. We found that the presentation of virtual biological motion can prominently induce shoaling behavior. We have shown what aspects of this motion are critical in the induction of shoaling behavior. Motion and behavioral characteristics can be valuable in recognizing animal species, sex, and group members. Studies using biological motion stimuli will enhance our understanding of how non-human animals extract and process information which is vital for their survival (Nakayasu & Watanabe, 2014).

We have developed a novel method for behavior analysis using 3D computer graphics. The fine control of various features of living fish have been difficult to achieve in studies of fish behavior. However, computer graphics allow us to manipulate morphological and motion cues systematically. Therefore, we have constructed 3D computer graphic

animations of medaka based on tracking coordinate data and photo data obtained from real medaka. These virtual 3D models will allow us to represent medaka faithfully and to undertake a more detailed analysis of the properties of the visual stimuli that are critical for the induction of various behaviors. This year, we began studying artificial intelligence (AI) programmed virtual 3D models (Figure 1). The AI models will lead us in future work on animal behaviors.

Simultaneously, we began studying “behavioral lateralization” as a characteristic which can affect the formation of shoals. Like humans, fishes have lateral differences in their movement and perception. However, there have been few studies to examine the influence of behavioral lateralization on their interaction. If each individual has a laterally biased response to surrounding companions or predators, how is the united movement as shoals realized? This study is expected to bring a new viewpoint for understanding the structure and behavior of schooling.



Figure 1. Unsupervised learning of video representations using a deep learning method (LSTMs). The AI predicts fish position at time 1 in reference to fish position at time 0.

II. Psychophysical study of Human vision

Another of our major subjects is the psychophysical and theoretical studies of the visual illusions experienced by human beings (*Homo sapiens*). 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. We developed a simple conceptual model explaining the flash-lag effect. In recent years, we have made more developed novel visual illusions, such as the shelf-shadow illusion .

Publication List:

[Original papers]

- Hoshino, A., et al. (2016). Genome sequence and analysis of the Japanese morning glory *Ipomoea nil*. *Nat. Commun.* 7, 13295.
- Yasugi, M., and Hori, M. (2016). Predominance of parallel- and cross-predation in anglerfish. *Marine Ecol.* 37, 576-587.