Title	ランダム点平行運動の順応による運動知覚の変化
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Abstract

The motion illusion is a phenomenon in which a physically stationary object is seen as moving. A typical and widely known type of motion illusion is motion after-effect. The traditional definition of Motion After-Effect (MAE) is that, after prolonged observation of a stimulus moving in one direction, a stationary object appears to move in the opposite direction. The duration of the MAE is the most crucial measure in MAE experiments.

The aim of this study is to construct a computational model that predicts the relationship between the speed of the adaptation motion stimulus and the duration of the MAE (the Speed Property of MAE) and to explain the findings of psychophysical experiments on MAE in computational terms.

In this study, a video of random point parallel motion stimulus was used as stimuli in a psychophysical experiment to investigate the Speed Property of MAE. The perception of motion in random point parallel motion is thought to occur in the middle temporal visual area. This study investigated the Speed Property of the MAE using random point parallel motion as the visual stimulus and showed that the duration of MAEs tends to shorten as the speed of the adaptive motion stimulus increases.

Neurons that observe long-duration motion are less likely to fire and perceive salient motion in the opposite direction. According to the ratio theory, paired direction-sensitive neurons jointly respond to the perceptual process of motion. No motion is perceived when the two paired neurons are equally active (equilibrium). When a more robust activation of one neuron unbalances the two neuronal activities, motion is perceived. The activation of that neuron causes adaptation, meaning that the response is weakened. After the motion has disappeared, the active neuron will send fewer signals than its paired neuron.

Pavan's modelling studies illustrated the principles of ratio theory and its concrete realisation. The kinetic energy model is a theoretical model that explains how the visual system perceives the direction of motion and is one of the concrete realisations of the ratio theory.

To investigate whether existing research (Pavan-model) can explain the Speed Property of MAE, Numerical Experiment 1 was conducted. The aim of Numerical Experiment 1 was to examine whether the duration of MAE predicted by the Pavan-model correlated with the speed of the adaptation motion stimulus. The random point motion video stimuli used in each computational experiment were randomly generated, and the predicted MAE durations varied with the same combination of parameters, but it was found that the predicted MAE durations produced by the adaptive motion stimuli at different speeds were almost identi-

cal. In other words, the MAE durations predicted by the Pavan-model did not correlate with the speed of the adaptive-motor stimulus.

Whole-response theory offers a new explanation for direct perception and speed perception. The authors assume that a computational model based on the whole-response theory could explain the relationship between the speed of the adaptation motion stimulus and the MAE duration. In this study, the Speed Property of MAE was mathematically formulated by constructing a computational model, which is called the 'Observer Model'. In addition, the 'Observer Model' simulated the effects of three different types of neural changes on the response of the simulated neurons, looking for potentially relevant neural adaptation patterns in the relationship between the speed of the adaptation motion stimulus and the duration of the MAE.

The physical speed and physical direction of the simulated motion stimulus were set as inputs to the 'Observer Model'. The absolute value of the variable used as input represents the physical speed of the simulated motion stimulus, and the positive or negative value of the variable represents the physical direction of the simulated motion stimulus. If the variable given as input is a positive number, the physical direction of the simulated motion stimulus is horizontal right. If the variable given as input is a negative number, the physical direction of the simulated motion stimulus is the horizontal left. This simplification makes it possible to represent physical velocity and physical direction simultaneously.

The outputs of the 'Observer Model' are the perceived speed and perceived direction of the model. The absolute values of the explanatory variables as outputs represent the perceived speed of the model and positive and negative values represent the perceived direction of the model. Positive and negative values indicate whether the perceived direction of the model is horizontally right or horizontally left.Similarly, the explanatory variable as output is called the 'perceived speed of the model'. The responses of the simulated neurons using the 'Observer Model' and their preference speeds are used to calculate the overall response. The response of each simulated neuron is a function of its preferred speed and the 'speed of the simulated motion stimulus'. The overall response is a weighted average of the responses of all the simulated neurons, with the preferred speed of the simulated neuron as a weight.

The validity of the 'Observer Model' was explored by analyzing the goodness of fit of its predictions to the results of psychophysical experiments. In addition, neural adaptation patterns that may be related to the Speed Property of MAE were explored. As a result, it was found that the 'Observer Model' based on the whole-response theory can explain the occurrence of MAE. It was also found that neural adaptation, which decreases the intensity of neuronal responses, can explain