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Roll of Rhythmic Component in Proactive Control of Human Hand

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Abstract

Evolutionally, the strategy of catching prey should have been important to survive in constantly changing environment. Prediction mechanism should have developed to compensate the delay of sensory-motor system. In previous study, "proactive control" was found, in which motion of hands preceded the virtual moving target. The results implied that the positive phase shift of the hand motion represents the proactive nature of the visual-motor control system to minimize the transient error of the hand motion when the target changes unexpectedly. In our study, visual target moves in circle (13cm in diameter) in computer screen, and each subject is asked to keep track with the target motion in circle by the motion of a cursor. As frequency of target increases, rhythmic component in velocity of cursor was found in spite of the fact that velocity of target is constant. The generation of rhythmic component cannot be explained by only feedback mechanism for the phase shift of target and cursor in sensory-motor system. Therefore, it implies that rhythmic component was generated to predict the velocity of target, which is feed forward mechanism in sensory-motor system. In presentation, we discuss the generation of rhythmic component and its roll in feed forward mechanism.

1 Introduction

Evolutionally, the strategy of catching prey should have been important to survive in constantly changing environment. Prediction mechanism should have developed to compensate the delay of sensory-motor system. In previous study, "proactive control" was found([1],[2]), in which motion of hands preceded the virtual moving target. The results implied that the positive phase shift of the hand motion represents the proactive nature of the visual-motor control system to minimize the transient error of the hand motion when the target changes unexpectedly.

In this paper, we studied the enhancement of proactivity by discretization of visual information in human visual-motor system by performing hand tracking experiments. The results showed that the magnitudes of the phase di erence of the hand motion with respect to the target motion increased when the target is shown intermittently. As frequency of target increases, rhythmic component in velocity of cursor was found in spite of the fact that velocity of target is constant. The generation of rhythmic component cannot be explained by only feedback mechanism for the phase shift of target and cursor in sensory-motor system. Therefore, it implies that rhythmic component was generated to predict the velocity of target, which is feed forward mechanism in sensory-motor system. In this research, we discuss the generation of rhythmic component and its roll in feed forward mechanism.

2 Method and Analysis

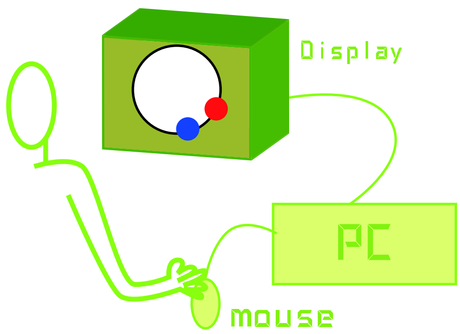

Figure1: Schematic picture of the hand tracking experiment

A subject was seated at 50cm in front of computer screen, and was asked to trace a moving visual target (red circle of 6mm diameter) as accurately as possible by the motion of a cursor (blue circle of 6mm diameter) in the screen produced by hand motion through a mechanical computer mouse(Fig.1).

Experiments are performed in two conditions; in a rst condition, target in circle trajectory is shown continuously, in a second condition, target is intermittently shown, i.e., the target is shown for only 40 percent of trajectory. subject rst follow the moving target, and when the target disapears, subject has to follow the circle line in a process of guessing target velocity and position. We analyze following physical quantities;

1. Phase shift between target and tracer
2. Velocity of tracer as a function of time
3. Frequency analysis of tracer velocity

3 Results and Discussion

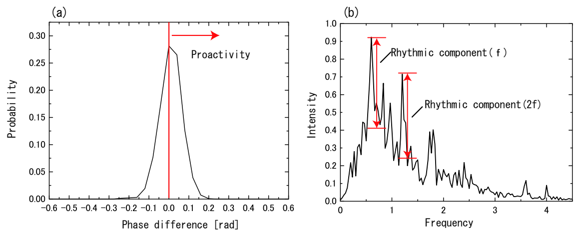

Figure2: (a) Distribution of phase shift (b) Frequency analysis of tarcer velocity

Proactivity of hand motion is caluculated as follows. Distribution of phase shift between target and tracer is tted by gaussan distribution and center of gaussin function is obtained. To nd rhythmic component of hand motion, frequency analysis is performed on velocity of tracer. The strength of rhythmic component was measured by a height of peak as shown in Fig.2.

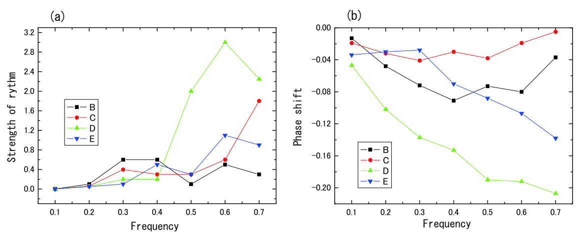

Figure3: In continuous trajectory of target (a) The strength of rhythmic component as a function of frequency (b) Proactivity as a function of frequency

In a rst experimental condition when the target was shown continuously in circle orbital, Rhythmic component in hand movement was enhanced as the frequency of target increases(Fig.3). However, phase shift was negative in all frequency; hand motion of the subject delayed the target motion. In a second condition when the target was shown intermittently, one subject showed proactivity(Fig.4), i.e., hand motion of the subject preceded the target motion. In the inter-stimulus-interval(when the target is not shown), correction motion to decrease phase shift between target and tracer can not perform(feed-back mechanism), thus, only feed-forward mechanism in which the velocity of target is estimated would work. In this case, the strengh of rhythmic component increased, thus the rhythmic component might play a role in feed-forward mechanism. These considerations indicate that proactivity emerges when feed-forward mechanism works more than feed-back of position correction. In the presentation, we would like to talk about detail analysis based on the emergence of rhythmic component and its roll in feed forward mechanism in visual-motor system.

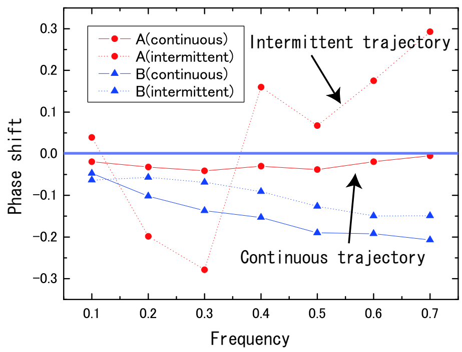

Figure4: Proactivity as a function of frequency in two experimental condition

References

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