Title	感覚と報酬の予測誤差に基づく内部順モデルの適応 - 計算論的モデルと行動実験検証
Author(s)	佐藤，仁是
Citation	
Issue Date	2016-03
Type	Thesis or Dissertation
Text version	author
URL	http://hdl.handle.net/10119/13623
Rights	
Description	Supervisor : 田中 宏和，情報科学研究科，修士

Formation of internal forward model with sensory and reward prediction errors : Computational and behavioral confirmations

Hitoshi Sato (1410025)

School of School of Information Science,
Japan Advanced Institute of Science and Technology

February 10,2016

Keywords: Visuomotor adaptation, Internal forward model, Sensory prediction error, Reward prediction error.

Human has the great ability of learning. Visuomotor adaptation is adaptation ability that cancels an imposed visual rotations. The subjects conduct to reaching movement using their invisible hand from start position to target position by described cursor (visual feedback) with rotation. After trial by trials, the subjects adapt to the visual rotation using a difference between cursor position and predicted hand position. At this time, a predicted hand position is generated by an internal forward model that is the mechanism of brain.

An internal forward model provides prediction of movement consequence for voluntary motor control. This model support adaptive behaviors to novel movement perturbation (i.e., visual rotation). So human can adapt the new environment because of an internal forward model adapt by provided errors. In this study, we addressed the question of what type of errors drives adaptation of internal forward models.

In previous study, subjects can adapt visual rotations with not only sensory prediction errors (the error between a cursor position and predicted hand position) but also reward prediction errors (the error between provided reward values and predicted reward values). The subjects are separated two conditions, error condition that is provided visual feedback (i.e., cursor position) and reward condition that is provided reward feedback (i.e., the information of hit or miss), and they are conducted visuomotor adaptation. Those two conditions can adapt visual rotation but there are distinct adaptation mechanisms by each conditions, sensory error based and reward error based. As a result, in previous study,

an internal model learns to rotations not with reward prediction errors but with sensory prediction errors in visuomotor adaptation paradigm.

There are, however, two issues in assessing the degree of internal model adaptation in previous study. First, the Subjects report a hand position that they predicted after finish a reaching movement when they already adapted visual rotations. So there is effects for cognitive process rather than motor control. The cognitive process and the behavior process results can be different to effect experimental conditions and beliefs by prior knowledge. There are the suggestions that the results of movement process and cognitive process of human are dissociated in optical illusion condition. And it is same condition not only a visual illusory figure but also size-weight illusion. In size-weight illusion paradigm, the subjects pick up two boxes, small one and big one, after that the subjects feel small one is heavier than big one despite on those boxes weight are same. The reason for this is the subjects have prior knowledge that the small box weight is light compare to the big one. Second, an adaptation state of internal model was confirmed using by non-adapated hand. In visuomotor adaptation experiments, the subjects conducted the reaching movement to the target using their right hand. But when to confirm an adaptation state of internal model, the subjects reported their position estimates after movement was completed using their left hand. In this case, there is possibility to evaluate the results of the subjects reported by that the using hand is different between adaptation paradigm and confirmation paradigm of state of internal model. By these study results, we thought if we confirm an internal model whether adapt to visual rotation or not, is previous study experiment with cognitive process appropriate method? We thought it is necessary to confirm a adaptation state of internal model by movement directly in a different way from the previous study. So the purpose of this study is to confirm a state of internal model directly without the effect of human cognitive process.

We proposed a new behavioral experiment, target jump trials. In target jump trials, a target unpredictably jumped during reaching movement on post-adaptation phase of visuomotor adaptation. When the subjects get a jumped target, they make online movement corrections. The result of online movement corrections is known as that is generated relied on the difference between a target location and a predicted hand position of internal model. Specifically, if states of internal model are difference in each conditions (error and reward condition), the online movement corrections are generated completely different in target jump trials. So we can compare to difference of internal model state about adaptation by novel experiment of the movement paradigm without the effect of cognitive process. We confirm to compare a state of internal model by target jump trials behavioral experiment and numerical simulation.

The learning model that is suggested previous study of visuomotor adaptation is con-

structed error based learning process and reward based learning process. In the error conditions that the subjects can get visual feedback, an internal model learn provided rotations by Kalman filter using sensory prediction error. But in the reward conditions, the subjects cannot get the visual feedback because they are not provided a cursor. Instead, the subjects in reward condition can get the reward information. The subjects are provided rewards (sound feedback of hit or miss to the target) and they can adapt to visual rotation by reinforcement learning using reward prediction errors instead of sensory prediction errors. As a result, this learning model simulation results can explain a results of visuomotor adaptation experiment. We reproduce a results of target jump trials using this model.

By those experiment and simulation results, the results between this study and the results in previous study are different. In the behavioral result of target jump trials on each conditions, error and reward conditions, those movement corrections are different but corrected direction of motion were same. So sensory prediction error affect a adaptation of internal forward model with rotation. In the reward condition that is not provided visual feedback, however, the behavioral result and the simulation result were different. By those different results, we confirm the state of internal models in this reward condition results by simulation. As a result, in this study, an internal forward model updates when subject learn with sensory feedback. And there is one possibility to adapt an internal model to added rotation in the condition of not only that subjects are provided visual feedback (error condition) but also that subjects are not provided visual feedback (reward condition) that is different results from the previous studies suggestion.