30 Body representation for quick and skillful action

Uncertainty of hand-state estimate regulates stretch reflex

Abstract

Reflexive motor control mechanisms are embedded in the brain to unconsciously correct ongoing body movements. They do this by detecting changes in the external world and ones own posture, via sensory signals from eyes and limbs. We investigated the information processing underlying the functional and context-dependent regulation of reflexive responses. We found an interesting attenuation of muscle response to resisting sudden changes in limb movement, which occurred if visual feedback of the limb movement was not given or was distorted. The result suggests that the brain regulates reflexive responses depending on body states estimated by combining multimodal information such as vision and bodily sensations, rather than single modality information as previously thought. We will further explore the computational mechanisms of reflexive sensorimotor control, which may be beneficial to analyzing the performance of athletes or to developing effective sports training methods.

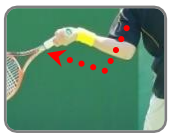
Movement correction without consciousness

* Reflexive muscle contraction occurring in response to sudden extension of a muscle to recover the posture

Consciousness

Motor correction through consciousness (≥ 200 ms)

Stretch reflex: Somatosensory-motor response (~50 ms)



Motor command

Somatosensory input

- Postural change
- Interaction with environment

Reflex responses enable quick compensation against disturbances to movement and posture

Informational processing for reflex regulation

Conventional hypothesis: unimodal processing

Somatosensory information → Stretch reflex modulation

Proposed hypothesis: multimodal processing

Visual information

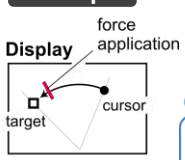
Somatosensory information

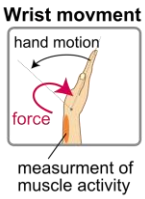
Multisensory integration → Stretch reflex modulation

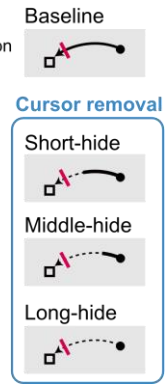
Visual information contributes to regulation of stretch reflex

- Stretch reflex was evoked by applying force during a wrist movement
- Testing if removing visual cue of hand position (cursor) affects the reflexive response
- The stretch reflex was smaller with longer cursor removal
- Suggesting uncertainty of hand states estimated by multisensory integration underlies the reflexive motor control

Setup

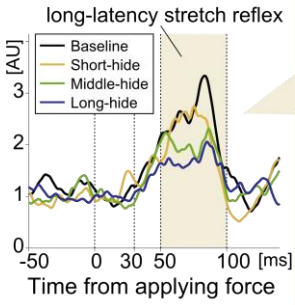




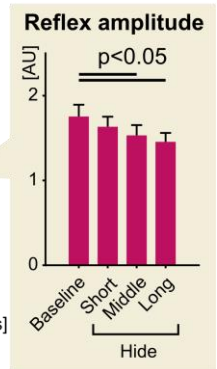


Results

Muscle activity around force application



Reflex amplitude



References

[1] S. Ito, H. Gomi, "Visually-updated hand state estimates modulate the proprioceptive reflex independently of motor task requirements," *eLife*, 9:e52380, 2020.

[2] S. Ito, H. Gomi, "Online modulation of proprioceptive reflex gain depending on uncertainty in multisensory state estimation," *Proc. The Society for Neuroscience 49th Annual Meeting*, 2019.

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オープンハウス 2020