



Title	The ipsilateral dorsal premotor cortex, but not the primary motor cortex, plays a complementary role in dexterous finger control
Author(s)	三浦, 玄
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論文内容の要旨

氏 名 (三 浦 玄)	
論文題名	The ipsilateral dorsal premotor cortex, but not the primary motor cortex, plays a complementary role in dexterous finger control (巧緻な手指運動における同側背側運動前野と一次運動野の機能的差異)
論文内容の要旨	
Human finger movements are primarily controlled by contralateral motor areas, specifically the dorsal premotor cortex (PMd) and the primary motor cortex (M1), but activation in ipsilateral motor areas has also been reported during complex motor tasks requiring high dexterity. However, the functional significance of these ipsilateral motor activations and their age-related changes have not been fully elucidated to date. In this study, I first clarified the functional significance of ipsilateral motor activation involved in complex finger movements in younger adults and examined its changes with aging in older adults using functional magnetic resonance imaging (fMRI). Furthermore, I used transcranial static magnetic field stimulation (tSMS) to provide causal evidence in younger adults for the functional dissociation between the ipsilateral PMd and M1 suggested by the fMRI findings. The fMRI results for younger and older adults were compared using a simple button-pressing task and a complex stick-rotation task developed by this laboratory. In younger adults, as expected, the ipsilateral motor areas were inhibited during the simple task. However, during the complex task, while inhibition in the ipsilateral M1 was maintained, the ipsilateral PMd transitioned to activation. Notably, this activation was higher in individuals with lower maximum performance, suggesting that this activity is recruited to complement motor clumsiness. In contrast, older adults did not show significant inhibition in the ipsilateral areas even during the simple task. During the complex task, both the ipsilateral PMd and M1 were activated, but this activity showed no correlation with maximum performance, indicating a potential loss of active complementary function. These findings in younger adults suggested that the ipsilateral PMd plays a complementary role distinct from that of the ipsilateral M1. Therefore, I causally verified these functional differences using tSMS, which can suppress neural activity at the stimulation site. Inhibitory intervention on the ipsilateral PMd significantly decreased stick-rotation performance, establishing its role in complementing motor function. Conversely, intervention on the ipsilateral M1 improved performance, suggesting that the suppression of ipsilateral M1 activity is crucial for preventing motor interference with the contralateral hemisphere. In conclusion, this research established a causal functional dissociation between the ipsilateral PMd and M1 during complex finger movements. The younger brain employs a region-specific strategy: it recruits the ipsilateral PMd to complement task demands while maintaining M1 inhibition to prevent interhemispheric interference, similar to simple movements. Conversely, the aging brain appears unable to maintain such a sophisticated interhemispheric strategy, likely due to a chronic decline in interhemispheric inhibition associated with aging.	

論文審査の結果の要旨及び担当者

氏 名 (三 浦 玄)			
	(職)	氏 名	
論文審査担当者	主 査	招へい教授	鈴木 隆文
	副 査	教授	北澤 茂
	副 査	教授	西本 伸志
	副 査	招へい准教授	林 正道
論文審査の結果の要旨 ヒトの手指運動は主に対側運動野(背側運動前野:PMdや一次運動野:M1)によって制御されるが、複雑手指運動の制御は同側のPMdやM1によって補完されるといわれてきた。本研究では、手指の巧緻性が要求される棒回し課題を独自開発し、機能的MRIを用いて、同側のM1ではなく、PMdが対側感覚運動領野と連携して、不器用な複雑運動の補完機能を担うことを証明した。また、この課題遂行中に、経頭蓋静磁場刺激(tSMS)で、同側のPMdまたはM1を抑制すると、前者ではパフォーマンスが低下、後者では向上し、複雑運動時の同側のPMdとM1の役割の相違を因果的に立証した。本研究は、脳機能マッピングと脳機能因果性検証を組み合わせ、同側PMdの活動促進と同側M1の活動抑制が手指の器用さを向上させる望ましい戦略であることを提案し、同側M1のtSMSによる抑制で高齢者の手指の巧緻性を改善できる応用可能性までも立証した独創的なものである。審査会での発表もわかりやすく活発な質疑応答となった。以上より、博士の学位を授与するに値するものと認める。なお、チェックツール“iThenticate 2.0”を使用し、剽窃、引用漏れ、二重投稿等のチェックを終えていることを申し添えます。			