【文献調査】
Neurofeedback Using Real-Time Near-Infrared Spectroscopy Enhances Motor Imagery Related Cortical Activation

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1 タイトル

リアルタイム近赤外分光法を用いたニューロフィードバックは皮質活動に関連して運動想起を高める

2 著者

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3 出典

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4 アブストラクト

これまでの証拠は運動想起および運動遂行が共通の神経ネットワークを共有することを示す．したがって，脳卒中患者のリハビリテーション制度には，運動想起の形態の精神的訓練が有利な結果をもたらしている．運動想起を直接モニタリングすることは困難であるため，運動想起に関連する皮質活動のフィードバック（ニューロフィードバック）は，運動想起の精神的訓練の有効性を高めるのに役立つ可能性がある．近赤外分光法（NIRS）によって媒介されるリアルタイムニューロフィードバックシステムの実現可能性および有効性を決定するために，2 つの別の実験を行った．実験 1 は，5 人の被験者で行われ，運動実行タスク中のリアルタイム皮質酸素化ヘモグロビン信号フィードバックが，オフラインで計算された基準ヘモグロビン信号と相関するかどうかを評価した．結果は，NIRS 媒介ニューロフィードバックシステムが酸素化ヘモグロビンシグナル変化をリアルタイムで確実に検出することを実証した．実験 2 では，21 人の被験者が，関連する皮質信号および関連性のない偽信号からのフィードバックを用いて，指の運動の運動想起を実施した．実際のニューロフィードバックは，擬似フィードバックと比較して，前頭皮質の著しく大きな活性化および運動感覚運動想起に対するより大きな自己評価スコアを誘導した．これらの知見は，NIRS を介するリアルタイム神経フィードバックシステムが運動感覚運動想起の性能に及ぼす可能性と潜在的有効性を示唆している．しかしながら，これらの結果は，このシステムが脳卒中患者における精神的練習の効果を高めることができるかどうかを決定するさらなる臨床試験を保証する．

5 キーワード

6 参考文献

6.1 運動想起について

[1] M. Jeannerod, Mental imagery in the motor context,” Neuropsychologia, vol. 33, no. 11, pp. 1419–1432, 1995.

6.2 運動想起と運動実行のニューラルネットワークについて

[2] J. Decety, D. Perani, M. Jeannerod, V. Bettinardi, B. Tadary, R. Woods, J.C. Mazziotta and F. Fazio, Mapping motor representations with positron emission tomography,” Nature, vol. 371, no. 6498, pp. 600–602, 1994.

[3] E. Gerardin, A. Sirigu, S. Lehéricy, J.-B. Poline, B. Gaymard, C. Marsault, Y. Agid and D. Le Bihan, Partially overlapping neural networks for real and imagined hand movements," Cerebral cortex, vol. 10, no. 11, pp. 1093–1104, 2000.

[4] A. Guillot, C. Collet, V.A. Nguyen, F. Malouin, C. Richards and J. Doyon, Functional neuroanatomical networks associated with expertise in motor imagery," Neuroimage, vol. 41, no. 4, pp. 1471–1483, 2008.

[5] A. Guillot, C. Collet, V.A. Nguyen, F. Malouin, C. Richards and J. Doyon, Brain activity during visual versus kinesthetic imagery: an fMRI study," Human brain mapping, vol. 30, no. 7, pp. 2157–2172, 2009.

[6] M. Lotze, U. Heymans, N. Birbaumer, R. Veit, M. Erb, H. Flor and U. Halsband, Differential cerebral activation during observation of expressive gestures and motor acts," Neuropsychologia, vol. 44, no. 10, pp. 1787–1795, 2006.

[7] P.L. Jackson, M.F. Lafleur, F. Malouin, C.L. Richards and J. Doyon, Functional cerebral reorganization following motor sequence learning through mental practice with motor imagery," Neuroimage, vol. 20, no. 2, pp. 1171–1180, 2003.

6.3 運動想起によるリハビリの有用性

[8] S.J. Page, P. Levine and A. Leonard, Mental practice in chronic stroke," Stroke, vol. 38, no. 4, pp. 1293–1297, 2007.

[9] S.J. Page, J.P. Szaflarski, J.C. Eliassen, H. Pan and S.C. Cramer, Cortical plasticity following motor skill learning during mental practice in stroke," Neurorehabilitation and neural repair, vol. 23, no. 4, pp. 382–388, 2009.

[10] N. Sharma, V.M. Pomeroy and J.-C. Baron, Motor imagery," Stroke, vol. 37, no. 7, pp 1941–1952, 2006.

[11] M. Ietswaart, M. Johnston, H.C. Dijkerman, S. Joice, C.L. Scott, R.S. MacWalter and S.J. Hamilton, Mental practice with motor imagery in stroke recovery: randomized controlled trial of efficacy," Brain, vol. 134, no. 5, pp. 1373–1386, 2011.

6.4 運動想起のモニタリングについて

[12] R. Roure, C. Collet, C. Deschaumes-Molinaro, G. Delhomme, A. Dittmar and E. Vernet- Maury, Imagery quality estimated by autonomic response is correlated to sporting performance enhancement," Physiology & Behavior, vol. 66, no. 1, pp. 63–72, 1999.

[13] F. Malouin, C.L. Richards, A. Durand and J. Doyon, Reliability of mental chronometry for assessing motor imagery ability after stroke," Archives of physical medicine and rehabilitation, vol. 89, no. 2, pp. 311–319, 2008.

[14] F. Malouin, C.L. Richards, P.L. Jackson, M.F. Lafleur, A. Durand and J. Doyon, The kinesthetic and visual imagery questionnaire (kviq) for assessing motor imagery in persons with physical disabilities: a reliability and construct validity study," Journal of Neurologic Physical Therapy, vol. 31, no. 1, pp. 20–29, 2007.

6.5 訓練効果の個人差や提示手法に依存することについて

[15] K.J. Munroe, P.R. Giacobbi Jr, C. Hall and R. Weinberg, The four ws of imagery use: Where, when, why, and what," The Sport Psychologist, vol. 14, no. 2, pp. 119–137, 2000.

[16] P. Ruby and J. Decety, Effect of subjective perspective taking during simulation of action: a pet investigation of agency," Nature neuroscience, vol. 4, no. 5, pp. 546–550, 2001.

[17] L. Warner and M.E. McNeill, Mental imagery and its potential for physical therapy," Physical Therapy, vol. 68, no. 4, pp. 516–521, 1988.

6.6 運動想起が運動動画より運動学習に有効であることについて

[18] C.M. Stinear, W.D. Byblow, M. Steyvers, O. Levin and S.P. Swinnen, Kinesthetic, but not visual, motor imagery modulates corticomotor excitability," Experimental Brain Research, vol. 168, no. 1-2, pp. 157–164, 2006.

6.7 BCI について

[19] J.J. Daly and J.R. Wolpaw, Brain–computer interfaces in neurological rehabilitation," The Lancet Neurology, vol. 7, no. 11, pp. 1032–1043, 2008.

[20] B.H. Dobkin, Brain–computer interface technology as a tool to augment plasticity and outcomes for

neurological rehabilitation," The Journal of physiology, vol. 579, no. 3, pp. 637–642, 2007.

6.8 EEG におけるリアルタイム処理の先行研究

[21] A. Delorme and S. Makeig, EEG changes accompanying learned regulation of 12-Hz EEG activity," IEEE Transactions on neural systems and Rehabilitation engineering, vol. 11, no. 2, pp. 133–137, 2003.

[22] T. Egner and J.H. Gruzelier, EEG biofeedback of low beta band components: frequency- specific effects on variables of attention and event-related brain potentials," Clinical neurophysiology, vol. 115, no. 1, pp. 131–139, 2004.

[23] T. Fuchs, N. Birbaumer, W. Lutzenberger, J.H. Gruzelier and J. Kaiser, Neurofeedback treatment for attention-deficit/hyperactivity disorder in children: a comparison with methylphenidate," Applied psychophysiology and biofeedback, vol. 28, no. 1, pp. 1–12, 2003.

[24] B. Kotchoubey, U. Strehl, C. Uhlmann, S. Holzapfel, M. König, W. Fröscher, V. Blankenhorn and N. Birbaumer, Modification of slow cortical potentials in patients with refractory epilepsy: a controlled outcome study," Epilepsia, vol. 42, no. 3, pp. 406–416, 2001.

6.9 fMRI におけるリアルタイム処理の先行研究

[25] E. Bagarinao, K. Matsuo, T. Nakai and S. Sato, Estimation of general linear model coefficients for real-time application," Neuroimage, vol. 19, no. 2, pp. 422–429, 2003.

[26] R.W. Cox, A. Jesmanowicz and J.S. Hyde, Real-time functional magnetic resonance imaging," Magnetic resonance in medicine, vol. 33, no. 2, pp. 230–236, 1995.

[27] R. Christopher deCharms, F. Maeda, G.H. Glover, D. Ludlow, J.M. Pauly, D. Soneji, J.D. Gabrieli and S.C. Mackey, Control over brain activation and pain learned by using real-time functional MRI," Proceedings of the National Academy of Sciences of the United States of America, vol. 102, no. 51, pp. 18626–18631, 2005.

[28] S. Posse, D. Fitzgerald, K. Gao, U. Habel, D. Rosenberg, G.J. Moore and F. Schneider, Real-time fMRI of temporolimbic regions detects amygdala activation during single-trial self-induced sadness," Neuroimage, vol. 18, no. 3, pp. 760–768, 2003.

[29] R. Christopher deCharms, K. Christoff, G.H. Glover, J.M. Pauly, S. Whitfield and J.D. Gabrieli, Learned regulation of spatially localized brain activation using real-time fMRI," Neuroimage, vol. 21, no. 1, pp. 436–443, 2004.

6.10 BCI について

[30] Y. Hoshi and M. Tamura, Detection of dynamic changes in cerebral oxygenation coupled to neuronal function during mental work in man," Neuroscience letters, vol. 150, no. 1, pp. 5–8, 1993.

[31] A. Villringer, J. Planck, C. Hock, L. Schleinkofer and U. Dirnagl, Near infrared spectroscopy (NIRS): a new tool to study hemodynamic changes during activation of brain function in human adults," Neuroscience letters, vol. 154, no. 1, pp. 101–104, 1993.