

【文献調査】

Synchronous activity of two people 's prefrontal cortices during a cooperative task measured by simultaneous near-infrared spectroscopy

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1 タイトル

同時近赤外分光法により測定された協調作業中の2人のprefrontal corticesの同期活動

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3 出典

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4 アブストラクト

社会過程の一つである協力中の脳活動を検討した。我々は、複数の参加者の同時に起きる脳活動とその協調作業のパフォーマンスとの関係を調査した。2人の参加者の脳活動を同時に測定するために、wearable near-infrared spectroscopy (NIRS) システムが用いられた。参加者の各ペアは協調作業を行い、NIRS システムにより脳血流量の相対的变化を測定する。タスクとして、聴覚的な合図の後、参加者は心の中で10秒を数え、ボタンを押すよう指示された。また、ボタンを押すタイミングを調整してできるだけ同期させるように指示された。各参加者の2つのボタンプレスと参加者のどちらが速いかの情報、すなわち「intertime interval」は、各試行後にビープ音によって参加者にフィードバックされる。

各参加者のprefrontal corticesの活性パターン間の時空間共分散が高い場合、それらのボタンプレス時間の間の時間間隔はより短かった。

この結果は、2人の参加者の脳の同期化された活性パターンが、協調作業において相互作用するときのパフォーマンスと関連していることを示唆している。

5 キーワード

near-infrared spectroscopy, wearable optical topography, brain activity, hemoglobin, simultaneous measurement, hyperscanning

6 参考文献

6.1 精神障害者は社会性に関する研究

[1] S. Baron-Cohen, A.M. Leslie and U. Frith, "Does the autistic child have a "theory of mind"?", Cognition, vol. 21, no. 1, pp. 37-46, 1985.

[2] S. Baron-Cohen, H.A. Ring, S. Wheelwright, E.T. Bullmore, M.J. Brammer, A. Simmons and S.C. Williams, "Social intelligence in the normal and autistic brain: an fmri study," European Journal of Neuroscience, vol. 11, no. 6, pp. 1891-1898, 1999.

[3] E. Fombonne, "The prevalence of autism," Jama, vol. 289, no. 1, pp. 87-89, 2003.

6.2 社会的スキルについての研究

[4] J. Blair, A. Marsh, E. Finger, K. Blair and J. Luo, "Neuro-cognitive systems involved in morality," *Philosophical Explorations*, vol. 9, no. 1, pp. 13-27, 2006.

6.3 社会脳の研究

[5] M.S. Gazzaniga, *The social brain: Discovering the networks of the mind*, Basic Books (AZ), 1985.

[6] L. Brothers, "The social brain: a project for integrating primate behavior and neurophysiology in a new domain," *Concepts Neurosci.*, vol. 1, pp. 27-51, 1990.

[7] C.D. Frith, "The social brain?," *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, vol. 362, no. 1480, pp. 671-678, 2007.

[8] N. Fujii, S. Hihara and A. Iriki, "Dynamic social adaptation of motion-related neurons in primate parietal cortex," *PloS one*, vol. 2, no. 4, p.e397, 2007.

[9] L. Gao, J. Xu, B. Zhang, L. Zhao, A. Harel and S. Bentin, "Aging effects on early-stage face perception: An erp study," *Psychophysiology*, vol. 46, no. 5, pp. 970-983, 2009.

[10] V. Goel, J. Grafman, N. Sadato and M. Hallett, "Modeling other minds.," *Neuroreport*, vol. 6, no. 13, pp. 1741-1746, 1995.

[11] P.C. Fletcher, F. Happe, U. Frith, S.C. Baker, R.J. Dolan, R.S. Frackowiak and C.D. Frith, "Other minds in the brain: a functional imaging study of " theory of mind " in story comprehension," *Cognition*, vol. 57, no. 2, pp. 109-128, 1995.

[12] H.L. Gallagher, A.I. Jack, A. Roepstorff and C.D. Frith, "Imaging the intentional stance in a competitive game," *Neuroimage*, vol. 16, no. 3, pp. 814-821, 2002.

[13] S. Baron-Cohen, H. Ring, J. Moriarty, B. Schmitz, D. Costa and P. Ell, "Recognition of mental state terms. clinical findings in children with autism and a functional neuroimaging study of normal adults.," *The British Journal of Psychiatry*, vol. 165, no. 5, pp. 640-649, 1994.

[14] H. Fukui, T. Murai, J. Shinozaki, T. Aso, H. Fukuyama, T. Hayashi and T. Hanakawa, "The neural basis of social tactics: An fmri study," *Neuroimage*, vol. 32, no. 2, pp. 913-920, 2006.

[15] K. McCabe, D. Houser, L. Ryan, V. Smith and T. Trouard, "A functional imaging study of cooperation in two-person reciprocal exchange," *Proceedings of the National Academy of Sciences*, vol. 98, no. 20, pp. 11832-11835, 2001.

[16] J.P. Mitchell, M.R. Banaji and C.N. Macrae, "General and specific contributions of the medial prefrontal cortex to knowledge about mental states," *Neuroimage*, vol. 28, no. 4, pp. 757-762, 2005.

[17] M.B. Schippers, A. Roebroek, R. Renken, L. Nanetti and C. Keysers, "Mapping the information flow from one brain to another during gestural communication," *Proceedings of the National Academy of Sciences*, vol. 107, no. 20, pp. 9388-9393, 2010.

[18] G.J. Stephens, L.J. Silbert and U. Hasson, "Speakerlistener neural coupling underlies successful communication," *Proceedings of the National Academy of Sciences*, vol. 107, no. 32, pp. 14425-14430, 2010.

[19] S. Lloyd-Fox, A. Blasi, A. Volein, N. Everdell, C.E. Elwell and M.H. Johnson, "Social perception in infancy: a near infrared spectroscopy study," *Child development*, vol. 80, no. 4, pp.986-999, 2009.

[20] T. Grossmann and M.H. Johnson, "Selective prefrontal cortex responses to joint attention in early infancy," *Biology Letters*, vol. 6, no. 4, pp. 540-543, 2010.

[21] M. Suda, Y. Takei, Y. Aoyama, K. Narita, T. Sato, M. Fukuda and M. Mikuni, "Frontopolar activation during face-to-face conversation: an in situ study using near-infrared spectroscopy," *Neuropsychologia*, vol. 48, no. 2, pp. 441-447, 2010.

[22] T. Grossmann, R. Oberecker, S.P. Koch and A.D. Friederici, "The developmental origins of voice processing in the human brain," *Neuron*, vol. 65, no. 6, pp. 852-858, 2010.

[23] Y. Minagawa-Kawai, S. Matsuoka, I. Dan, N. Naoi, K. Nakamura and S. Kojima, "Prefrontal activation associated with social attachment: facial-emotion recognition in mothers and infants," *Cerebral Cortex*, vol. 19, no. 2, pp. 284-292, 2008.

6.4 ウェアラブル NIRS を用いた研究

[24] H. Atsumori, M. Kiguchi, A. Obata, H. Sato, T. Katura, K. Utsugi, T. Funane and A. Maki, "Development of a multi-channel, portable optical topography system," in Engineering in Medicine and Biology Society, 2007. EMBS 2007. 29th Annual International Conference of the IEEE, pp. 3362-3364 2007.

[25] H. Atsumori, M. Kiguchi, A. Obata, H. Sato, T. Katura, T. Funane and A. Maki, "Development of wearable optical topography system for mapping the prefrontal cortex activation," Review of Scientific Instruments, vol. 80, no. 4, p.043704, 2009.

[26] H. Atsumori, M. Kiguchi, T. Katura, T. Funane, A. Obata, H. Sato, T. Manaka, M. Iwamoto, A. Maki, H. Koizumi, et al., "Noninvasive imaging of prefrontal activation during attention demanding tasks performed while walking using a wearable optical topography system," Journal of biomedical optics, vol. 15, no. 4, pp. 046002-046002, 2010.

6.5 NIRS に関する研究

[27] F.F. Jobsis, "Noninvasive, infrared monitoring of cerebral and myocardial oxygen sufficiency and circulatory parameters," Science, vol. 198, no. 4323, pp. 1264-1267, 1977.

[28] B. Chance, Z. Zhuang, C. UnAh, C. Alter and L. Lipton, "Cognition-activated low-frequency modulation of light absorption in human brain," Proceedings of the National Academy of Sciences, vol. 90, no. 8, pp. 3770-3774, 1993.

[29] 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.

[30] 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.

[31] A. Maki, Y. Yamashita, Y. Ito, E. Watanabe, Y. Mayanagi and H. Koizumi, "Spatial and temporal analysis of human motor activity using noninvasive nir topography," Medical physics, vol. 22, no. 12, pp. 1997-2005, 1995.

[32] H. Koizumi, Y. Yamashita, A. Maki, T. Yamamoto, Y. Ito, H. Itagaki and R. Kennan, "Higherorder brain function analysis by transcranial dynamic near-infrared spectroscopy imaging," Journal of Biomedical Optics, vol. 4, no. 4, pp. 403-413, 1999.

[33] E. Watanabe, A. Maki, F. Kawaguchi, K. Takashiro, Y. Yamashita, H. Koizumi and Y. Mayanagi, "Non-invasive assessment of language dominance with near-infrared spectroscopic mapping," Neuroscience letters, vol. 256, no. 1, pp. 49-52, 1998.

[34] H. Sato, T. Takeuchi and K.L. Sakai, "Temporal cortex activation during speech recognition: an optical topography study," Cognition, vol. 73, no. 3, pp. B55-B66, 1999.

[35] Y. Minagawa-Kawai, K. Mori, I. Furuya, R. Hayashi and Y. Sato, "Assessing cerebral representations of short and long vowel categories by nirs," Neuroreport, vol. 13, no. 5, pp. 581-584, 2002.

[36] A. Obata, K. Morimoto, H. Sato, A. Maki and H. Koizumi, "Acute effects of alcohol on hemodynamic changes during visual stimulation assessed using 24-channel near-infrared spectroscopy," Psychiatry Research: Neuroimaging, vol. 123, no. 2, pp. 145-152, 2003.

[37] T. Suto, M. Fukuda, M. Ito, T. Uehara and M. Mikuni, "Multichannel near-infrared spectroscopy in depression and schizophrenia: cognitive brain activation study," Biological psychiatry, vol. 55, no. 5, pp. 501-511, 2004.

[38] G. Taga, Y. Konishi, A. Maki, T. Tachibana, M. Fujiwara and H. Koizumi, "Spontaneous oscillation of oxy-and deoxy-hemoglobin changes with a phase difference throughout the occipital cortex of newborn infants observed using non-invasive optical topography," Neuroscience letters, vol. 282, no. 1, pp. 101-104, 2000.

[39] G. Taga, K. Asakawa, A. Maki, Y. Konishi and H. Koizumi, "Brain imaging in awake infants by near-infrared optical topography," Proceedings of the National Academy of Sciences, vol. 100, no. 19, pp. 10722-10727, 2003.

[40] M. Pena, A. Maki, D. Kovacic, G. Dehaene-Lambertz, H. Koizumi, F. Bouquet and J. Mehler, "Sounds and silence: an optical topography study of language recognition at birth," Proceedings of the National

Academy of Sciences, vol. 100, no. 20, pp. 11702-11705, 2003.

[41] T. Nakano, H. Watanabe, F. Homae and G. Taga, "Prefrontal cortical involvement in young infants' analysis of novelty," *Cerebral Cortex*, vol. 19, no. 2, pp. 455-463, 2008.

[42] F. Homae, H. Watanabe, T. Otobe, T. Nakano, T. Go, Y. Konishi and G. Taga, "Development of global cortical networks in early infancy," *Journal of Neuroscience*, vol. 30, no. 14, pp. 4877- 4882, 2010.

[43] Y. Ito, R.P. Kennan, E. Watanabe and H. Koizumi, "Assessment of heating effects in skin during continuous wave near infrared spectroscopy," *Journal of biomedical optics*, vol. 5, no. 4, pp. 383-390, 2000.

6.6 EEG に関する研究

[44] M. Kiguchi, N. Ichikawa, H. Atsumori, F. Kawaguchi, H. Sato, A. Maki and H. Koizumi, "Comparison of light intensity on the brain surface due to laser exposure during optical topography and solar irradiation," *Journal of biomedical optics*, vol. 12, no. 6, pp. 062108-062108, 2007.

[45] F. Babiloni, L. Astolfi, F. Cincotti, D. Mattia, A. Tocci, A. Tarantino, M. Marciani, S. Salinari, S. Gao, A. Colosimo, et al., "Cortical activity and connectivity of human brain during the prisoner's dilemma: an eeg hyperscanning study," in *Engineering in Medicine and Biology Society, 2007. EMBS 2007. 29th Annual International Conference of the IEEEIEEE*, pp. 4953- 4956, 2007.

[46] E. Tognoli, J. Lagarde, G.C. DeGuzman and J.S. Kelso, "The phi complex as a neuromarker of human social coordination," *Proceedings of the National Academy of Sciences*, vol. 104, no. 19, pp. 8190-8195, 2007.

[47] G. Dumas, J. Nadel, R. Soussignan, J. Martinerie and L. Garnero, "Inter-brain synchronization during social interaction," *PloS one*, vol. 5, no. 8, p.e12166, 2010.

[48] F.D.V. Fallani, V. Nicosia, R. Sinatra, L. Astolfi, F. Cincotti, D. Mattia, C. Wilke, A. Doud, V. Latora, B. He, et al., "Defecting or not defecting: how to " read " human behavior during cooperative games by eeg measurements," *PloS one*, vol. 5, no. 12, p.e14187, 2010.

[49] R.N. Aslin and J. Mehler, "Near-infrared spectroscopy for functional studies of brain activity in human infants: promise, prospects, and challenges," *Journal of Biomedical Optics*, vol. 10, no. 1, pp. 011009-0110093, 2005.

[50] R. Sitaram, H. Zhang, C. Guan, M. Thulasidas, Y. Hoshi, A. Ishikawa, K. Shimizu and N. Birbaumer, "Temporal classification of multichannel near-infrared spectroscopy signals of motor imagery for developing a brain computer interface," *NeuroImage*, vol. 34, no. 4, pp. 1416-1427, 2007.

6.7 MRI に関する研究

[49] P.R. Montague, G.S. Berns, J.D. Cohen, S.M. McClure, G. Pagnoni, M. Dhamala, M.C. Wiest, I. Karpov, R.D. King, N. Apple, et al., "Hyperscanning: simultaneous fmri during linked social interactions," 2002.

[50] D.N. Saito, H.C. Tanabe, K. Izuma, M.J. Hayashi, Y. Morito, H. Komeda, H. Uchiyama, H. Kosaka, H. Okazawa, Y. Fujibayashi, et al., " "stay tuned " : inter-individual neural synchronization during mutual gaze and joint attention," *Frontiers in integrative neuroscience*, vol. 4, , 2010.