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## Reduced Frontal P3a Amplitude in Migraine Patients during the Pain-Free Period

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The author wishes to apologize for incorrectly displaying the references.

We correct the lists of the references as follows.

5. Aguggia M, Saracco MG. Pathophysiology of migraine chronification. *Neurol Sci* 2010;31 Suppl 1:S15-S17.
6. Le Pira F, Zappalà G, Giuffrida S, Lo Bartolo ML, Reggio E, Morana R, et al. Memory disturbances in migraine with and without aura: a strategic problem? *Cephalalgia* 2000;20:475-478.
7. Calandre EP, Bembibre J, Arnedo ML, Becerra D. Cognitive disturbances and regional cerebral blood flow abnormalities in migraine patients: their relationship with the clinical manifestations of the illness. *Cephalalgia* 2002;22:291-302.
8. Waldie KE, Hausmann M, Milne BJ, Poulton R. Migraine and cognitive function: a life-course study. *Neurology* 2002;59:904-908.
9. Gómez-Beldarrain M, Carrasco M, Bilbao A, García-Moncó JC. Orbitofrontal dysfunction predicts poor prognosis in chronic migraine with medication overuse. *J Headache Pain* 2011;12:459-466.
10. Camarda C, Monastero R, Pipia C, Recca D, Camarda R. Interictal executive dysfunction in migraineurs without aura: relationship with duration and intensity of attacks. *Cephalalgia* 2007;27:1094-1100.
11. Schmitz N, Arkink EB, Mulder M, Rubia K, Admiraal-Behloul F, Schoonman GG, et al. Frontal lobe structure and executive function in migraine patients. *Neurosci Lett* 2008;440:92-96.
12. Kim JH, Suh SI, Seol HY, Oh K, Seo WK, Yu SW, et al. Regional grey matter changes in patients with migraine: a voxel-based morphometry study. *Cephalalgia* 2008;28:598-604.
13. Afridi SK, Giffin NJ, Kaube H, Friston KJ, Ward NS, Frackowiak RS, et al. A positron emission tomographic study in spontaneous migraine. *Arch Neurol* 2005;62:1270-1275.
14. Kim JH, Kim S, Suh SI, Koh SB, Park KW, Oh K. Interictal metabolic changes in episodic migraine: a voxel-based FDG-PET study. *Cephalalgia* 2010;30:53-61.
15. Schmitz N, Admiraal-Behloul F, Arkink EB, Kruit MC, Schoonman GG, Ferrari MD, et al. Attack frequency and disease duration as indicators for brain damage in migraine. *Headache* 2008;48:1044-1055.
16. Woodman GF. A brief introduction to the use of event-related potentials in studies of perception and attention. *Atten Percept Psychophys* 2010;72:2031-2046.
17. Polich J, Kok A. Cognitive and biological determinants of P300: an integrative review. *Biol Psychol* 1995;41:103-146.
18. Polich J. Updating P300: an integrative theory of P3a and P3b. *Clin Neurophysiol* 2007;118:2128-2148.
19. Volpe U, Mucci A, Bucci P, Merlotti E, Galderisi S, Maj M. The cortical generators of P3a and P3b: a LORETA study. *Brain Res Bull* 2007;73:220-230.
20. Baving L, Rellum T, Laucht M, Schmidt MH. Children with oppositional-defiant disorder display deviant attentional processing independent of ADHD symptoms. *J Neural Transm* 2006;113:685-693.
21. Banaschewski T, Brandeis D, Heinrich H, Albrecht B, Brunner E, Rothberger A. Association of ADHD and conduct disorder--brain electrical evidence for the existence of a distinct subtype. *J Child Psychol Psychiatry* 2003;44:356-376.
22. Anderson NE, Baldrige RM, Stanford MS. P3a amplitude predicts successful treatment program completion in substance-dependent individuals. *Subst Use Misuse* 2011;46:669-677.
23. Wang W, Schoenen J. Interictal potentiation of passive "oddball" auditory event-related potentials in migraine. *Cephalalgia* 1998;18:261-265; discussion 241.
24. Headache Classification Subcommittee of the International Headache Society. The International Classification of Headache Disorders: 2nd edition. *Cephalalgia* 2004;24 Suppl 1:9-160.
25. Delorme A, Makeig S. EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics including independent component analysis. *J Neurosci Methods* 2004;134:9-21.
26. Oostenveld R, Fries P, Maris E, Schoffelen JM. FieldTrip: Open source software for advanced analysis of MEG, EEG, and invasive electrophysiological data. *Comput Intell Neurosci* 2011;2011:156869.
27. Maris E, Oostenveld R. Nonparametric statistical testing of EEG- and MEG-data. *J Neurosci Methods* 2007;164:177-190.

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28. Vannatta K, Getzoff EA, Powers SW, Noll RB, Gerhardt CA, Hershey AD. Multiple perspectives on the psychological functioning of children with and without migraine. *Headache* 2008;48:994-1004.
29. Moutran AR, Villa TR, Diaz LA, Noffs MH, Pinto MM, Gabbai AA, et al. Migraine and cognition in children: a controlled study. *Arq Neuropsiquiatr* 2011;69:192-195.
30. Mulder EJ, Linssen WH, Passchier J, Orlebeke JF, de Geus EJ. Interictal and postictal cognitive changes in migraine. *Cephalalgia* 1999;19:557-565; discussion 541.
31. Clemens B, Bánk J, Piros P, Bessenyey M, Veto S, Tóth M, et al. Three-dimensional localization of abnormal EEG activity in migraine: a low resolution electromagnetic tomography (LORETA) study of migraine patients in the pain-free interval. *Brain Topogr* 2008;21:36-42.
32. Petrovic P, Petersson KM, Ghatan PH, Stone-Elander S, Ingvar M. Pain-related cerebral activation is altered by a distracting cognitive task. *Pain* 2000;85:19-30.
33. Valet M, Sprenger T, Boecker H, Willloch F, Rummeny E, Conrad B, et al. Distraction modulates connectivity of the cingulo-frontal cortex and the midbrain during pain—an fMRI analysis. *Pain* 2004;109:399-408.
34. Lorenz J, Minoshima S, Casey KL. Keeping pain out of mind: the role of the dorsolateral prefrontal cortex in pain modulation. *Brain* 2003;126:1079-1091.
35. Brighina F, Piazza A, Vitello G, Aloisio A, Palermo A, Daniele O, et al. rTMS of the prefrontal cortex in the treatment of chronic migraine: a pilot study. *J Neurol Sci* 2004;227:67-71.
36. Zakzanis KK, Mraz R, Graham SJ. An fMRI study of the Trail Making Test. *Neuropsychologia* 2005;43:1878-1886.
37. Faber PL, Tei S, Chen C, Hsiao P, Lehmann D. 3. Brain LORETA functional imaging, EEG spectral power, and self-rated headache pain. *Clin Neurophysiol* 2011;122:e2.
38. Parisi P, Verrotti A, Paolino MC, Urbano A, Bernabucci M, Castaldo R, et al. Headache and cognitive profile in children: a cross-sectional controlled study. *J Headache Pain* 2010;11:45-51.
39. Eccleston C, Crombez G. Pain demands attention: a cognitive-affective model of the interruptive function of pain. *Psychol Bull* 1999;125:356-366.
40. Houlihan ME, McGrath PJ, Connolly JF, Stroink G, Allen Finley G, Dick B, et al. Assessing the effect of pain on demands for attentional resources using ERPs. *Int J Psychophysiol* 2004;51:181-187.
41. Seminowicz DA, Davis KD. Pain enhances functional connectivity of a brain network evoked by performance of a cognitive task. *J Neurophysiol* 2007;97:3651-3659.
42. Seidel S, Hartl T, Weber M, Matterey S, Paul A, Riederer F, et al. Quality of sleep, fatigue and daytime sleepiness in migraine - a controlled study. *Cephalalgia* 2009;29:662-669.
43. Kruit MC, Launer LJ, Overbosch J, van Buchem MA, Ferrari MD. Iron accumulation in deep brain nuclei in migraine: a population-based magnetic resonance imaging study. *Cephalalgia* 2009;29:351-359.
44. Lipton RB, Bigal ME. Looking to the future: research designs for study of headache disease progression. *Headache* 2008;48:58-66.
45. Kim BK, Chu MK, Lee TG, Kim JM, Chung CS, Lee KS. Prevalence and impact of migraine and tension-type headache in Korea. *J Clin Neurol* 2012;8:204-211.
46. Bigal ME, Lipton RB. Migraine at all ages. *Curr Pain Headache Rep* 2006;10:207-213.
47. Stewart WF, Linet MS, Celentano DD, Van Natta M, Ziegler D. Age- and sex-specific incidence rates of migraine with and without visual aura. *Am J Epidemiol* 1991;134:1111-1120.
48. Valeriani M, Galli F, Tarantino S, Graceffa D, Pignata E, Miliucci R, et al. Correlation between abnormal brain excitability and emotional symptomatology in paediatric migraine. *Cephalalgia* 2009;29:204-213.
49. Siniatchkin M, Kropp P, Gerber WD. What kind of habituation is impaired in migraine patients? *Cephalalgia* 2003;23:511-518.
50. Evers S, Quibeldey F, Grotemeyer KH, Suhr B, Husstedt IW. Dynamic changes of cognitive habituation and serotonin metabolism during the migraine interval. *Cephalalgia* 1999;19:485-491.
51. Evers S, Bauer B, Grotemeyer KH, Kurlemann G, Husstedt IW. Event-related potentials (P300) in primary headache in childhood and adolescence. *J Child Neurol* 1998;13:322-326.
52. Evers S, Bauer B, Suhr B, Husstedt IW, Grotemeyer KH. Cognitive processing in primary headache: a study on event-related potentials. *Neurology* 1997;48:108-113.
53. Demarquay G, Caclin A, Brudon F, Fischer C, Morlet D. Exacerbated attention orienting to auditory stimulation in migraine patients. *Clin Neurophysiol* 2011;122:1755-1763.
54. Zohsel K, Hohmeister J, Flor H, Hermann C. Altered pain processing in children with migraine: an evoked potential study. *Eur J Pain* 2008;12:1090-1101.
55. Chen W, Shen X, Liu X, Luo B, Liu Y, Yu R, et al. Passive paradigm single-tone elicited ERPs in tension-type headaches and migraine. *Cephalalgia* 2007;27:139-144.
56. Gerber WD, Stephani U, Kirsch E, Kropp P, Siniatchkin M. Slow cortical potentials in migraine families are associated with psychosocial factors. *J Psychosom Res* 2002;52:215-222.
57. Buodo G, Palomba D, Sarlo M, Naccarella C, Battistella PA. Auditory event-related potentials and reaction times in migraine children. *Cephalalgia* 2004;24:554-563.
58. Siniatchkin M, Kirsch E, Kropp P, Stephani U, Gerber WD. Slow cortical potentials in migraine families. *Cephalalgia* 2000;20:881-892.
59. Polich J, McIsaac HK. Comparison of auditory P300 habituation from active and passive conditions. *Int J Psychophysiol* 1994;17:25-34.