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Sleep Deprivation Affects Working Memory in Low but Not in High Complexity for the N-Back Test

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ABSTRACT

Sleep clearly influences learning and memory since sleep deprivation and stress impairs both cognitive processes. Working memory is an essential cognitive process and refers to a short-term holding of incoming information required to update the long-term mnemonic storage and to manipulate new elements in order to solve problems and make decisions. Nevertheless, the influence of sleep deprivation on working memory has scarcely been studied. In this study we evaluated working memory using the N-back test after increasing periods of wakefulness. Healthy young males were kept awake for 36 hours and the two N-back tasks with low (1-Back) and high (3-Back) levels of complexity were applied every 6 hours. Additionally, salivary cortisol was determined along the study. Unlike the control non-deprived participants, the sleep deprived volunteers showed a significant decrease in their efficiency to solve the 1-Back task after 24 hours of sleep deprivation. However, no differences were observed after 30 and 36 hours of sleep deprivation. Concerning the 3-Back task no differences were observed after sleep deprivation. Regarding reaction time, the deprived group manifested slower responses for the 1-Back task and for the 3-Back task after 30 hours and 36 hours of sleep deprivation, respectively. Cortisol levels presented the normal daily oscillation and no differences were observed between groups. This data suggests that sleep deprivation affects basal states of attention instead of working memory while performing simple tasks. The impact of sleep deprivation on the cognitive performance depends on the moment of day when the task is applied and the complexity of the tests used to assess these mnemonic skills.

KEYWORDS

Sleep Deprivation; Working Memory; Cortisol Levels; N-Back Task; Stress

Cite this paper

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References

- [1] M. G. Frank, "The Mystery of Sleep Function: Current Perspectives and Future Directions," *Reviews in the Neuroscience*, Vol. 17, No. 4, 2006, pp. 375-392.
- [2] E. Mignot, "Why We Sleep: The Temporal Organization of Recovery," *PLoS Biology*, Vol. 6, No. 4, 2008, pp. 661-669.
- [3] T. H. Monk, C. F. 3rd Reynolds, D. J. Buysse, J. M. DeGrazia and D. J. Kupfer, "The Relationship between Lifestyle Regularity and Subjective Sleep Quality," *Chronobiology International*, Vol. 20, No. 1, 2003, pp. 97-107.
- [4] J. Waterhouse, Y. Fukuda and T. Morita, "Daily Rhythms of the Sleep-Wake Cycle," *Journal of Physiology Anthropology*, Vol. 31, No. 1, 2012, pp. 1-14.
- [5] P. C. Kyllonen and R. E. Christal, "Reasoning Ability Is (Little More Than) Working Memory Capacity?!" *Intelligence*, Vol. 14, No. 4, 1990, pp. 389-433. doi:10.1016/S0160-2896(05)80012-1

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- [6] B. Rypma and M. D' Esposito, " The Roles of Prefrontal Brain Regions in Components of Working Memory: Effects of Memory Load and Individual Differences," *Proceeding of National Academy of Sciences of the United States of America*, Vol. 96, No. 11, 1999, pp. 6558-6663. doi:10.1073/pnas.96.11.6558
- [7] W. C. Choo, W. W. Lee, V. Venkatraman, F. S. Sheu and M. W. Chee, " Dissociation of Cortical Regions Modulated Byboth Working Memory Load and Sleep Deprivation and by Sleep Deprivation Alone," *Neuroimage*, Vol. 25, No. 2, 2005, pp. 579-587. doi:10.1016/j.neuroimage.2004.11.029
- [8] J. Lim and D. F. Dinges, " Sleep Deprivation and Vigilant Attention," *Annals of the New York Academy of Science*, Vol. 1129, No. 1129, 2008, pp. 305-322. doi:10.1196/annals.1417.002
- [9] N. Goel, H. Rao, J. S. Durmer and D. F. Dinges, " Neurocognitive Consequences of Sleep Deprivation," *Seminars on Neurology*, Vol. 29, No. 4, 2009, pp. 320-339. doi:10.1055/s-0029-1237117
- [10] J. Jenkins and K. Dallenbach, " Obliviscence During Sleep and Waking," *The American Journal of Psychology*, Vol. 35, 1924, pp. 605-612. doi:10.2307/1414040
- [11] S. S. Yoo, P. T. Hu, N. Gujar, F. A. Jolesz and M. P. Walker, " A Deficit in the Ability to Form New Human Memories without Sleep," *Nature Neurosciene*, Vol. 10, No. 3, 2007, pp. 385-392. doi:10.1038/nn1851
- [12] A. Baddeley, " Working Memory," *Science*, Vol. 255, No. 5044, 1992, pp. 556-559. doi:10.1126/science.1736359
- [13] A. Baddeley, " Working Memory," *Current Biology*, Vol. 20, No. 4, 2010, pp. 136-140. doi:10.1016/j.cub.2009.12.014
- [14] M. W. Chee, L. Y. Chuah, V. Venkatraman, W. Y. Chan, P. Philip and D. F. Dinges, " Functional Imaging of Working Memory Following Normal Sleep and after 24 and 35 h of Sleep Deprivation: Correlations of Frontoparietal Activation with Performance," *Neuroimage*, Vol. 31, No. 1, 2006, pp. 419-428. doi:10.1016/j.neuroimage.2005.12.001
- [15] E. K. Vogel, G. F. Woodman and S. J. Luck, " Storage of Features, Conjunctions and Objects in Visual Working Memory," *Journal of Experimental Psychology, Human Perception and Performance*, Vol. 27, No. 1, 2001, pp. 92-114.
- [16] T. H. Turner, S. P. Drummond, J. S. Salamat and G. G. Brown, " Effects of 42 Hr of Total Sleep Deprivation on Component Processes of Verbal Working Memory," *Neuropsychology*, Vol. 21, No. 6, 2007, pp. 787-795. doi:10.1037/0894-4105.21.6.787
- [17] K. Jones and Y. Harrison, " Frontal Lobe Function, Sleep Loss and Fragmented Sleep," *Sleep Medicine Reviews*, Vol. 5, No. 6, 2001, pp. 463-475. doi:10.1053/smr.2001.0203
- [18] A. Muzur, E. F. Pace-Schott and J. A. Hobson, " The Prefrontal Cortex in Sleep," *Trends in Cognitive Science*, Vol. 6, No. 11, 2002, pp. 475-481. doi:10.1016/S1364-6613(02)01992-7
- [19] P. A. Reuter-Lorenz, J. Jonides, E. E. Smith, A. Hartley, A. Miller, C. Marshuetz and R. A. Koeppe, " Age Differences in the Frontal Lateralization of Verbal and Spatial Working Memory Revealed by PET," *Journal of Cognitive Neuroscience*, Vol. 12, No. 1, 2000, pp. 174-187. doi:10.1162/089892900561814
- [20] M. W. Chee and W. C. Choo, " Functional Imaging of Working Memory after 24 Hr. of Total Sleep Deprivation," *Journal of Neuroscience*, Vol. 24, No. 19, 2004, pp. 4560-4567. doi:10.1523/JNEUROSCI.0007-04.2004
- [21] S. P. Drummond, G. G. Brown, J. C. Gillin, J. L. Stricker, E. C. Wong and R. B. Buxton, " Altered Brain Response to Verbal Learning Following Sleep Deprivation," *Nature*, Vol. 403, No. 6770, 2000, pp. 655-657. doi:10.1038/35001068
- [22] F. Jiang, R. D. VanDyke, J. Zhang, F. Li, D. Gozal and X. Shen, " Effect of Chronic Sleep Restriction on Sleepiness and Working Memory in Adolescents and Young Adults," *Journal of Clinical and Experimental Neuropsychology*, Vol. 33, No. 8, 2011, pp. 892-900. doi:10.1080/13803395.2011.570252
- [23] B. S. McEwen, " Sleep Deprivation as a Neurobiologic and Physiologic Stressor: Allostasis and Allostatic Load," *Metabolism*, Vol. 55, No. 10, 2006, pp. S20-S23. doi:10.1016/j.metabol.2006.07.008

- [24] R. Leproult, G. Copinschi, O. Buxton and E. Van Cauter, " Sleep Loss Results in an Elevation of Cortisol Levels the Next Evening," *Sleep*, Vol. 20, No. 10, 1997, pp. 865-870.
- [25] A. Omisade, O. M. Buxton and B. Rusak, " Impact of Acute Sleep Restriction on Cortisol and Leptin Levels in Young Women," *Physiological Behavior*, Vol. 99, No. 5, 2011, pp. 651-656. doi:10.1016/j.physbeh.2010.01.028
- [26] F. S. Maheu, P. Collicutt, R. Kornik, R. Moszkowski and S. J. Lupien, " The Perfect Time to be Stressed: A Differential Modulation of Human Memory by Stress Applied in the Morning or in the Afternoon," *Progress in Neuropsychopharmacology and Biological Psychiatry*, Vol. 29, No. 8, 2005, pp. 1281-1288.
- [27] D. Schoofs, D. Preub and O. Wolf, " Psychosocial Stress Induces Working Memory Impairments in an N-Back Paradigm," *Psychoneuroendocrinology*, Vol. 33, No. 5, 2008, pp. 643-653. doi:10.1016/j.psyneuen.2008.02.004
- [28] J. H. Callicott, V. S. Mattay, A. Bertolino, K. Finn, R. Coppola, J. A. Frank, T. E. Goldberg and D. R. Weinberger, " Physiological Characteristics of Capacity Constraints in Working Memory as Revealed by Functional MRI," *Cerebral Cortex*, Vol. 9, No. 1, 1999, pp. 20-26. doi:10.1016/j.psyneuen.2008.02.004
- [29] K. Kuriyama, K. Mishima H. Suzuki, S. Aritake and M. Uchiyama, " Sleep Accelerates the Improvement in Working Memory Performance," *Journal of Neuroscience*, Vol. 28, No. 40, 2008, pp. 10145-10150. doi:10.1523/JNEUROSCI.2039-08.2008
- [30] A. M. Owen, K. M. McMillan, A. R. Laird and E. Bullmore, " N-Back Working Memory Paradigm: A Meta-Analysis of Normative Functional Neuroimaging Studies," *Hum Brain Mapping*, Vol. 25, No. 1, 2005, pp. 46-59. doi:10.1002/hbm.20131
- [31] A. E. Ruiz-Contreras, G. Soria-Rodríguez, G. A. Almeida-Rosas, P. A. García-Vaca, M. Delgado-Herrera, M. Méndez-Díaz and O. Prospéro-García, " Low Diversity and Low Frequency of Participation in Leisure Activities Compromise Working Memoryefficiency in Young Adults," *Acta Psychologica*, Vol. 139, No. 1, 2012, pp. 91-96. doi:10.1016/j.actpsy.2011.10.011
- [32] C. E. Kellog and N. W. Morton, " Beta III," *Manual Moderno*, México, 2003.
- [33] D. H. Hellhammer, S. Wüst and B. M. Kudielka, " Salivary Cortisol as a Biomarker in Stress Research," *Psychoneuroendocrinology*, Vol. 34, No. 2, 2009, pp. 163-171.
- [34] W. J. Inder, G. Dimeski and A. Russell, " Measurement of Salivary Cortisol in 2012—Laboratory Techniques and Clinical Indications," *Clinical Endocrinology*, Vol. 77, No. 5, 2012, pp. 645-651. doi:10.1111/j.1365-2265.2012.04508.x
- [35] A. Abi-Dargham, O. Mawlawi, I. Lombardo, R. Gil, D. Martinez, Y. Huang, D. R. Hwang, J. Keilp, L. Kochan, R. Van Heertum, J. M. Gorman and M. Laruelle, " Prefrontal Dopamine D1 Receptors and Working Memory in Schizophrenia," *Journal of Neuroscience*, Vol. 22, No. 9, 2002, pp. 3708-3719.
- [36] T. S. Braver, J. D. Cohen, L. E. Nystrom, J. Jonides, E. E. Smith and D. C. Noll, " A Parametric Study of Prefrontal Cortex Involvement in Human Working Memory," *Neuroimage*, Vol. 5, No. 1, 1997, pp. 49-62. doi:10.1006/nimg.1996.0247
- [37] E. R. De Kloet, M. S. Oitzl and M. Jo?ls, " Stress and Cognition: Are Corticosteroids Good or Bad Guys?" *Trends in Neuroscience*, Vol. 22, No. 10, 1999, pp. 422-426. doi:10.1016/S0166-2236(99)01438-1
- [38] K. Dedovic, A. Duchesne, J. Andrews, V. Engert and J. C. Pruessner, " The Brain and the Stress Axis: The Neural Correlates of Cortisol Regulation in Response to Stress," *Neuroimage*, Vol. 47, No. 3, 2009, pp. 864-871. doi:10.1016/j.neuroimage.2009.05.074
- [39] C. Libedinsky, D. V. Smith, C. S. Teng, P. Namburi, V. W. Chen, S. A. Huettel and M. W. Chee, " Sleep Deprivation Alters Valuation Signals in the Ventromedial Prefrontal Cortex," *Frontiers in Behavioral Neuroscience*, Vol. 5, No. 1-10, 2011, p. 70. doi:10.3389/fnbeh.2011.00070
- [40] S. E. Petersen and M. I. Posner, " The Attention System of the Human Brain: 20 Years after," *Annual Review of Neuroscience*, Vol. 35, No. 35, 2012, pp. 73-89. doi:10.1146/annurev-neuro-062111-150525

