Chem. Senses 33: 223–224, 2008
doi:10.1093/chemse/bjm076
Advance Access publication November 20, 2007

LETTER TO THE EDITOR

Higher Sensitivity to Perithreshold Odors when Sitting than when Supine May Be Correlated with Postural Differences in Locus Coeruleus Activity

Darren M. Lipnicki

Center of Space Medicine Berlin, Arnimallee 22, 14195 Berlin, Germany

Correspondence to be sent to: Darren M. Lipnicki, Zentrum für Weltraummedizin Berlin, Arnimallee 22,14195 Berlin, Germany. e-mail: darrenlipnicki@hotmail.com

Lundström et al. (2007) report an effect of posture on perithreshold odor sensitivity, which they found to be higher when sitting than when lying down (consistent with earlier work described in Lundstrom et al. 2006). The explanation for this result focused on cognitive mechanisms, with support seen in there being better performance on the Raven's Progressive Matrices test when sitting than when lying down. I suggest here how a postural difference in locus coeruleus (LC) activity may be correlated with these findings.

With its widespread noradrenergic innervation of the brain, the LC is an important modulator of perception and of other behavioral processes that include arousal, attention, and cognition (Berridge and Waterhouse 2003). Noradrenergic modulation of olfaction can begin in the olfactory bulb (Doucette et al. 2007), a recipient of fibers from the LC (Shipley et al. 1985). Evidence suggests that noradrenergic output from the LC to the olfactory bulb increases the ability to detect perithreshold odors, with LC activation shown to increase mitral cell responsivity to electrical stimulation of the olfactory epithelium at perithreshold intensities (Jiang et al. 1996). Congruent with this, application of noradrenaline to slice preparations was found to enhance the early excitatory response of mitral cells to perithreshold level stimulation of the olfactory nerve (Ciombor et al. 1999).

There is reason to think that posture affects LC activity, which is modulated by baroreceptors in the aorta, carotid arteries, heart, and lungs that respond to blood volume load. Both LC activity and cortical noradrenaline release increase when baroreceptor load is lessened and decrease when baroreceptor load is intensified (Persson and Svensson 1981; Murase et al. 1994). Gravitational effects on blood distribution result in a greater baroreceptor load when lying down than when more upright (Mohrman and Heller 2003). This suggests that LC and central noradrenergic activity are reduced when lying down (Elam et al. 1984); an idea supported by electroencephalographic evidence (Cole 1989) and consistent with faster solution times for anagrams when supine than when more upright (Lipnicki and Byrne 2005), given a detrimental effect of central noradrenergic activity on the ability to solve anagrams (Beversdorf et al. 2002). In contrast to anagrams, there is evidence that monoaminergic activity improves performance on the Raven's Progressive Matrices test (Mattay et al. 1996), suggesting that the finding of Lundström et al. of higher Raven's Progressive Matrices test scores when sitting than when supine may also be correlated with postural differences in LC activity.

In what I have outlined above, my primary intention has been to show that postural differences in LC activity may be correlated with the finding of Lundström et al. of perithreshold odor sensitivity being higher when sitting than when lying down. This effect could be produced directly by noradrenergic enhancement of mitral cell responsivity to perithreshold odors when sitting and/or indirectly through a modulation of cognitive processes. The extent to which each of these mechanisms may be involved, and any degree of interaction between them, remains to be determined.

Acknowledgement

Darren M. Lipnicki is supported by a Research Fellowship from the Alexander von Humboldt Foundation.

References

Berridge CW, Waterhouse BD. 2003. The locus coeruleus-noradrenergic system: modulation of behavioral state and state-dependent cognitive processes. Brain Res Rev. 42:33–84.

Beversdorf DQ, White DM, Chever DC, Hughes JD, Bornstein RA. 2002. Central beta-adrenergic modulation of cognitive flexibility. Neuroreport. 13:2505–2507.

Ciombor KJ, Ennis M, Shipley MT. 1999. Norepinephrine increases rat mitral cell excitatory responses to weak olfactory nerve input via alpha-1 receptors in vitro. Neuroscience. 90:595–606.

Cole RJ. 1989. Postural baroreflex stimuli may affect EEG arousal and sleep in humans. J Appl Physiol. 67:2369–2375.

Doucette W, Milder J, Restrepo D. 2007. Adrenergic modulation of olfactory bulb circuitry affects odor discrimination. Learn Mem. 14:539–547.

Elam M, Yao T, Svensson TH, Thoren P. 1984. Regulation of locus coeruleus neurons and splanchnic, sympathetic nerves by cardiovascular afferents. Brain Res. 290:281–287.

Jiang M, Griff ER, Ennis M, Zimmer LA, Shipley MT. 1996. Activation of locus coeruleus enhances the responses of olfactory bulb mitral cells to weak olfactory nerve input. J Neurosci. 16:6319–6329.

Lipnicki DM, Byrne DG. 2005. Thinking on your back: solving anagrams faster when supine than when standing. Brain Res Cog Brain Res. 24: 719–722.

Lundström JN, Boyle JA, Jones-Gotman M. 2006. Sit up and smell the roses better: olfactory sensitivity to phenyl ethyl alcohol is dependent on body position. Chem Senses. 31:249–252.

Lundström JN, Boyle JA, Jones-Gotman M. 2007. Body position-dependent shift in odor percept present only for perithreshold odors. Chem Senses. Advance Access published August 30, 2007, doi: 10.1093/chemse/bjm059.

Mattay VS, Berman KF, Ostrem JL, Esposito G, Van Horn JD, Bigelow LB, Weinberger DR. 1996. Dextroamphetamine enhances "neural network-specific" physiological signals: a positron-emission tomography rCBF study. J Neurosci. 16:4816–4822.

Mohrman DE, Heller LJ. 2003. Cardiovascular physiology. 5th ed. New York: Lange Medical Books/McGraw-Hill.

Murase S, Inui K, Nosaka S. 1994. Baroreceptor inhibition of the locus coeruleus noradrenergic neurons. Neuroscience. 61:635–643.

Persson B, Svensson TH. 1981. Control of behaviour and brain noradrenaline neurons by peripheral blood volume receptors. J Neural Transm. 52:73–82.

Shipley MT, Halloran FJ, de la Torre J. 1985. Surprisingly rich projection from the locus coeruleus to the olfactory bulb in the rat. Brain Res. 329: 294–299.

Accepted October 15, 2007