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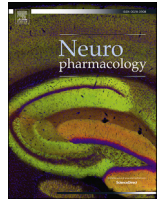
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Editorial

Histamine receptors



Histamine and its receptors in the nervous system received recognition late in comparison to the other aminergic transmitters, after the detection of histaminergic neurons in the posterior hypothalamus (Panula et al., 1984; Watanabe et al., 1984). Four G-protein coupled receptors have been identified in vertebrates (Panula et al., 2015), at least 3 of which fulfill important functions in the brain. H₁Rs mediate mostly neuronal excitation and are blocked by the classical antihistamines causing sedation, H₂R activation also excites certain neurons, H₂R-antagonists revolutionized stomach ulcer treatment and H₃Rs are inhibitory autoreceptors and heteroreceptors with complex pre- and postsynaptic functions. For the most recently described H₄R mediation of neural actions are so far uncertain. In this issue a number of specific functions in the nervous system are reviewed or presented by authors using different approaches and methods from molecules to mind, from synapse to behavior. Whereas the cloning of the H₃R (Lovenberg et al., 1999) transformed the drug development for this target, the H₁R and H₂R are still being investigated as important postsynaptic histamine receptors in the brain. For example, the metabolic side effects of antipsychotics are largely due to H₁R antagonism in the hypothalamus. In this issue Provensi et al. 2016 review feeding disorders and therapeutic opportunities to prevent obesity and metabolic syndrome. Tabarean (2016) treats the role of histamine receptors in the hypothalamic energy homeostasis. Parmentier et al. (2016) demonstrate the prominent role of the H₁R in cortical activation. J-C Schwartz (2016) who made major discoveries in the field since almost half a century, detected the H₃R and, together with J-M Lecomte developed the first H₃R antagonist/inverse agonist drug that just entered the market (Wakix).

There is evidence from clinical studies that H₂R antagonists may be useful in schizophrenia, but no new brain-penetrating drugs have been developed. The potential of H₃R antagonists in brain disorders is still evident, although their capacity to improve cognition has not been shown in clinical studies. They are being used to treat sleep/wakefulness disorders. Animal studies from several laboratories have shown that H₃R antagonists inhibit alcohol drinking, alcohol-induced place preference and cue-induced reinstatement of alcohol seeking. However, clinical studies have not been carried out. Several histamine H₃R antagonists have been developed over the last decade but only one has been filed so far (Dauvilliers et al., 2013). Hudkins et al. (2016) and Sadek et al. (2016) describe the production, development and testing of new H₃R antagonists. Furthermore Sadek and Stark (2016) compare the affinity, selectivity and efficacy of typical ligands for all histamine receptors.

Bolam and Ellender (2016) review the complex mechanisms by

which histamine regulates striatal functions through H₁R, H₂R and H₃R. Keeping in mind that many other parts of the motor system, including the thalamus and cortex, also are regulated by histamine, the complexity of this system is evident. Histamine interacts with many other neurotransmitter systems. An important finding was that lack of histamine synthesis due to a mutation in the synthesizing enzyme histidine decarboxylase is associated with Gilles de la Tourette syndrome (Ercan-Sencicek et al., 2010). Subsequently, histaminergic regulation of the striatum has become an important field (Rapanelli and Pittenger, 2016). In the striatal areas, including the nucleus caudatus and accumbens, interactions with dopamine are particularly important (Aquino-Miranda et al., 2016). DeLuca et al. (2016) report a dopaminergic neuron group in the tuberomammillary nucleus and revisit the H₃R autoreceptor function.

A role of the H₄R in brain has not been conclusively shown: some studies have suggested the presence of this receptor in neurons, whereas others have not found evidence of neuronal expression. Some of the early experimental H₃R drugs have later proven to be good ligands at H₄R as well, which may complicate interpretation of pharmacological studies. There is evidence of H₄R expression in non-neuronal cells in the brain. The importance of the tools used to assess the role of histamine receptors in the brain is emphasized in the review by Schneider et al. (2016). They conclude that there is no evidence so far for H₄R expression and function in nervous tissue. Petri et al. (2016) investigated the presynaptic interaction of H₃R and H₄R on four peripheral tissues and one brain tissue model in vitro. Only H₃R activation reduced the release of other transmitters, none of the synaptic sites displayed H₄R mediated effects.

Zlomuzica et al. (2016) review the role of histamine and its receptors in cognition and possible prevention of cognitive decline in Alzheimer's dementia. Yeung et al. (2016) show ventral hippocampal infusions of histamine causing anxiolysis and an increase in theta activity, whereas the anxiolytic diazepam reduces theta. These results question the functional role of theta frequency depression in the hippocampus for anxiolysis. Nuutinen et al. (2016) report the effects of H₃R antagonism on motivational aspects of alcohol reinforcement and suggest a therapeutic strategy to reduce craving and to prevent relapse.

The histaminergic system in brain is recognized now as a major player in the ascending activation of the forebrain, the hypothalamic homeostasis and the endocrine system (Haas et al., 2008) and histamine receptors are still actively explored on a wide range of therapeutic targets. This motivated us to assemble a number of reviews and research papers in this special issue.

References

- Aquino-Miranda, G., Escamilla-Sánchez, J., González-Pantoja, R., Bueno-Nava, A., Arias-Montaño, J.A., 2016. Histamine H3 receptor activation inhibits dopamine synthesis but not release or uptake in rat nucleus accumbens. *Neuropharmacology* 106, 91–101. <http://dx.doi.org/10.1016/j.neuropharm.2015.07.006>.
- Bolam, J.P., Ellender, T.J., 2016. Histamine and the striatum. *Neuropharmacology* 106, 74–84. <http://dx.doi.org/10.1016/j.neuropharm.2015.08.013>.
- De Luca, R., Suvorava, T., Yang, D., Baumgärtel, W., Kojda, G., Haas, H.L., Sergeeva, O.A., 2016. Identification of histaminergic neurons through histamine 3 receptor-mediated autoinhibition. *Neuropharmacology* 106, 102–115. <http://dx.doi.org/10.1016/j.neuropharm.2015.08.025>.
- Dauvilliers, Y., Bassetti, C., Lammers, G.J., Arnulf, I., Mayer, G., Rodenbeck, A., Leher, P., Ding, C.L., Lecomte, J.M., Schwartz, J.C., HARMONY 1 study group, 2013. Pitolisat versus placebo or modafinil in patients with narcolepsy: a double-blind, randomised trial. *Lancet Neurol.* 12, 1068–1075.
- Ercan-Sencicek, A.G., Stillman, A.A., Ghosh, A.K., Bilguvar, K., O’Roak, B.J., Mason, C.E., Abbott, T., Gupta, A., King, R.A., Pauls, D.L., Tischfield, J.A., Heiman, G.A., Singer, H.S., Gilbert, D.L., Hoekstra, P.J., Morgan, T.M., Loring, E., Yasuno, K., Fernandez, T., Sanders, S., Louvi, A., Cho, J.H., Mane, S., Colangelo, C.M., Biederer, T., Lifton, R.P., Gunel, M., State, M.W., 2010. L-histidine decarboxylase and Tourette’s syndrome. *N. Engl. J. Med.* 362, 1901–1908.
- Haas, H.L., Sergeeva, O.A., Selbach, O., 2008. Histamine in the nervous system. *Physiol. Rev.* 88, 1183–1242.
- Hudkins, R.L., Gruner, J.A., Raddatz, R., Mathiasen, J.R., Aimone, L.D., Marino, M.J., Bacon, E.R., Williams, M., Ator, M.A., 2016. 3-(1’-Cyclobutylspiro [4H-1, 3-benzodioxine-2, 4’-piperidine]-6-yl)-5, 5-dimethyl-1, 4-dihydropyridazin-6-one (CEP-32215), a new wake-promoting histamine H3 antagonist/inverse agonist. *Neuropharmacology* 106, 37–45. <http://dx.doi.org/10.1016/j.neuropharm.2015.09.025>.
- Lovenberg, T.W., Roland, B.L., Wilson, S.J., Jiang, X., Pyati, J., Huvar, A., Jackson, M.R., Erlander, M.G., 1999. Cloning and functional expression of the human histamine H3 receptor. *Mol. Pharmacol.* 55, 1101–1107.
- Nuutinen, S., Mäki, T., Rozov, S., Bäckström, P., Hyytiä, P., Piepponen, P., Panula, P., 2016. Histamine H3 receptor antagonist decreases cue-induced alcohol reinstatement in mice. *Neuropharmacology* 106, 156–163.
- Panula, P., Chazot, P.L., Cowart, M., Gutzmer, R., Leurs, R., Liu, W.L., Stark, H., Thurmond, R.L., Haas, H.L., 2015. International union of basic and clinical pharmacology. XCVIII. Histamine receptors. *Pharmacol. Rev.* 67, 601–655.
- Panula, P., Yang, H.Y., Costa, E., 1984. Histamine-containing neurons in the rat hypothalamus. *Proc. Natl. Acad. Sci. U. S. A.* 8, 2572–2576.
- Parmentier, R., Zhao, Y., Perier, M., Akaoka, H., Lintunen, M., Hou, Y., Panula, P., Watanabe, T., Franco, P., Lin, J.S., 2016. Role of histamine H1-receptor on behavioral states and wake maintenance during deficiency of a brain activating system: a study using a knockout mouse model. *Neuropharmacology* 106, 20–34. <http://dx.doi.org/10.1016/j.neuropharm.2015.12.014>.
- Petri, D., Schlicker, E., 2016. A search for presynaptic inhibitory histamine receptors in guinea-pig tissues: Further H3 receptors but no evidence for H4 receptors. *Neuropharmacology* 106, 129–134. <http://dx.doi.org/10.1016/j.neuropharm.2015.06.020>.
- Provensi, G., Blandina, P., Passani, M.B., 2016. The histaminergic system as a target for the prevention of obesity and metabolic syndrome. *Neuropharmacology* 106, 3–12. <http://dx.doi.org/10.1016/j.neuropharm.2015.07.002>.
- Rapanelli, M., Pittenger, C., 2016. Histamine and histamine receptors in Tourette syndrome and other neuropsychiatric conditions. *Neuropharmacology* 106, 85–90. <http://dx.doi.org/10.1016/j.neuropharm.2015.08.019>.
- Watanabe, T., Taguchi, Y., Shiosaka, S., Tanaka, J., Kubota, H., Terano, Y., Tohyama, M., Wada, H., 1984. Distribution of the histaminergic neuron system in the central nervous system of rats; a fluorescent immunohistochemical analysis with histidine decarboxylase as a marker. *Brain Res.* 295, 13–25.
- Tabarean, I.V., 2016. Histamine receptor signaling in energy homeostasis. *Neuropharmacology* 106, 13–19. <http://dx.doi.org/10.1016/j.neuropharm.2015.04.011>.
- Schwartz, J.C., Lecomte, J.M., 2016. Clinical trials with H3-receptor inverse agonists: What they tell us about the role of histamine in the human brain. *Neuropharmacology* 106, 35–36. <http://dx.doi.org/10.1016/j.neuropharm.2016.04.006>.
- Sadek, B., Saad, A., Subramanian, D., Shafiqullah, M., Łażewska, D., Kieć-Kononowicz, K., 2016. Anticonvulsant and procognitive properties of the non-imidazole histamine H3 receptor antagonist DL77 in male adult rats. *Neuropharmacology* 106, 46–55. <http://dx.doi.org/10.1016/j.neuropharm.2015.10.023>.
- Sadek, B., Stark, H., 2016. Cherry-picked ligands at histamine receptor subtypes. *Neuropharmacology* 106, 56–73. <http://dx.doi.org/10.1016/j.neuropharm.2015.11.005>.
- Schneider, E.H., Seifert, R., 2016. The histamine H 4-receptor and the central and peripheral nervous system: a critical analysis of the literature. *Neuropharmacology* 106, 116–128. <http://dx.doi.org/10.1016/j.neuropharm.2015.05.004>.
- Yeung, M., Treit, D., Dickson, C.T., 2016. Ventral hippocampal histamine increases the frequency of evoked theta rhythm but produces anxiolytic-like effects in the elevated plus maze. *Neuropharmacology* 106, 146–155. <http://dx.doi.org/10.1016/j.neuropharm.2015.09.024>.
- Zlomuzica, A., Dere, D., Binder, S., Silva, M.A.D.S., Huston, J.P., Dere, E., 2016. Neuronal histamine and cognitive symptoms in Alzheimer’s disease. *Neuropharmacology* 106, 135–145. <http://dx.doi.org/10.1016/j.neuropharm.2015.05.007>.

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