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Evidence that parvalbumin GABAergic neurons play a role in pacing kainate-induced theta-frequency activity in the rat medial septum/diagonal band of Broca in vitro

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We have previously demonstrated (unpublished data) that extracellular field activity at theta frequency (4-15 Hz) can be evoked in the medial septum/diagonal band of Broca (MS/DB) slice in vitro in the presence of kainate. To investigate the involvement of the neuronal populations of the MS/DB in this activity, we carried out simultaneous intracellular and extracellular field recordings.

MS/DB slices were prepared from male Wistar rats (21 days) which were terminally anaesthetised with pentobarbitone sodium (120 mg kg^{-1}, I.P.). The animals were transcardially perfused with ~25 ml of modified ACSF and rapidly decapitated. Longitudinal slices (450 µm) were placed in an interface recording chamber and maintained at 32°C. Persistent theta oscillations were induced by bath application of 100 nM kainate.

Previously we have demonstrated that the kainate-induced theta frequency activity in the MS/DB is significantly reduced upon application of the $GABA_A$ receptor antagonist bicuculline. Here we show that there is also a significant reduction in the peak power at theta range following application of the AMPA/kainate receptor antagonist NBQX (10 µM, n = 4, $P < 0.05$, Man-Whitney rank sum test), but not after application of the specific AMPA antagonist SYM 2206 (10 µM, n = 12) or the NMDA receptor antagonist D-AP5, (50 µM, n = 12). Moreover, we demonstrate that the regions where we find extracellular field recordings of kainate-induced theta frequency activity correspond to areas of the MS/DB that have parvalbumin immunopositive somata. Therefore these data suggest that the theta activity is dependent upon both kainate receptor and $GABA_A$ receptor activation. Intracellular recordings were made from three types of MS/DB neuron during extracellular field recordings of kainate-induced theta-frequency activity. These neurons were identified as fast-spiking, slow-firing and regular-spiking according to previous criteria (Gorelova & Reiner, 1996; Morris et al. 1999). The fast-spiking type (n = 5) displayed spontaneous and persistent rhythmic single spiking activity at theta frequencies. The slow-firing (n = 5) and regular-spiking (n = 1) types displayed non-rhythmic single spiking activity. Previous studies have shown that fast-spiking and regular-spiking neurons in the MS/DB are GABAergic and that parvalbumin is localised selectively in the fast-spiking neuron type; conversely the slow-firing neurons were shown to be cholinergic. We conclude that the parvalbumin GABAergic neurons may pace rhythmic theta activity in the MS/DB.

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Where applicable, experiments conform with Society ethical requirements