Alpha Rhythm

During relaxed wakefulness the human brain exhibits pronounced rhythmic waves in the alpha frequency band (8-13 Hz), the most prominent of which is the ‘classical’ alpha rhythm, that is clearly evident over the occipital cortex and was originally discovered by the ground-breaking work of Hans Berger in the 1920’s.

Thus, humans who are sitting quietly with their eyes closed (i.e. in a behavioural state of relaxed wakefulness) exhibit prominent rhythmic activity at around 10 Hz

in the EEG. These ‘waves of the first order’ (as Berger originally called them) or ‘alpha waves’ are drastically diminished in amplitude or blocked upon eye opening or during certain types of mental effort. The classical alpha rhythm, therefore, is mostly considered to represent a ‘resting’ or ‘idling’ state of brain. EEG activities at alpha frequency, however, are not only a feature of an idle brain, since they are not entirely blocked by eye opening, and can be associated with certain aspects of perception. Moreover, the well-characterized properties of the alpha rhythm (including its ‘slow’ and ‘fast’ variants) in early infancy, childhood and adulthood, as well as in comatose patients, and the clear slowing of this rhythm in many neurological disorders, make this EEG activity a useful tool in neurology. The sources of the electrical events that are reflected in the scalp EEG as alpha waves are located in the neocortex. It has been less clear, however, where the rhythm generator that drives these events resides. Recent evidence from human and animal, invasive and non-invasive studies, now points to a complex interaction between cortical and thalamic oscillators as the basis for alpha rhythms. Interestingly, the thalamic
mechanism that lead to the generation of the alpha rhythm are similar to those of the theta waves present in the early stage of non-REM sleep. Thus, at the thalamic level, alpha and theta waves form a continuum of activity which is underpinned by the same intrinsic neuronal and network behaviour (Figs. 1 & 2).
Masking text
OUR RESEARCH
Our work has significantly contributed to an increased understanding of the cellular and network mechanisms that underlie the alpha rhythm. In particular, our major findings in this field include:

Ø discovery of ‘High Threshold Bursts’ (Fig. 2) as a novel form of firing of thalamocortical neurons and their synchronization by gap-junction coupling (Fig. 3) as the mechanism for alpha rhythm generation in thalamo- cortical neurons
(see publications 2, 4 and 7, below)

Ø characterization of the essential contribution by thalamic interneurons to alpha rhythm expression (Fig. 4)
(see publication 1, below);

Ø identification of a major contribution by thalamic neuronal ensembles to the EEG alpha rhythm
(see publications 1 and 6, below)
masking text

We are now investigating the cellular and network processes that operate in the occipital cortex during the alpha rhythm, and whether the alpha band component that accompanies EEG waves during certain aspects of perception originates from thalamic and cortical mechanisms similar to those of the classical alpha rhythm.

Details of our discoveries in this field can be found in the following publications:
1. Lörincz, M., Kekesi, K., Juhasz, G., Crunelli, V. andHughes, S.W. (2009). Temporal framing of thalamic relay-mode firing by phasic inhibition during the alpha rhythm. Neuron, 63, 683-696.
2. Lörincz, M., Crunelli, V. andHughes, S.W. (2008) Cellular dynamics of cholinergically induced alpha (8-13 Hz) rhythms in sensory thalamic nuclei in vitro. J. Neurosci., 28, 660-671.
3. Hughes, S. W., Lörincz, M., Cope D.W. and Crunelli, V. (2008). NeuReal: An interactive simulation system for implementing artificial dendrites and large hybrid networks. J. Neurosci. Meth., 169, 290-301.
4. Hughes, S.W. and Crunelli, V. (2007). Just a phase they're going through: The complex interaction of intrinsic high-threshold bursting and gap junctions in the generation of thalamic alpha and theta rhythms. Int. J. Psychophysiol., 64, 3-17.
5. Crunelli, V.,Cope, D.W. and Hughes, S.W. (2006). Thalamic T-type Ca2+ channels and NREM sleep. Cell Calcium, 40, 175-190.
6. Hughes, S.W. and Crunelli, V. (2005). Thalamic mechanisms of EEG alpha rhythms and their pathological implications. Neuroscientist, 11, 1-16.
7. Hughes, S.W., Lörincz, M., Cope, D.W., Blethyn, K.L., Kékesi, K.A., Parri, H.R., Juhász, G. and Crunelli, V. (2004) Synchronized oscillations at alpha and theta frequencies in the lateral geniculate nucleus. Neuron, 42, 253-68.