Visual stimuli elicit depolarizing waves that propagate across the visual cortex in freshwater turtles. These waves can be studied using multiple electrode arrays (Prechtl, 1994) or voltage sensitive dyes (Senseman, 1996). They occur in both alert turtles and in *in vitro* preparations of the eyes and brain. Recent work in our laboratories (Ghosh et al., 2002) suggests that information about the position of stimuli in visual space is coded in the spatiotemporal dynamics of the waves. We have constructed a large-scale model of the visual cortex, including inputs from the dorsal lateral geniculate complex, that accurately simulate cortical waves following the presentation of simulated retinal flashes, light flashes at spots on the retina and moving spots. Although our model supports the hypothesis that the waves in turtle visual cortex result from synaptic interactions within the cortex, it is not known what roles specific types of ligand-gated receptors play in controlling the dynamics of the wave. The purpose of this study was to investigate the roles of the AMPA and NMDA subtypes of glutamate receptors and of the GABAa and GABAb subtypes of GABA receptors in controlling the velocities and durations of cortical waves.

The model consists of 744 cortical neurons and 201 geniculate neurons. The cortical neurons include pyramidal cells and two types of inhibitory interneurons (stellate cells and horizontal cells). Individual neurons were modeled as multicompartment models that were constrained by anatomical and physiological data obtained from real cortical cells. Geniculate neurons were modeled as single compartment models with axons that extend from lateral to medial across the cortex. The location of geniculocortical synapses was based upon anatomical data. The spatial distributions of each type of cortical neuron was based on anatomical data, and the ratios of each of the types of neurons were chosen so as to preserve the ratios observed in real cortices. Voltage-gated channels were modeled using Hodgkin-Huxley like kinetic schemes. Apparent unitary postsynaptic potentials for AMPA-, NMDA-, GABAa- and GABAb-receptor mediated events were constrained by physiological data. The model was implemented using *Genesis*. Diffuse flashes of light presented to the retina were simulated by simultaneously activating all of the geniculate neurons for 150 ms. The resulting cortical waves were recorded as stored as movies. The latencies of the waves along three transects across the cortex were measured as the latency to the half-height of the wave (see Senseman and Robbins, 2002). The densities of each type of receptor on specific types of cortical neurons were systematically varied and the effects of these alterations on the velocities of the waves and the durations of the waves were calculated.

Intracortical axons are known to access both the AMPA and NMDA subtypes of glutamate receptors (Larson-Prior et al., 1991). As an example of the effect of glutamate receptors on wave behavior, the density of AMPA receptors at the synapses effected by pyramidal cell collaterals on other pyramidal cells were varied

from 50 % to 150 % of the densities present in the model. Increasing the densities increased the velocity of the waves up the the value of 150 %, at which point the cortex became unstable and activity persisted indefinitely. Decreasing the densities decreased the velocity of the waves. The latency plots were non-linear, indicating that the velocity of the wave changes as it propagates from lateral to medial across the cortex. Inhibitory neurons access both GABAa and GABAb receptors on their postsynaptic targets (Khatri and Ulinski, 2000). As an example of the effect of GABA receptors on wave behavior, the density of GABAa receptors was varied from 75 % to 115 % of the density present in the model. Varying the density of GABAa receptors systematically varied the duration of the wave. Increasing the density from 100 % to 115 % caused the wave to die out in 500 ms, rather than nearly 1,200 ms. Decreasing the density to 75 % caused the wave to become unstable. Other effects of changing the densities of receptor types on specific populations of neurons will be presented as well.

These simulations indicate that the spatiotemporal dynamics of the waves in turtle visual cortex are determined by the balance of excitatory and inhibitory mechanisms operating in the cortex. Relatively small changes in the densities of GABAa receptors, for example, can have major effects on the temporal dynamics of the wave. Since information about stimuli in visual space appears to be coded in the dynamics of the wave, we expect that these finding will help us understand how information can be coded in ways that are quite different than the topographic representations that are common in mammalian sensory cortices.

References:

Ghosh, B. K., Z. Nenadic and P. S. Ulinski 2002 Modeling and estimation problems in turtle visual cortex. IEEE Trans. BioMed. Eng., in press.

Khatri, V. and P. S. Ulinski 2000 Functional significance of inhibitory interactions between inhibitory interneurons in visual cortex. Neurocomputing, 32 – 33: 425 – 432.

Larson-Prior, L. J., P. S. Ulinski and N. T. Slater 1991 Excitatory amino acid receptor-mediated transmission in geniculocortical and intracortical pathways within visual cortex. J. Neurophysiol. 66: 293 – 306.

Senseman, D. M. 1996 Correspondence between visually evoked voltage-sensitive dye signals and synaptic activity recorded in cortical pyramidal cells with intracellular microelectrodes. Vis. Neurosci. 13: 963 – 977.

Senseman, D. M. and K. A. Robbins 2002 High-speed VSD imaging of visually evoked cortical waves: Decomposition into intra- and intercortical wave motions. J. Neurophysiol., in press.