# DETECTION OF INTERAURAL TIME DIFFERENCES IN THE ALLIGATOR 387.8.


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In birds and mammals, precisely timed spikes encode the timing of acoustic stimuli, and arrive at an array of coincidence detectors to encode interaural time differences (ITD). Crocodilians are a sister group to the birds, and our studies of their auditory brainstem reveal similar principles of organization to birds. In vitro whole cell patch recordings from the cochlear nucleus magnocellularis (NM) of embryonic alligators revealed one or two well timed spikes in response to a depolarizing current injection (n=11), while coincident stimulation of the inputs to the dorsal and ventral dendritic layers of the nucleus laminaris (NL) (n=10) increased the probability of action potential generation in NL neurons, showing that NL neurons act as coincidence detectors. In vivo recordings from alligators between 1-3 years old at 32C revealed units in NM and NL with best frequencies between 100-2100Hz. Single units in and around NM (n= 48) phase locked to the auditory stimulus with vector strength values similar to those of birds, while binaural units recorded in NL (n=35) were sensitive to ITDs. NL neurons phase-locked to both monaural and binaural stimuli. The arrival time of phase-locked spikes in these neurons differed between the ipsilateral and contralateral inputs. When this disparity was nullified by their best ITD, the neurons responded maximally. Thus crocodilians, birds and mammals employ similar algorithms for ITD detection.



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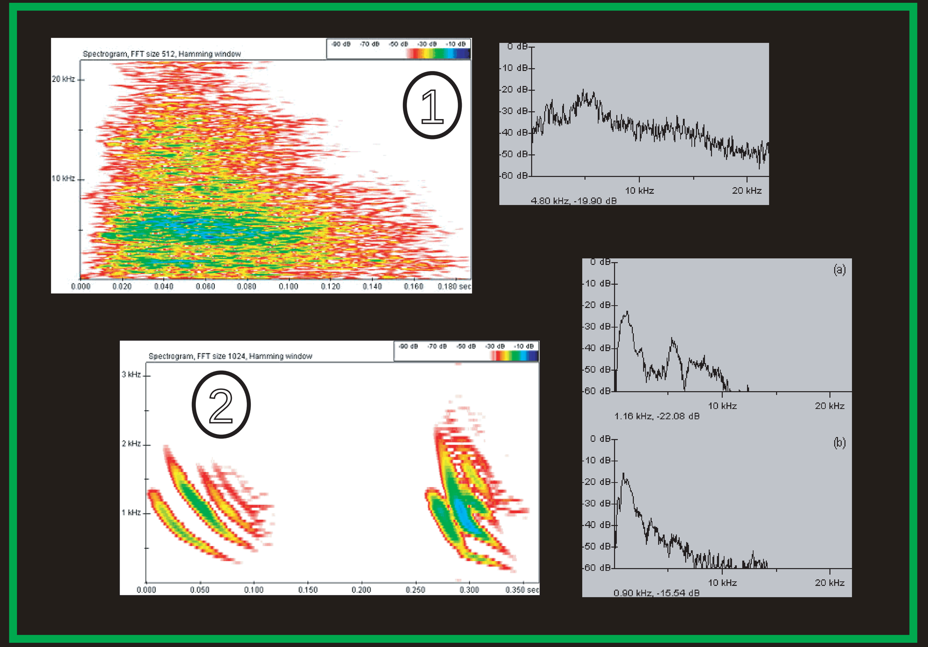
## Introduction

Alligators are known to use vocal and nonvocal acoustic signals for communication at the interface between air and water (Garrick et al. 1978). During these behaviors, sound energy is concentrated at frequencies at or below 1kHz. Audition in either media may also play a role in orienting towards prey or conspecifics. (3)

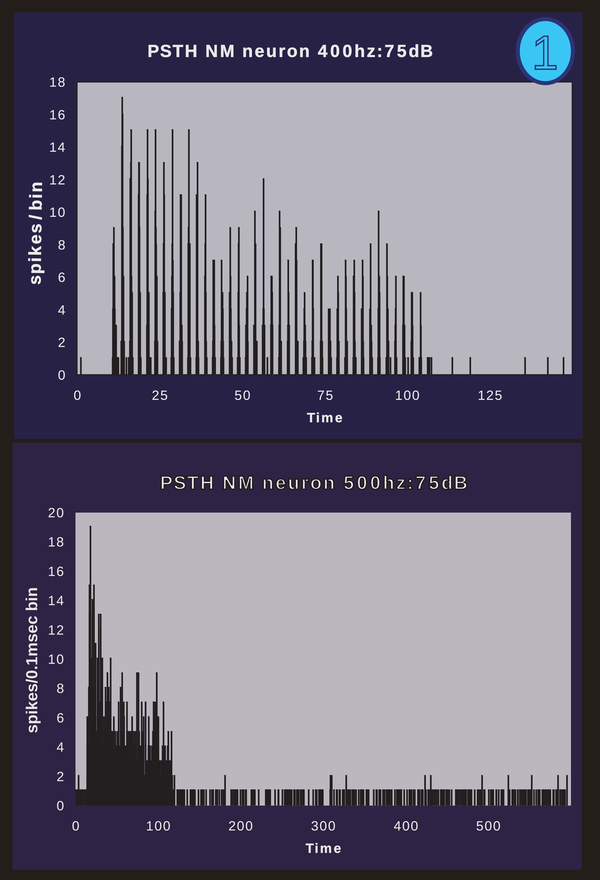


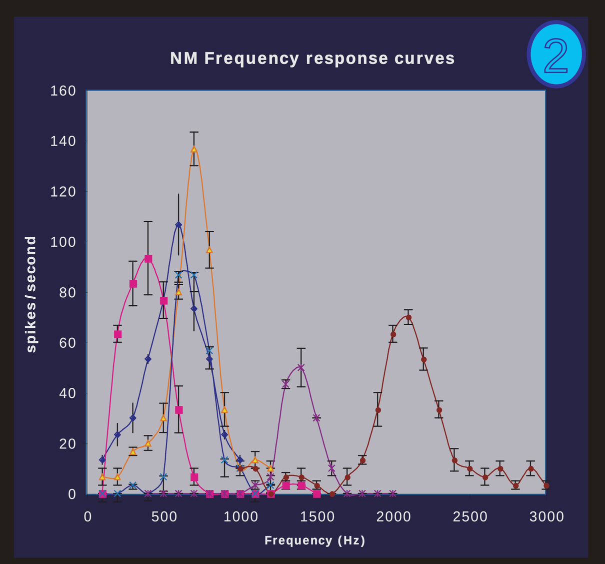
(1) This spectrogram shows a very brief, low level threat - a "cough". The power spectrum (right) shows the average intensities of the frequencies over the entire call. There is very little structure to the call, which covers a wide bandwidth of frequencies (over 20 kHz), but intensities are high (peak frequency: 4.80 kHz).

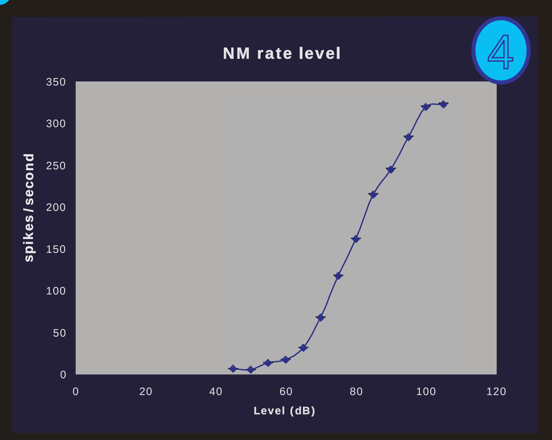
(2) This second spectrogram shows two hatching calls. The spectral structure of these calls is distinct - a concave, frequency modulated downsweep. Each call comprises the fundamental and several detectable harmonics. The maximum energy of the call is not necessarily in the fundamental harmonic.The power spectraon the right show the first (a) and second (b) of these calls, and show peak frequencies at 1.16 kHz and 0.90 kHz respectively.

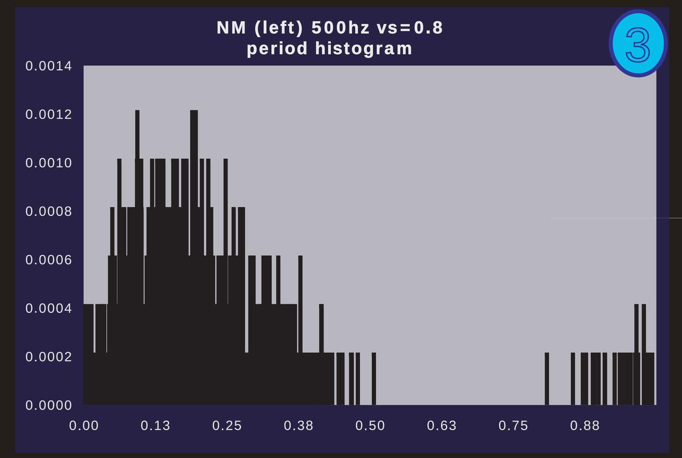
(3) There are two primary cochlear nuclei in birds and crocodilians, nucleus angularis (NA) and magnocellularis (NM) (Cajal, 1908; Boord and Rasmussen, 1963; Sachs and Sinnott, 1978; for review see Carr, 1992) and two second order nuclei, nucleus laminari (NL) and the superior olivary nucleus (SON). In birds, NM and NA are the origin of two parallel ascending auditory pathways, with NM projecting to NL, where ITDs are first computed, and NA projecting to the lateral lemniscal nuclei and the inferior colliculus hase and sound level difference signals for localization in azimuth and elevation.

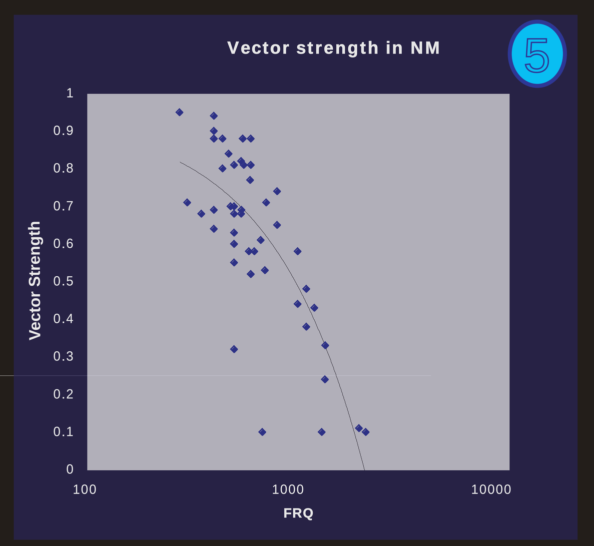
## Nucleus Magnocellularis neuron physiology



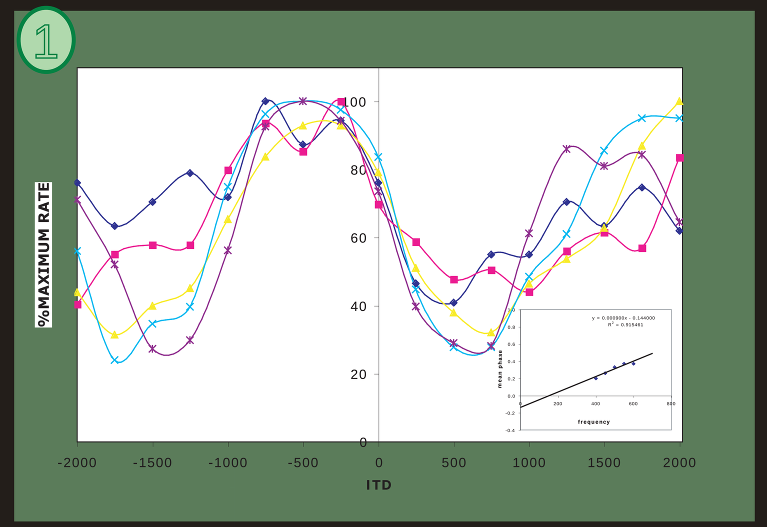



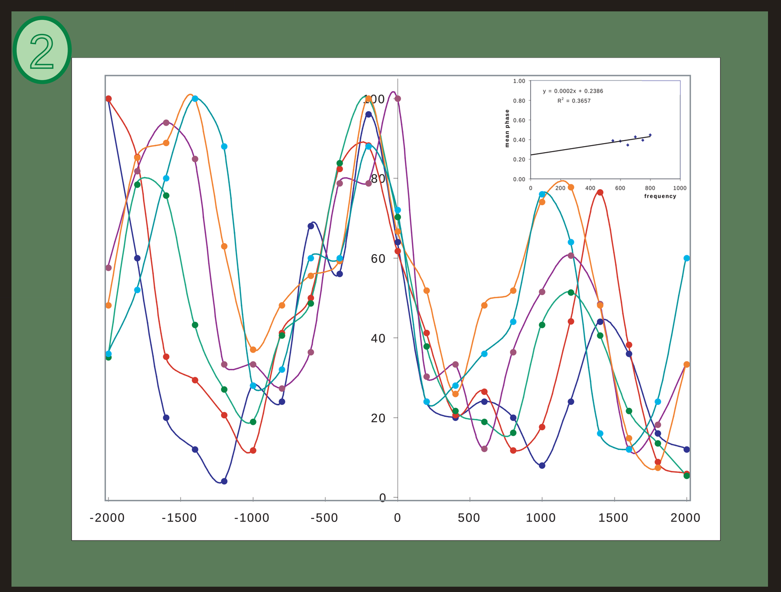



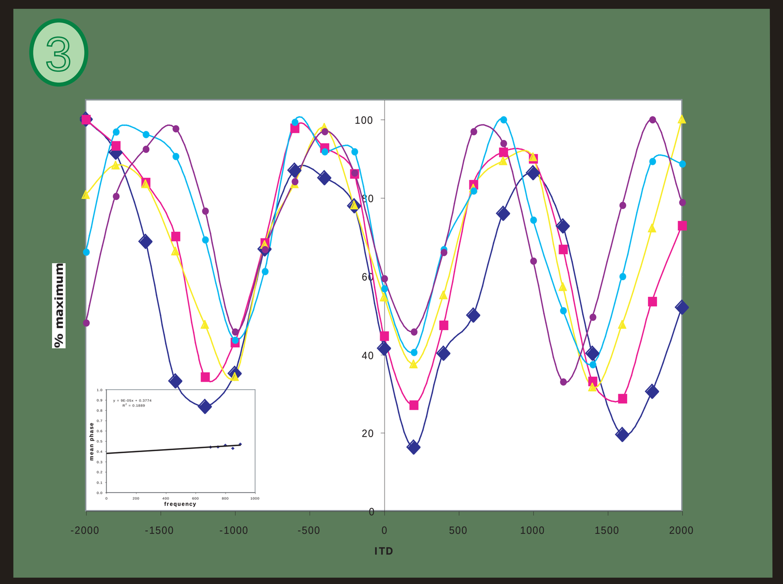




(1) Two PSTH examples of NM neurons, note phase locking and different time scales. (2) Frequency response curves of 6 different NM neurons. (3) Period histogram of sample NM neuron. (4) Rate level response curve. (5) Vector strength plot of all NM neurons recorded.

## Characteristic delay calculations in NL suggest different coding strategies



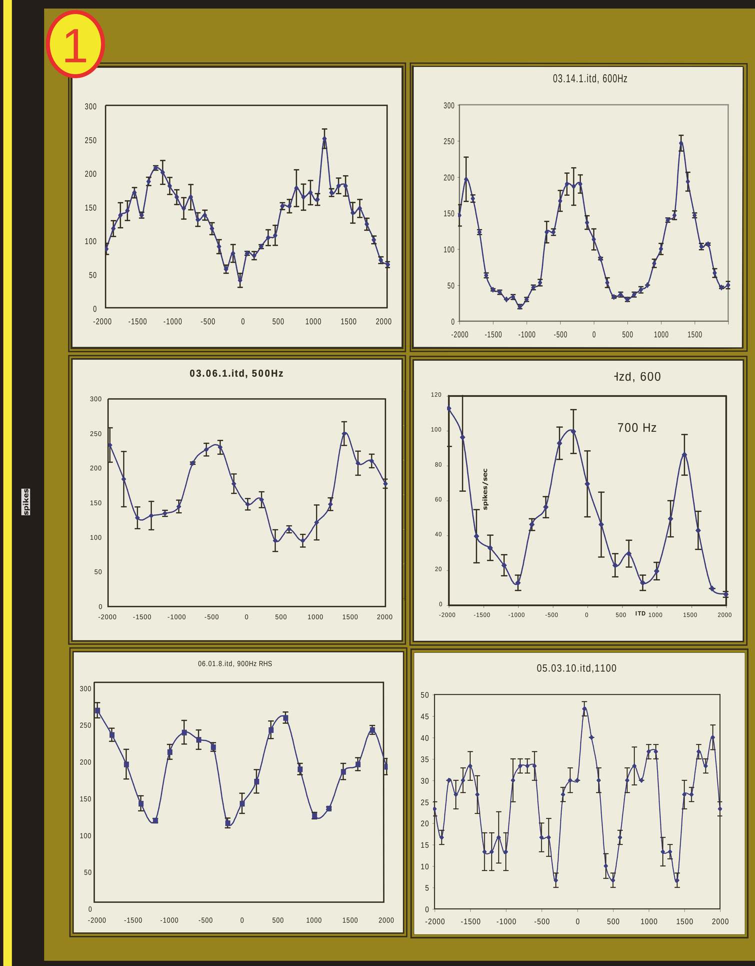


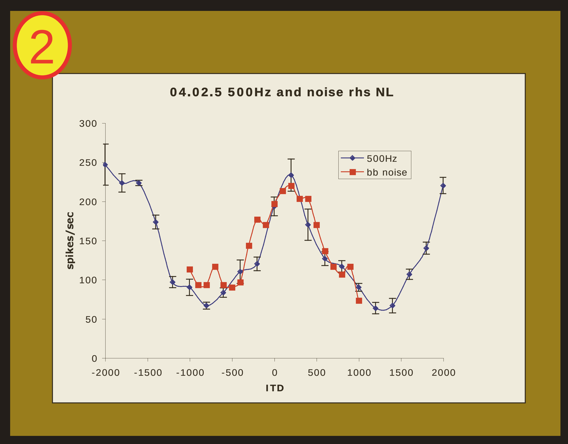


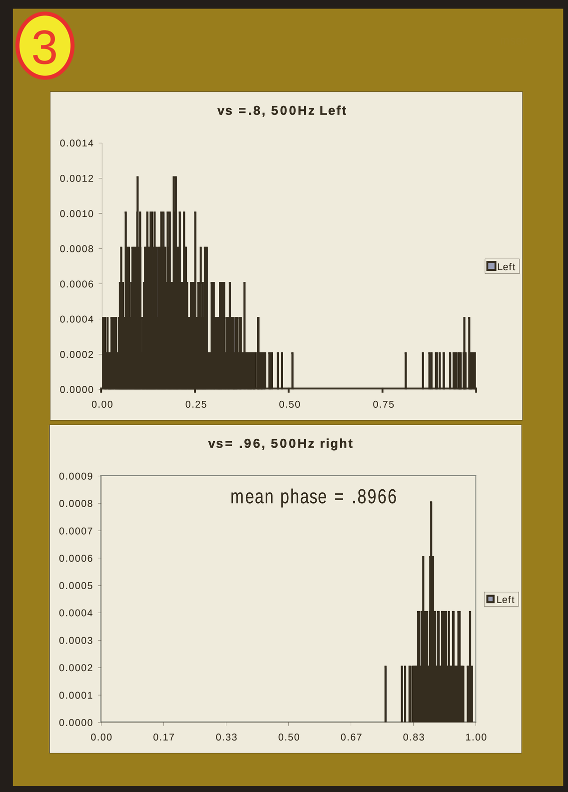
CDs were calculated by plotting the response of each neuron as a function of stimulus tone. The resulting delay curves were normalized and converted to IPD. Mean interaural phase (MP) was determined and plotted as a function of frequency. The y-intercept or characteristic phase (CP) for all alligator NL neurons varied between ± 1, although most clustered about ± 0.2 cycles. No simple division into "peak", "slope" or "trough"response types could be made.

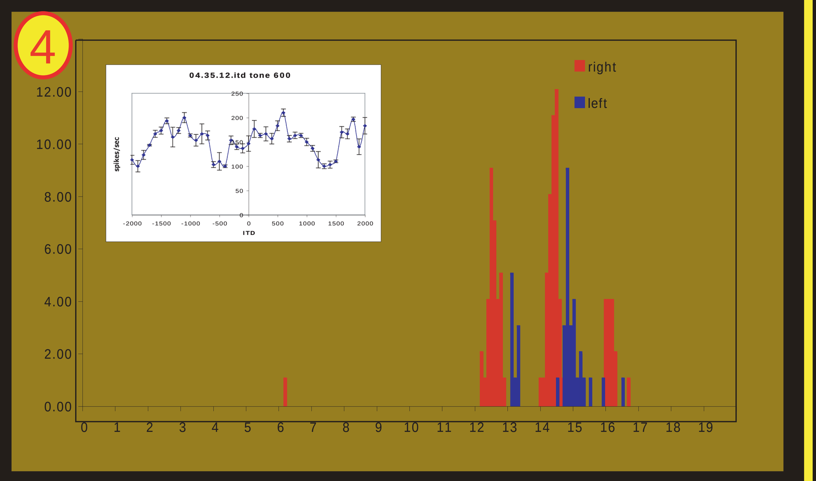
## NL neurons encode ITDs *invivo*

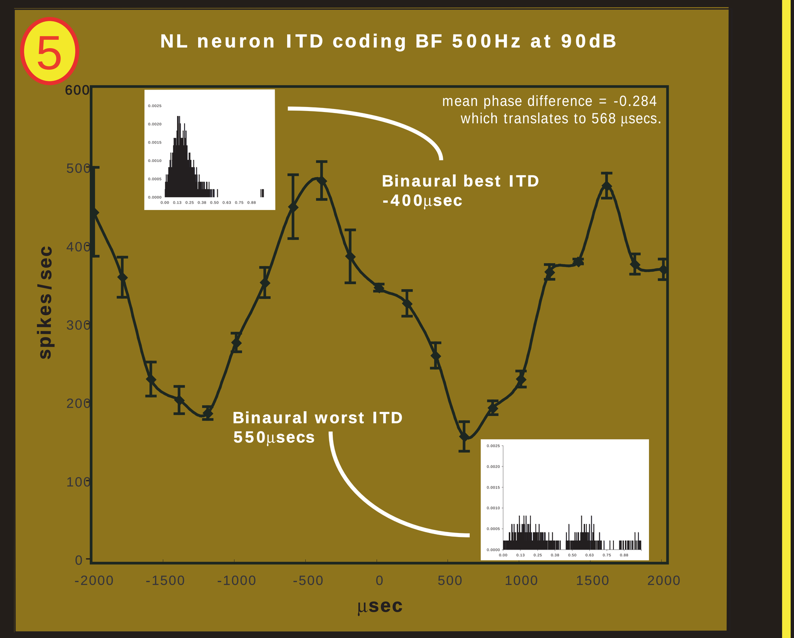
(1) Sample ITD curves of 6 different NL neurons. (2) Response types of individual NL neuron to BF and noise. (3) PH of NL neuron being stimulated ipsi and contralaterally. (4) Click delays match best ITD. (5) PH at best and worst ITDs.



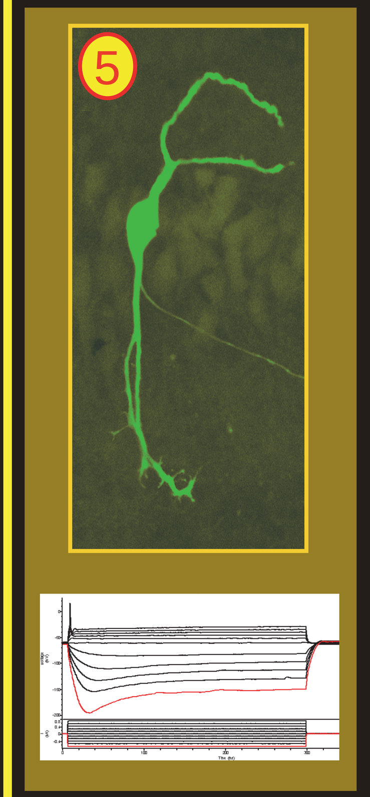


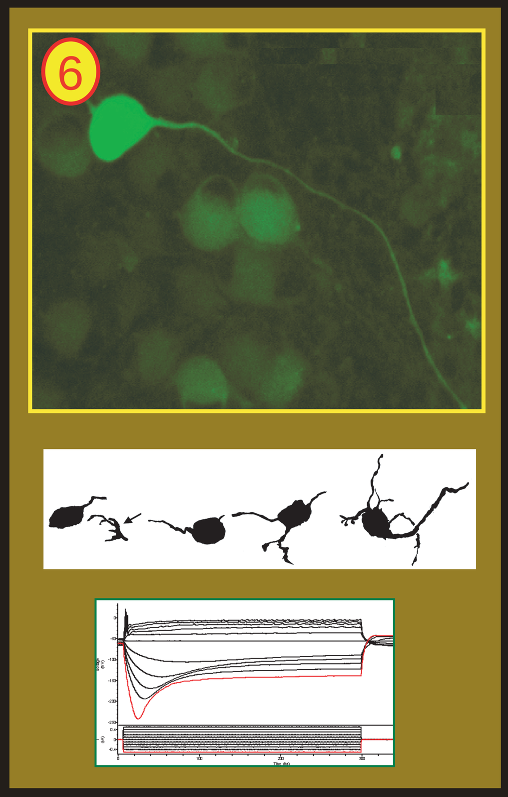


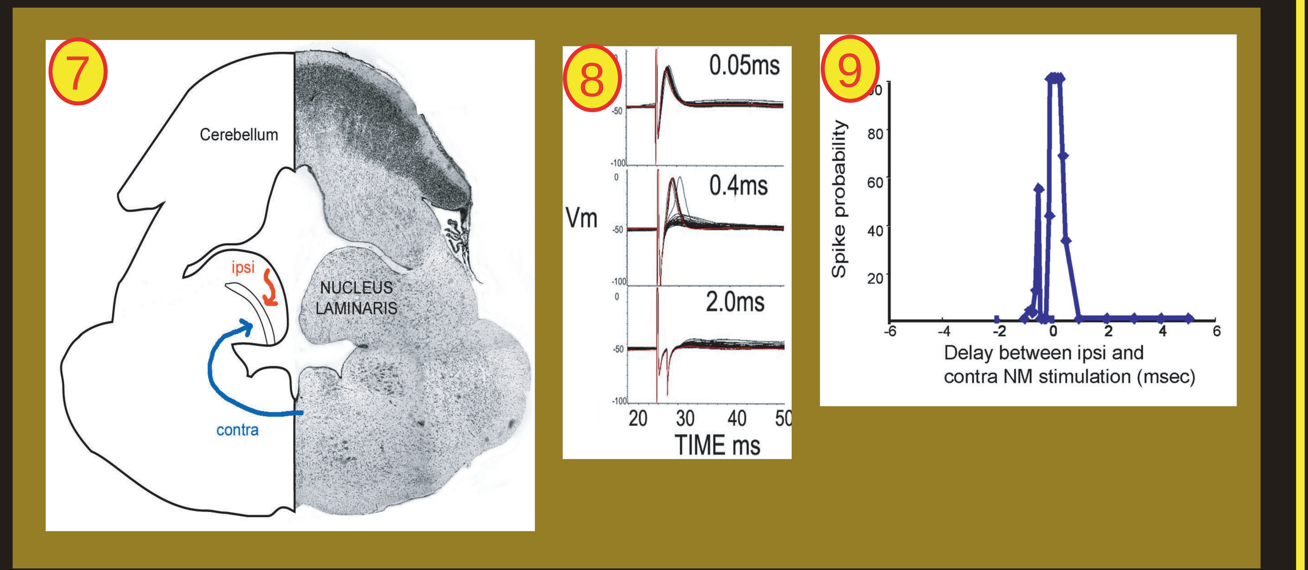






## and act as coincidence detectors *in vitro.*








Lucifer yellow injections and current clamp tracings of NL (5) and NM (6) neurons in a slice. Also show are 4 camera lucida reconstructions of NM neurons. (7) cresyl violet photomicrograph of typical slide. Note the ipsalateral and contralateral inputs into NL, red and blue tracts, were stimulated separately. (8) Current clamp records of a NL neuron stimulated at three different time intervals. (9) Summary of spike probability vs.delay between stimulation of opposite NL dendrites.

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