**Name:**  Sara Steele

**COURSES**

Fall Year 1

Course: CELLULAR, MOLECULAR, & DEVELOPMENTAL NEUROSCIENCE (NEURL-GA2201)

Final Grade: A

Course: MATHEMATICAL TOOLS FOR NEUROSCIENCE (NEURL-GA 22O7)

Final Grade: A

Course: LAB NEURAL SCIENCE 1 (NEURL-GA 2203)

Final Grade: A

Spring Year 1

Course: SENSORY & MOTOR NEUROSCIENCE (NEURL-GA 2202)

Final Grade: A

Course: LAB NEURAL SCIENCE 2 (NEURL-GA 2204)

Final Grade: A-

Course: COGNITIVE NEUROSCIENCE (PSYCH-GA.2221.1.001.SP12)

Final Grade: A-

Rotation: Eero Simoncelli

Fall Year 2

Course: Perception (David Heeger), Final Grade: A

Course:

Spring Year 2

Course: Special Topics: Computational Models (John Rinzel). Final Grade: A-

Course: Brain Computer Interfaces (NYU Poly, Jon Viventi). Final Grade: A

Total Graded Courses: 9

Total Ungraded Courses: 1 (Perceptual Dynamics, John Rinzel, Fall 2012)

**ROTATIONS**

Rotation 1: Eero Simoncelli

To try to get direct evidence of the change to the internal representation of the stimulus following a decision, I developed a novel psychophysical task for probing subjects' representation of motion direction. In addition, I developed and updated the model proposed by Alan Stocker to reflect the new task. My approach to probing the shape of probabilistic representations of motion direction was to make the stimuli that were probabilistic ensembles, as well, and to ask subjects whether individual tokens presented after an ensemble were consistent with the preceding display. So, ensembles of directions were produced by making random dot kinetograms in which the motion of each dot was drawn from a distribution. After viewing the ensemble, viewers were shown a single dot (a “probe”) moving in one of several fixed single directions, and asked whether it had been present in the previous display. The percent of “yes” answers for each of the probe directions was used to reconstruct the probability distributions subjects were using to represent the stimulus feature of direction. I investigated whether this approach would also work for stimuli with large uncertainty by decreasing motion coherence for monodirectional displays. In addition, I investigated the approach of the probe task for elucidating the probabilistic representation of orientation, both in ensembles (where orientation of each grating is drawn from a distribution) and with noise (eg low stimulus contrast). I was able to show that for stimuli with larger uncertainty, whether from wider distribution of features or from increased noise, the subjects would find a wider range of probe directions/orientations consistent with the previous display. While this approach had many problems which were never resolved, it was successful in its basic premise and also served to inspire other research projects.

Rotation 2: Bijan Pesaran

From March to July of 2011 I worked with Bijan Pesaran. My project involved testing different optogenetic vectors in rats. I injected rats with virus, after incubation I measured light-activated multi-unit and LFP activity from the neurons near the injection site, and after physiology I conducted histology on the brains to see where the virus was expressed.

**DISSERTATION**

Advisor: John Rinzel

Committee: Eero Simoncelli, Alex Reyes, Elyse Sussman

Committee Meetings:

Date: 6/2012; 5/29/2013

When presented with ABA tone sequences with an intermediate frequency difference between the tones, subjects report alternating between two distinct percepts of the sound (Pressnitzer & Hupe, 2006). In some epochs, the tones sound coherently grouped in a galloping rhythm, whereas in the other epochs, the tones sound like two unrelated monotonic beep trains at different frequencies and rhythms. The progression from the first of these perceptual states to the second is thought to recruit intrinsic mechanisms that the auditory system relies on for stream segregation, i.e., the ability to distinguish different sound sources in a mixture (van Noorden, 1975). We developed a statistical model to describe the buildup of the segregated percept from coherent epochs. The buildup function is the probability as a function of time that a subject will perceive an unchanging stimulus as two distinct sound sources, given that the percept started as coherent. Rather than treating buildup as a process of accumulation over time of sensory evidence or of some intrinsic neuronal process, such as adaptation, our model explains the evolving probability of segregation over time as a simple consequence of alternations between random durations drawn independently from distributions for the two percepts. In our model, segregation dynamics can be predicted by these distributions of percept durations alone. To evaluate these predictions, we collected data from human subjects as well as from neural competition model simulations. We constructed buildup functions by estimating the probability over time that a fixed stimulus was perceived as two streams based on either averaging over short trials, or by constructing an event-triggered average aligned to each switch into the coherent percept for long trials. Preliminary experimental data is consistent with the predictions of our statistical model-- by fitting a gamma distribution to the percept durations for each percept (one stream vs two streams) we can simulate buildup functions that matched those found experimentally. Moreover, we found that scrambling the order of the experimentally observed percept durations does not significantly change our computed buildup function. Simulations using noisy competition models give similar results, even though there are some correlations between durations from percept to percept. Finally, we have solved analytically our statistical model for the buildup dynamics. Our buildup functions, which treat percept durations as statistically independent, provide good approximations for the buildup functions obtained from both behavioral data and simulations from competition models.

As a general framework, this model can be applied to both auditory and visual perceptual grouping bistability (eg perception of plaid motion), and represents a significant alternative account to accumulation-based models like diffusion models, which are appropriate for relating stimulus strength to single decisions, but typically do not allow for multistability or perceptual changes in a dynamically changing environment.

While this work has been largely successful, I am dissatisfied with the current absence of any direct account of sensory coding. I would like to be able to implement a front-end to the alternation model framework which directly relates the stimulus, for instance, a spectrogram or a moving plaid, to the activity of populations representing different perceptual grouping states. While I have some experience producing and implementing sensory network models, the problem of determining the strength of grouping cues directly from stimulus characteristics is quite complicated.

Focusing on the auditory case, sound sources are decomposed from the jumbled external signal according to many cues: separation of frequency components; coherence of component onsets, offsets, and modulations; relative scaling of component intensities; rhythmic and timing regularities; localization cues like ITD and IPD; and, importantly, from higher-level combinations of these cues. In fact, the auditory system is particularly notorious for being able to rapidly and flexibly form representations of repeating patterns of sounds of fairly high levels of complexity over multiple timescales. Auditory neurons show novelty detection not only for frequencies, intensities and locations, but for regularities in sequences of sounds. For instance, mismatch negativity studies in humans and stimulus-specific adaptation studies in animal electrophysiology show that with as few as three repetitions of a complex sequence like five sequential tones of different frequencies, a deviation in that regularity will evoke a reliable change in brain activity. This extremely rapid formation of representations is critical for the ability to “tune in” to, and “tune out” of, sound sources of behavioral relevance. Furthermore, these basic principles exemplified in auditory processing are likely integral to dynamic formation of perceptual representations across modalities.**PRESENTATIONS:**

**First Year talk:**

Probing perceptual representations

**Third Year talk**

Title

**CONFERENCES:**

**Attended: SFN 2010, 2011, 2012; ARO 2013**

**Presentations:**

**PUBLICATIONS:**

**Posters: SFN 2012:**

**A statistical dynamic model for buildup of stream**

**segregation with an ambiguous ABA auditory stimulus**

**Papers:**

Bornstein A.M., Nylen E.L., **Steele S.A.** (2011). Unblocking the neural substrates of model-based value. Journal of Neuroscience, 31(28):10117-10118.

**Steele S. A.,** Lau H. *In press.* The function of consciousness in controlling behavior. *Joint Attention and Agency*. Eds H. Terrace & J. Metcalfe. Oxford University Press

**FUNDING:**

MacCracken