Sexual differences in functional recovery following injury to the auditory system of the adult cricket

Telegryllus oceanicus

Mollie Friedlander, 2014

In most species, loss of sensory input causes irreversible damage and loss of function without effective compensatory neuronal reorganization. The auditory system of the field cricket offers a beautifully complex demonstration of an exception to the norm. Crickets’ ears are on their “knees,” and auditory nerves extend from the eardrum of each foreleg to form highly specific connections (“synapses”) with interneurons in the central nervous system (CNS), which in turn relay sensory information to the brain. In forming these connections, CNS dendrites (branchlike projections of neurons that receive information from sensory nerves) typically respect the midline, remaining on one side of the body. However, removal of the auditory organ by amputation of one leg (“deafferentation”) prompts ipsilateral dendrites in both larval and adult crickets to grow across the midline, form functional synapses with the contralateral auditory nerve, and partially restore responsiveness to auditory stimulation by 6 days after deafferentation (Figure 1).

Neurons communicate through electrical signals called action potentials, which can be observed through extracellular recordings. The action potentials of AN-2 (the interneuron of interest for this study) respond best to frequencies above 15kHz and are easily identifiable as the largest in extracellular neck connective recordings (Figure 2). As time after removal of the foreleg increases, an increase in AN-2 dendritic extension across the midline is accompanied by a decrease in functional discrepancies between the intact and deafferented AN-2. Previous functional studies have characterized this phenomenon without differentiating between genders. However, recent morphological studies indicate that there are differences between males and females in the rate of recovery from injury-induced deafferentation. In female crickets, compensatory growth is robust during the first few days but reaches a plateau approximately 3 days after foreleg amputation. Contrastingly, male dendritic extension occurs steadily and reaches lengths approximately twice as long as those observed in females (Pfister et al., 2013). The purpose of our study was to investigate whether these morphological differences correlate with gender differences in functional recovery.

We compared the responses of AN-2 to specific auditory cues in male and female adult Telegryllus oceanicus. To characterize recovery of functional response in both genders, we measured excitatory thresholds, number of action potentials fired per sound stimulus, and response latency 2, 3, 6, 9 and 11 days following deafferentation. We predicted that gender differences in functional recovery would mirror those observed in compensatory dendritic growth. Specifically, we hypothesized that recovery would occur rapidly then plateau between 3 and 6 days in females, whereas male recovery would demonstrate a linear trajectory. Preliminary results are inconclusive regarding marked differences between genders, and a larger sample size is necessary to determine whether our data is consistent with the hypothesized trends. Intriguingly, we did demonstrate clear signs of functional recovery in both male and female crickets as soon as 2 days following deafferentation. This is the first study in which functional response to auditory stimulation has been recorded at such an early time point.

Figure 1. Compensatory neuronal growth in the cricket auditory system. A) In healthy crickets, CNS dendrites (green and gray) typically respect the midline, remaining on one side of the body. B) Removal of the auditory organ by amputation of one leg prompts ipsilateral dendrites (green) to grow across the midline and form connections with the contralateral auditory nerve (red) (Pfister, 2013).

Figure 2. The activity of AN-2 in response to a 15kHz, 80dB stimulus. In healthy, intact auditory systems, AN-2’s action potentials are easily identifiable as the largest in extracellular neck connective recordings. Immediately following removal of the ear (“deafferentation”), AN-2 loses physiological response to sound (red). However, as soon as 2 days and through 11 days following deafferentation, AN-2 regains response to the same stimulus (green).

Faculty Mentors: Hadley Horch and Patsy Dickinson
Funded by the Maine IDeA Network of Biomedical Research Excellence (INBRE) Summer Fellowship