Responses of central pattern generators in the American lobster STNS to a family of neuropeptides

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This summer, I worked in the Dickinson lab examining central pattern generators in the American lobster stomatogastric nervous system (STNS). The STNS is a network of neurons that control digestion, commonly found in arthropods such as insects and crustaceans. The stomatogastric ganglion (STG) in this system is comprised of 30 primary neurons that form two central pattern generators (CPGs) – neural networks capable of producing rhythmic muscular sequences without cues from outside the central nervous system.[1] CPGs can dictate rhythmic motions in invertebrates and vertebrates alike, and can be flexibly modulated by neuropeptide hormones, which are short amino acid chains that act as neurotransmitters. Neuromodulation is a form of nervous system communication distinct from typical synaptic transmission, in that chemicals such as peptide hormones flood a system to act on multiple neurons at once, rather than communicating at just one synapse.

Neuropeptides are common neuromodulators that can flexibly affect the STNS, and are therefore often studied in this system. My work focuses on the GSEFLamide neuropeptide family, which was identified in a collaborative 2017 study.[2] Each of the two CPGs I'm studying controls a distinct part of the lobster's stomach: the gastric mill pattern controls three teeth used to break down food, and the pyloric pattern controls an active filter that leads to the lobster's midgut.[3] The peptides that modulate these CPGs originate either from descending projection neurons that secrete peptides onto the STG's receptors, or from the neuroendocrine system releasing peptides into the bloodstream.[3,4] Previous experiments by the Dickinson lab have shown that different peptide family isoforms, which vary by just a few amino acids, can have differing functional effects on the lobster cardiac system, yet similar effects on the STNS.[5] My research this summer has considered the potential similar or distinct STNS effects of the GSEFLamide peptide family.

To examine the effects of this family of peptides (containing six isoforms) on the STNS, each system was dissected from the lobster via a two-part procedure; the lobster was cold-anesthetized, before the foregut was removed, from which the STNS was manually dissected. This dissection isolated the STG as well as three other STNS ganglia, and all of their corresponding motor nerves, which control the motor patterns described previously. The STG was then de-sheathed, to allow peptides to act on the system. The dissected STNS activity was then recorded extracellularly from individual motor nerves. Once the recording system was fully set up and baseline recording taken, one isoform from the GSEFLamide family was diluted and applied through the perfusion system. Spike2, a data recording and analysis program, was used to record the system's response to each peptide, and then analyze those changes by considering action potential burst frequency and density.

The data recorded from these preparations thus far indicates that the GSEFLamides show similar effects on the gastric mill STNS pattern to those observed in the lobster cardiac system. The gastric mill pattern is fairly consistently activated when all isoforms except AVGSEFLamide are applied. While the reason AVGSEFLamide has no effect on the gastric mill pattern is unknown, this phenomenon was also noted in the lobster cardiac system, indicating a potentially more global lack of function for this isoform. The pyloric pattern, however, is largely unaffected any of the GSEFLamide isoforms. The reason for these observed differences in response by the pyloric and gastric patterns is also unknown – while the differences are presumably due to varied receptor distribution among these systems, we don't know the reasons for such distribution. I look forward to continuing this research this coming school year as I pursue my honors project.

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