Do the PS neurons use two neurotransmitters in different locations within the stomatogastric nervous system to coordinate motor patterns?

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The stomatogastric nervous system (STNS) of the American lobster, Homarus americanus, provides a good model system for studying the modulation of central pattern generators (CPGs), which are groups of neurons that control rhythmic movement such as walking, breathing, or chewing. The STNS and the CPGs contained within it are responsible for generating the motor output that controls the rhythmic movements of the foregut. Since lobsters eat a range of organisms, from sea urchins to other lobsters, the CPGs within the STNS need to undergo extensive neuromodulation in order to generate the different types of chewing required for the consumption of a variety of food types. There are four main regions of the foregut: the oesophagus, cardiac sac, gastric mill, and pylorus. The oesophagus is responsible for swallowing food, the cardiac sac mixes food with digestive enzymes, the gastric mill contains two lateral teeth and a medial tooth that chew food, and the pylorus filters food into the midgut. The main ganglion within this system, the stomatogastric ganglion (STG), contains the gastric mill and pyloric CPGs, which are responsible for controlling the gastric mill and pylorus, respectively. Whereas the connections between the neurons within these two CPGs have been extensively studied, the neurons within the paired commissural ganglia (CoGs) that are responsible for generating the oesophageal rhythm are largely unknown.

Although each part of the foregut is controlled by its own CPG, in order for food to move functionally through the foregut, coordination of these CPGs is necessary. Many studies have shown that neuropeptides as well as specific neurons within the STNS can alter CPG coordination. Previous work done in the Dickinson lab has shown that upon application of the neuropeptide myosuppressin, a member of the FMRF-amide peptide family, to the STG, the gastric mill and pyloric motor patterns fuse so that one distinct motor pattern is created from the two patterns. A single pyloric-gastric pattern similar to that seen upon myosuppressin application to the STG was recorded in the lobster Homarus gammarus upon activation of a pair of modulatory neurons, the pyloric suppressor (PS) neurons (Meyrand et al. 1994). It is known that the PS neurons contain histamine as well as a FMRF-amide-like peptide, leading to the hypothesis that the PS neurons use myosuppressin in the STG to exert their modulatory effects. However, PS neuron activation in H. gammarus also excites the oesophageal rhythm (Meyrand et al. 1994), which myosuppressin does not do. This led to the hypothesis that the PS neurons use myosuppressin in the STG to alter the gastric mill and pyloric patterns while using histamine in the CoGs to excite the oesophageal pattern. Preliminary experiments had suggested that application of histamine to the CoGs has been shown to excite the oesophageal rhythm, and the H2 histamine receptor blocker, pyrilamine, has been shown to block the PS neurons’ ability to excite the rhythm (Emily Gabranski, honors thesis).

The first goal of this project was to replicate the histamine results in order to increase the number of subjects included in the study. Results of these experiments showed that the effects of histamine on the CoGs are less uniform than was previously thought. In some preparations, histamine inhibited the oesophageal pattern, and in others it excited the pattern, as seen in previous work (Gabranski, honors thesis). This inconsistency could be a result of histamine being applied to different regions of the CoG, or histamine might not be reaching the cells that are responsible for producing the excitatory effect. The histamine blocker experiments provided more consistent results. Pyrilamine, used at a 5x10^{-5} M concentration, blocked the PS neurons’ ability to excite the oesophageal rhythm (n= 4). This result supports the hypothesis that PS neurons use histamine to excite the oesophageal pattern. Future experiments will (1) determine whether pyrilamine affects the effects of PS stimulation in the STG, and (2) record from identified STG neurons to determine whether myosuppressin alters specific neuronal properties or synapses between neurons in order to exert its modulatory effects. Once this is known, the changes can be compared to how PS neuron activity alters the neurons within the two CPGs, which may give more insight into whether myosuppressin is actually being used by the PS neurons.

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