Context-specific effects of vasotocin on social approach in the goldfish

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Abstract: This summer, I continued my investigation into the context-specific effects of the neuropeptide vasotocin (VT) on the social behavior of *Carassius auratus,* the common goldfish. Because VT's effect on behavior has been demonstrated to be highly species and context-specific, I am interested in examining whether male goldfish respond differently to VT based on the social context and how such a difference is regulated in the brain. My work included behavioral testing, in which I placed fish in various social contexts and measured their response to VT, and fine-tuning an immunohistochemistry protocol to characterize the distribution of VT receptors throughout the brain.

Social behavior in vertebrates is regulated through the social behavior network (SBN), a highly conserved group of brain regions that work together to process external stimuli and produce appropriate social responses (O'Connell & Hofmann, 2011). VT is a peptide endogenously produced in teleosts in the preoptic area, which is an important part of the SBN (Walton et al., 2010). VT is analogous to vasopressin in mammals and has been shown to affect social behavior—including courtship, communication, and aggression—across many vertebrates. However, VT's specific regulation of such behavior can vary dramatically, and it has even been shown to have opposite effects in different species (Thompson & Walton, 2004). Thus, it is intriguing to examine the behavioral and physiological effects of VT in an effort to better understand its highly species- and context-specific influence on social behavior.

Goldfish live in shoals and are very social fish, making them good candidates for this project. Goldfish social behavior is guided by both visual and olfactory cues (Kobyashi et al., 2002). These olfactory cues are particularly important during courtship. Before ovulating, female goldfish release the pheromone 17α,20β, into the water, which prompts male goldfish to produce more testosterone. Several hours later, when they are ovulating, female goldfish then release another pheromone, PFG2α, into the water, which triggers male courtship behaviors (Kobyashi et al., 2002). Pheromones give information to the fish about the social context surrounding them. Thus, it is likely that the pheromone cues available to the fish will influence how vasotocin acts in the brain to affect social behavior.

Previous work in the Thompson lab has shown that centrally-injected VT has an inhibitory effect on social approach when a male goldfish is shown a visual cue of another male. This withdrawal from other male fish is understood to be regulated through a neural circuit in the hindbrain (Thompson & Walton, 2004). VT can also work through a neural circuit in the forebrain, which is not as well understood. Because the forebrain has many functions related to courtship, one hypothesis is that VT works through the forebrain when the goldfish is in a courtship context, resulting in a different effect on social behavior. Specifically, VT might work through the hindbrain to promote *withdrawal* when the fish is in a male-male context but work through the forebrain to promote *approach* when the fish is in a male-female courtship context. My project last summer was focused on whether peripherally-injected VT affects male goldfish behavior differently depending on the social context. As expected, I found that VT-injected male fish withdrew from other male fish significantly more than those injected with a control saline solution. However, VT did not have a significant effect on male approach to female fish when the males were put in a courtship context through priming with the pre-ovulatory pheromone 17α,20β. These results provide evidence for context-specific effects of VT on goldfish social behavior. This summer, I ran additional behavioral tests in an effort to determine whether the observed behavioral effects purely reflect an increased sensitivity to VT or whether they are dependent on pre-exposure to 17α,20β. The results from this study were inconclusive, requiring further investigation.

In addition to my behavioral work, I am interested in answering the question: How does goldfish neural circuitry explain this difference in VT's effect on social behavior? Based on behavioral data, it is likely that social context—acquired through visual and/or olfactory cues—can actually alter vasotocin signaling in fish, likely by changing the functioning of VT receptors. To begin investigating this question, I have been developing an immunohistochemistry protocol with a custom VT receptor antibody that will allow me to characterize VT receptors throughout the hindbrain and the forebrain. Further behavioral and anatomical testing during the 2018-2019 academic year will add to the growing knowledge base on how social behavior is regulated in a highly conserved but specific neural network across vertebrates.

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