Mapping and understanding the projections of *Apteronotus* fish related to spatial memory and cognition

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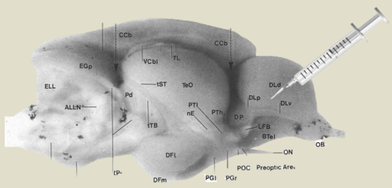
Introduction

- **Previous studies** on the weakly electric fish *Apteronotus* has indicated that these fish display learning and memory involving vision. Visual stimuli received by the eye follows a pathway similar to that of mammals.
- **These similar pathways** include signal filtering and feedback. It has been previously found that a main pathway involved is the projections from the preglomerular complex (PG) to the dorsolateral pallium (DL). It has been hypothesized that PG is homologous to the thalamus of the human brain, which filters information and sends it to the cortex for processing and understanding of what the fish is seeing. In *Apteronotus*, this thalamus like structure sends input to DL, providing evidence that this may be the cortex of the fish's brain.[1]
- **In this experiment**, dye was injected into the DL structure, and the connections of these regions were mapped out. The directionality and patterns of the connections will allow for a greater understanding of memory and cognition.

Methods & Materials

Preparation of the brain

- Fish were deeply anesthetized, and mini-Ruby and Alexa-647 Dextran biotinylated fluorescent dyes were injected into the DL structure of the brain.
- After 2 days of survival, fish were perfused directly into the heart with para-formaldehyde MS-222 lidocaine.
- Using a microtome, 25 µm thick coronal sections of the brain were cut and mounted.



- **Imaging**

- Images of each section were taken at 10X and 40X using a Zeiss AxioObserver.ZI.

Results

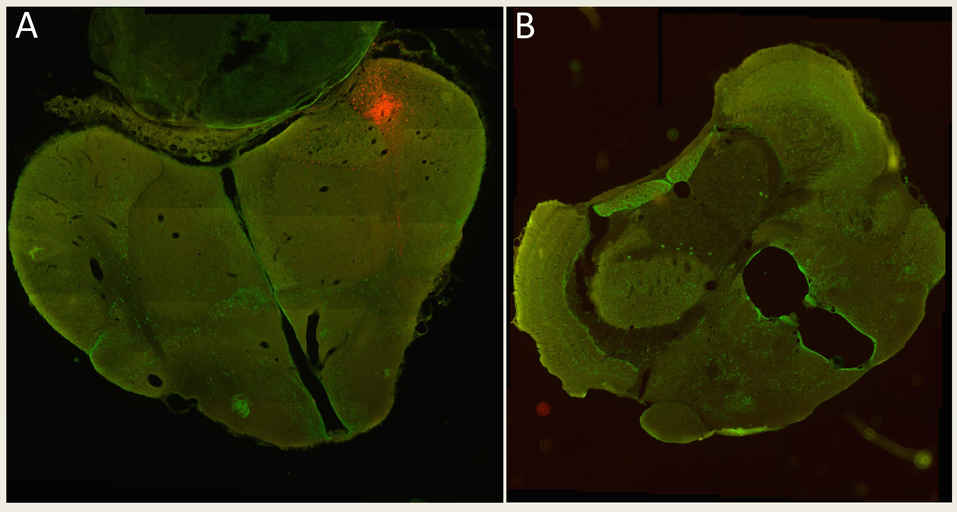


Figure 1. **Cross-sections of the brain showing A) a successful injection in DL and B) the presence of cell bodies in PG containing stain.** Images taken at 10X on 25µm thick coronal sections of the *Apteronotus* brain.

A. This cross-section shows the successful injection of DL, as neurons have been coloured red with dye. Lateral diffusion of the dye is observed.
B. Cross-section B contains neuronal cells stained red in the PG region.

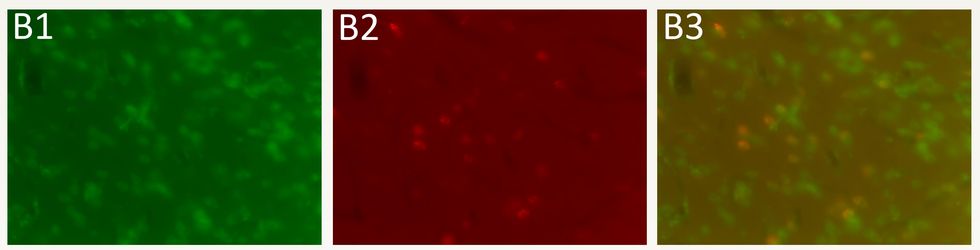


Figure 2. **Magnification of PG structure, demonstrating the retrograde motion of the dye.** Images taken at 40X on 25µm thick coronal section of the *Apteronotus* brain.

B1. Visualization of all neurons present in PG.
B2. Visualization of brain tissue stained with injected fluorescent dye.
B3. Overlay of both channels show that dye is present within the cell body of the PG neuron. This allows for characterization of the directionality of the connections.

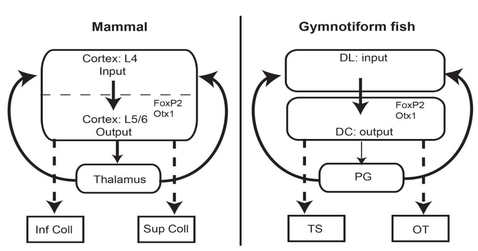


Figure 3. Neuronal pathways of the Mammalian and Gymnotiform fish brains.

Conclusions

It can be confirmed that there are strong connections between PG and DL, reinforcing the thalamus-cortex hypothesis.

Further studies on the pattern of organization will allow for a better understanding of how these fish are processing electro-sensory information. Confirming the presence of columns in DL will provide further evidence that it is homologous to the mammalian cortex.

Furthermore, a deeper look into the structure of DL and its neural projections will allow us to locate the communication regions such as the primary cortex, where memory is located[2], synaptic plasticity, etc.

References

[1]Anh-Tuan Trinh, Erik Harvey-Girard, Fellipe Teixeira, Leonard Maler. (2016). Cryptic laminar and columnar organization in the dorsolateral pallium of a weakly electric fish. *J Comp Neurol.* 524(2): 408–428. doi: 10.1002/cne.23874.

[2]Ana C.C. Giassi, Erik Harvey-Girard, Bridget Valsamis, Leonard Maler. (2012). Organization of the gymnotiform fish pallium in relation to learning and memory: I. Cytoarchitectonics and cellular morphology. *J Comp Neurol*. 520(15): 3314-37. doi: 10.1002/cne.23097.

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