THE EVOLUTION OF THE MORMYRID WEAKLY ELECTRIC FISH BRAIN AND ITS IMPACT ON SPECIES DIVERSIFICATION

WESLEYAN UNIVERSITY

TRiO RONALD E. McNAIR POSTBACCALAUREATE ACHIEVEMENT PROGRAM

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INTRODUCTION

In the Mormyrid family of weakly electric fish, species diversification has been correlated with coordinated changes in the exterolateral nucleus (EL) of the electrocommunication pathway in the brain and in the social behaviors exhibited by these fish. Specifically, previous work has established evolutionary distinctions in EL(anterior/posterior) have been associated with differences in the detection of differences in Electric Organ Discharge (EOD) waveform[1]. However, species differences in the time series of EODs and their coordination among groups larger than two have been less studied.

In this study, we are comparing two Mormyrid species: *Gnathonemus petersii* and *Brienomyrus brachyistius.* We focus on quantifying and describing their electrocommunication behavior when in larger groups (special emphasis on optimizing EODs signal to noise). Our preliminary experiments aim to 1) validate our approach by demonstrating the detection of 'echo responses' between pairs of fish and 2) develop a quantitative approach to describing the higher dimensional structure in communication among a group of 4 fish. In future studies, we will apply these methods to larger groups and in freely swimming fish. We will then leverage the ability to manipulate the social arrangement of fish among a group to examine how social dynamics exerts pressure on communication among a group, how communication is supported by neural circuits, and how these mechanisms differ across species.

METHODS

Subjects

- *B. brachyistius* and *G. petersii* fish were socially housed in 40 gallon tanks at Wesleyan University.
- Experimental groups consisted of 4 individuals from a single species.

Electrophysiology

- Each fish was constrained to a restricted physical space (using 'AZOO' boxes) during electrophysiology recordings. The group was physically arranged in a circle (*Fig. 1*).
- Individual fish EODs were recorded utilizing pairs of differential electrodes attached to each fish's box. The + and – leads of each electrode were placed at opposite sides of each fish's box.
- An Open-*ephys* acquisition board and Intan headstage system was used to sample (at 30kHz) the electrical activity of the group of fish, which was then saved using the Open-*ephys* GUI and processed using custom scripts written in Python[3]

Figure. 1: Fish (fixed in their fish homes) are oriented to form a circle to maximize interactions and allow for more diverse interactions between conspecifics. Physically constraining the fish maximizes the signal-to-noise ratio on each electrode.

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RESULTS

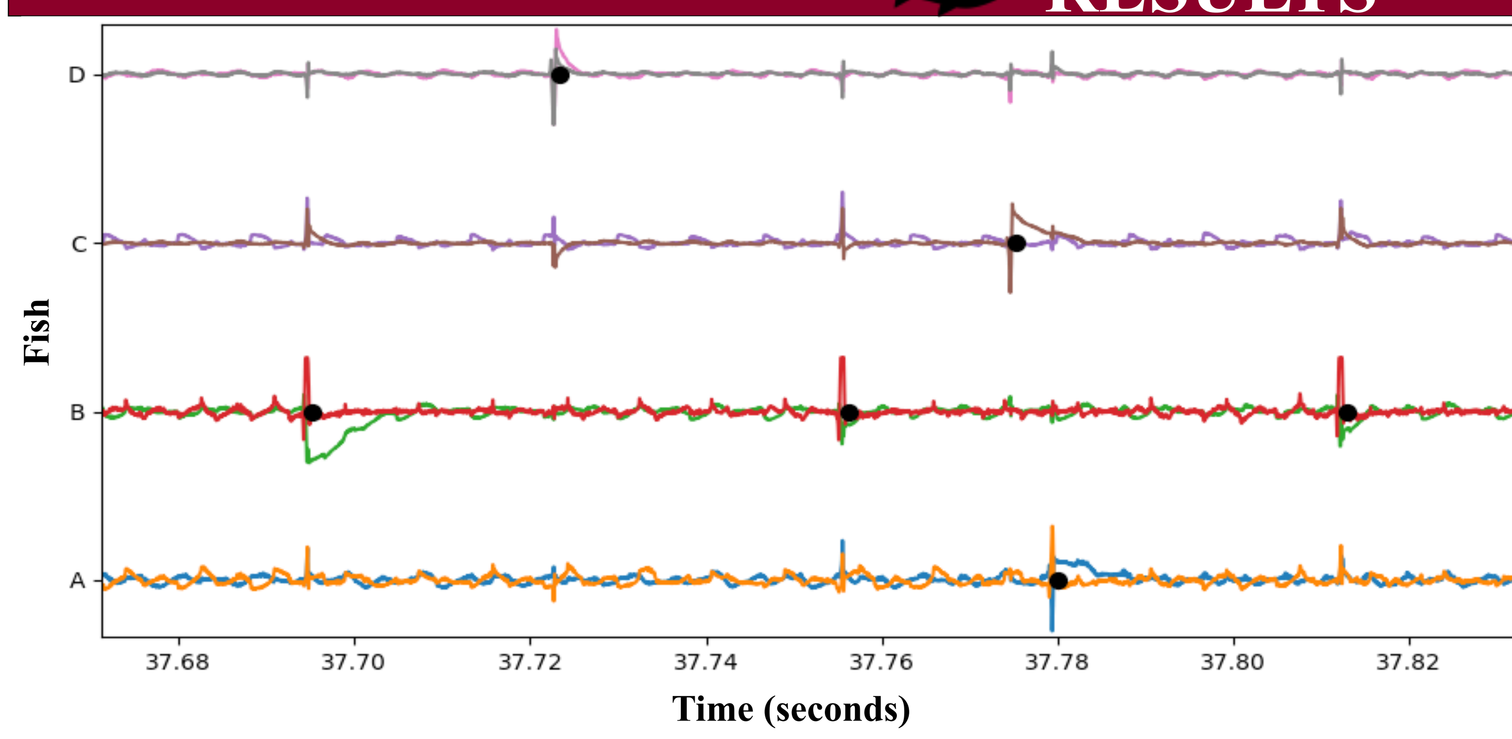


Figure 2: Segment of raw data of individual fishes' EOD waveforms over time. For each fish, the two electrode channels associated with their individual box are overlaid. Focal fish EODs marked via black dot. Noise from neighboring fish can be seen in the recording on each channel.

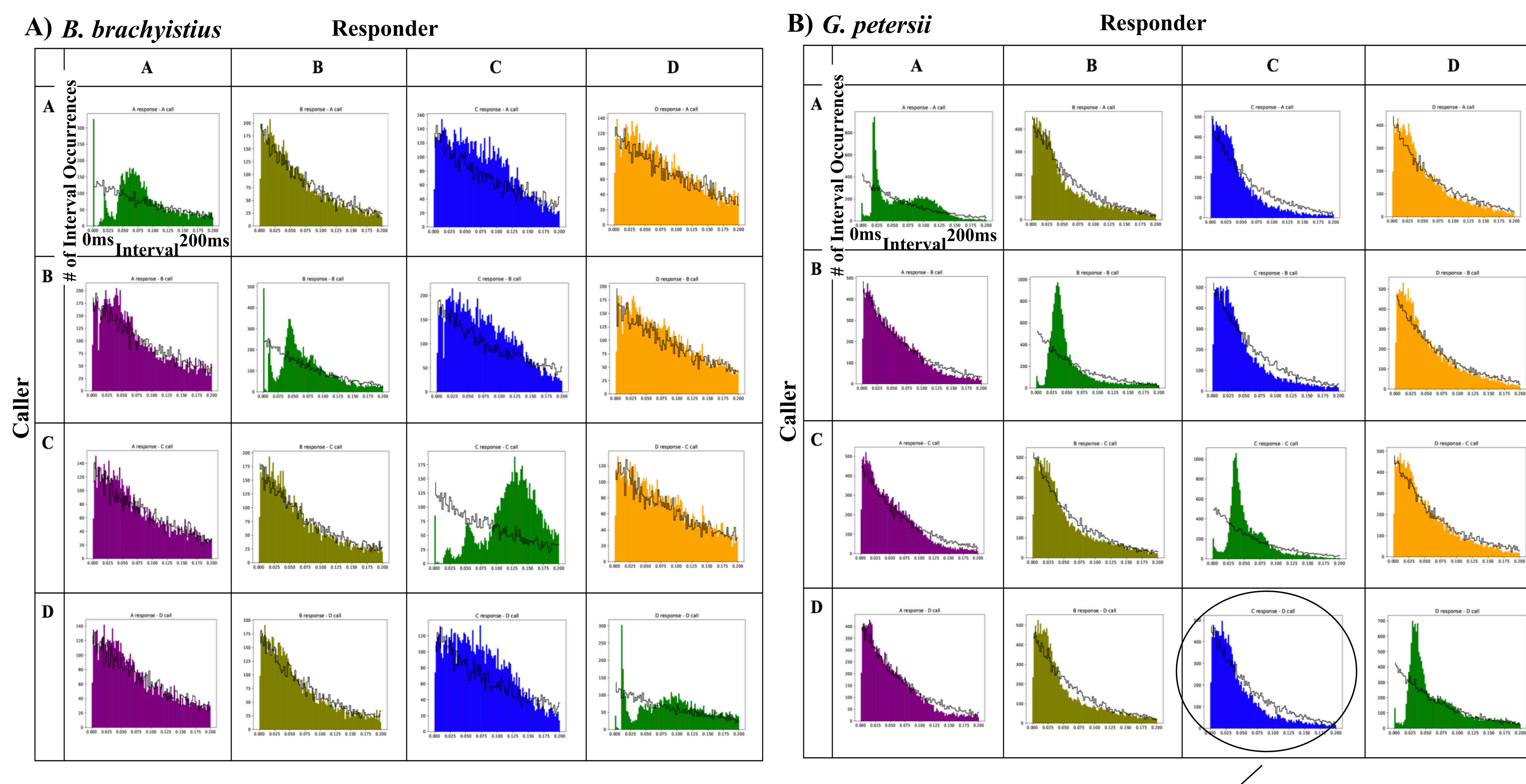
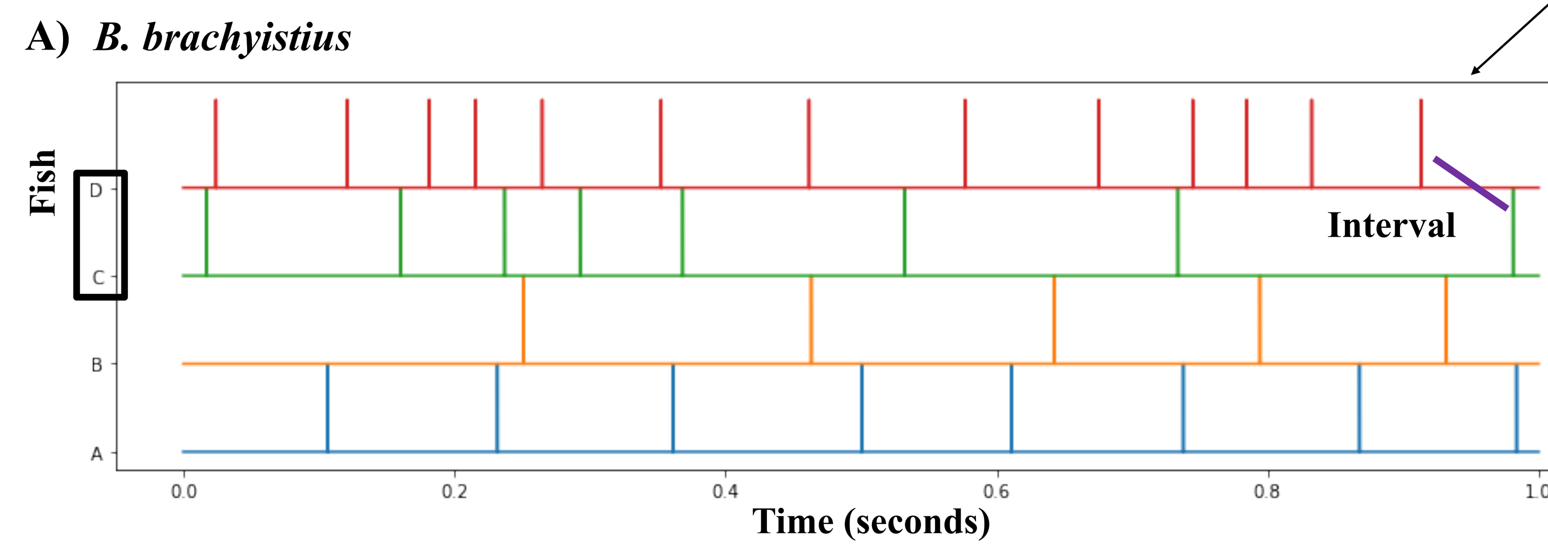


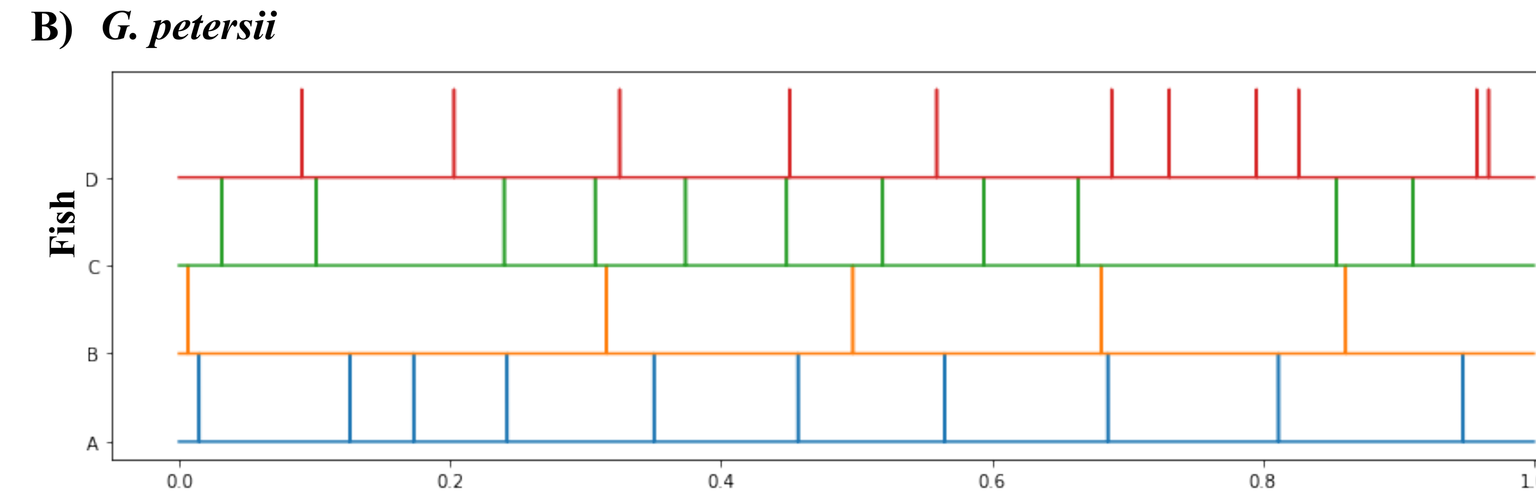
Figure. 3: Pairwise interactions among each group of fish. Interactions were quantified by measuring the intervals between EODs of each fish in each pair. Each EOD time of a caller fish (i.e B) was subtracted from the preceding EOD of its paired fish (i.e. A). From the distributions of these intervals, we can quantify the echo response between pairs of fish[2]
Null hypothesis (black line) overlays each pairing (note: no confidence interval was calculated at the time).
These initial results from *B. brachyistius* **(A)** and *G. petersii* **(B)** suggest that group communication within these species may have different coordination structures.

A) ***B. brachyistius***



Avg. EOD Rate (Hz)
6.9
7.0
10.1
7.5
Group: 31

B) ***G. petersii***



Avg. EOD Rate (Hz)
13.2
14.9
14.9
12.8
Group: 55

Figure 4: Plot of individual fish EOD times. For each fish, vertical lines denote the time of an EOD for that fish. Purple: Highlighted example of the interval measurement (described in *Figure 3*) using fish D as the caller and fish C as the responder. *B. brachyistius* **(A)** and *G. petersii* **(B)** have different average EOD group rates. Perhaps differences in communication structure are related to differences in group EOD rates.

FUTURE DIRECTIONS

- Will utilize EOD recordings and develop behavioral paradigms to:
  - Quantitatively describe species differences in social behavior and communication.
  - Examine how demands of different social behavior and communication are supported by associated neural circuits and how that also differs across species.
  - Explore the evolution in the electrocommunication pathway in relation to species-specific differences in social behavior.
  - Test if there needs to be something present (intrinsically or extrinsically) to induce behavioral differences between species (manipulation of social context – i.e predation model, shifts of interaction availability)

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