Spring 2018

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Communication is critical to survival and reproduction for many animals, facilitating essential social behaviors such as courtship, mating, coordinated group feeding, and territorial guarding. Weakly electric fish of the family *Mormyridae* allow for the study of animal communication because they have evolved an active sensory and communication system based on electrical signals. Mormyrids generate and receive pulses of electricity called electric organ discharges (EODs). Mormyrid EODs convey information about the species, sex, and identity of the sender. Variation of the inter-pulse interval (IPI), the time interval between EODs, has been shown to correlate with specific social behaviors. However, the contribution of electrocommunication to these behaviors in a natural setting is poorly understood. Studying electrocommunication requires a method that can accurately assign EODs to their senders in freely interacting fish. However, this poses a significant challenge as it is difficult to distinguish EODs of individuals within the same species. Previous studies have overcome this problem using playback recordings, dummy fish, or securing electrodes directly to individual fish, but such methods restrict natural behavior and thus, limit the study of natural electrocommunication. This paper describes a powerful new method developed to combat these limitations using an eight-channel electrode array and a MATLAB- based signal clustering algorithm that can classify EODs of two different fish while they are freely swimming and interacting, with a post-clustering sorting method that classifies unsorted EODs to a 99% accuracy. This novel tool has been used to gather preliminary data on social behavior in *Brevimyrus niger*, confirming that our method can reliably separate the EOD signals during social interactions within a single species. The ability to classify EODs while allowing free interaction provides the opportunity to conduct more naturalistic studies that will further our understanding of the evolution of complex behavioral and communication systems.