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Oral presentation

Invited talk: Coding strategies for multiscale sensory signals

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There are an increasing number of experimental studies of sensory neural systems devoted to understanding the processing of naturalistic stimuli. Such studies are necessary to reveal the whole spectrum of possible computations accomplished by neural systems. We discuss recent advances in this area in the context of the electric sense, which can be seen as a combination of the visual and auditory senses [1]. This sense is very advantageous for such studies because its input can be well characterized and modeled [2]: modulations of an endogenous electric organ discharge (EOD) carrier caused by objects such as rocks and food, and communication signals between the fish. Especially important is the fact that the anatomy enables electrophysiological recordings through many successive stages of processing.

This talk will briefly review earlier results on coherence shifts, oscillations and bursting in this sense, and present recent results from our experimental/theoretical collaboration. First, in the context of communication, the primary afferent neurons or "electroreceptors" exhibit transitions between synchronized and desynchronized states. The direction of the transition depends on whether the interaction is between fish of the same or opposite sex [3]. The decoding of this effect is performed by pyramidal cells, and depends on the frequency dependence of the synchronous discharges. We also present results showing that the synchronous discharges between afferents selectively encode high frequencies.

We then consider the cocktail party problem these animals face, with the goal of discovering the neural solution to this general problem. We address this issue in the context of the detection of slow time scale modulations of the EOD carrier. These slow modulations arise when many fish are in the vicinity of one another. We show that these modulations can be extracted via a Hilbert-type transform, and illustrate the circuitry that enables this computation [4]. Modeling shows that the effect requires strong neuronal nonlinearity, and can under certain circumstances benefit from the presence of noise when a population of neurons is considered [5]. This computation allows parallel transmission of high-frequency signals, as well as the low frequency envelope that results from social interactions.

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