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Vertebrate Motor Control: A Neuroethological Perspective

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Neuroethology explores the neural basis of behaviour across the full diversity of animal life. From a 'vertebrate motor control' point-of-view, the neuroethology domain would cover the full range of vertebrates, lampreys to primates, and focus on the motor control challenges of dynamic animals operating in dynamic environments. Impressive motor control solutions are particularly evident in situations arising from the biological imperatives of predation, movement, and mating; particularly when risk and energetic considerations are also in play. The neuroethology of the arms race between predation and escape [1] includes well studied examples such as: passive electroreception; active electrolocation; fish strike and escape mechanisms; prey capture in toads; owl sound localization; and bat echolocation. This may seem like an overly 'sensory' description of predation behaviour, but unlike many human movement paradigms with passive targets, predation in the animal world depends on stealth and a sequence of prey detection, localization and action; where action includes a covert whole-body approach to the prey to gain the right range and orientation to initiate a strike. Strike and escape behaviours require ultrafast movement typically generated by relatively simple neuronal networks. So human movement control has more in common with the approach to the prey than with the strike. It is interesting to note that, despite our dexterity, our strike abilities are quite limited; for example, try catching a fish, or bird with your bare hands! Some neuroethology cases of predation and escape will be presented with particular emphasis on the target approach. The control of whole-body movement, whether for prey approach, or in other contexts, relies extensively on central pattern generators. The understanding of CPGs has a strong neuroethology legacy from lamprey swimming (movement) to bird song (mating behaviour). This work has also led to significant insights into: the role of CPG efference copy in the cancelation of locomotion induced sensory reafference; the role of sensory input in optimizing locomotion efficiency; evolution of the cerebellum; and a possible role for a CPG/cerebellar combination in pattern generation, such as that seen in bird song [2, 3]. The aim of this presentation is to view the way in which human motor control is nested within the wider scope of vertebrate motor control, looking for possibilities in which the different domains can inform each other. The origins of the cerebellum from cerebellum-like structures endorses the view of the cerebellum as an array of adaptive filters, and its status as sitting on top of a pre-existing functional brain (subsumption architecture). And the long and complex evolutionary history of the brain provides an opportunity for neuroethology to inform our understanding of human motor control, and conversely for the depth of understanding of human sensorimotor control to feedback into our wider understanding of vertebrate neuroethology.

1. Sillar, K. T., Picton, L. D., & Heitler, W. J. (2016). The neuroethology of predation and escape. John Wiley & Sons.
2. Montgomery, J., & Bodznick, D. (2016). Evolution of the cerebellar sense of self. Oxford University Press.
3. Montgomery, J., & Perks, K. (2019). Understanding cerebellum in vertebrate neuroethology: From sensing in sharks and electric fish to motor sequences in movement and birdsong. Behavioral neuroscience, 133(3), 267.