Generation, Stability, and Robustness of Rhythmic Locomotion Patterns

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Rhythmic activity in neuronal networks underlies a wide range of repetitive behaviors essential for survival, including locomotion, digestion, and breathing. While oscillatory patterns may be produced locally within circuits, their functional impact often depends on interactions across neural populations and their response to feedback from the behaviors they control. This work focuses on locomotion patterns generated in the metathoracic segment of the stick insect's middle leg, modeled using a central pattern generator and antagonistic motoneuron pairs. Employing an 18-dimensional system of coupled ODEs, we identify the dynamic mechanisms responsible for generating specific stepping rhythms; analyze the robustness and adaptability of these patterns to parameter changes; and investigate the coordination of rhythmic outputs across limb segments. Due to its experimental accessibility and diverse stepping patterns, stick insect locomotion provides a valuable model for studying rhythm generation and control. This study not only deepens our understanding of rhythm generation in locomotion but also offers insights that extend to other rhythm-generating neuronal systems.

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