



Integration Timescales of Visuospatial Task Constraints and Composition Strategies in Sensory Feedback Responses

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Changing contexts and intentions continually shape our movement goals, requiring replanning and real-time adjustments. While it is established that stretch reflexes are tuned to our movement goals, the precise timescales at which they update during ongoing movements and the principles linking external perturbations to goal-directed reflex responses still remain unclear. To address these issues, we introduced new spatial targets during a reaching task and randomly applied various mechanical perturbations to the arm after one of four preview delays (0-200 ms relative to target onset), serving as cues to rapidly adjust the reach toward the new targets. We found that stretch reflexes were first modulated in the R3 epoch ~120 ms after target onset, closely following visuomotor reaction times and occurring faster than previously reported in a comparable postural task. Interestingly, we also observed smaller yet reliable reflex modulation within the R1 epoch after longer preview delays, suggesting that even the motor periphery can be independently and quickly tuned toward the updated goal. Overall, these results highlight a tight coupling between reflexive and voluntary control during dynamic motor tasks. Furthermore, nuanced analyses suggest a resource- and time-efficient strategy in the composition of reflex responses, in which local sensory information — such as changes in intramuscular pressure — can evoke task-aligned reflex responses without needing sensory integration from other muscles or sites, particularly during the early phase of long-latency reflexes. This distributed and nested control strategy provides a coherent framework reconciling past and recent findings while addressing overlooked factors in previous literature. We propose novel hypotheses and experimental predictions that extend these insights into movement control, planning, and adaptation.

motor control, stretch reflex, upper limb, online planning and control, electromyography