Dynamic interactions between sensory and decision-making circuits shape temporal evidence weighting

Demetrio Ferro[1*†], Citlalli Vivar[1†], Aaron J. Levi[2], Alexander C. Huk[2], Klaus Wimmer[1,3]

[1]Centre de Recerca Matemàtica, Edifici C, Campus Bellaterra, Bellaterra, 080193, Barcelona, Spain.
[2]Departments of Ophthalmology and Psychiatry & Behavioral Sciences, Fuster Laboratory for Cognitive Neuroscience, UCLA, Los Angeles, 90095, CA, USA.
[3]Department de Matemàtiques, Universitat Autònoma de Barcelona, Campus Bellaterra, Bellaterra, 080193, Barcelona, Spain.

*Corresponding author(s). E-mail(s): ferrodemetrio@gmail.com;
†These authors contributed equally.

Abstract

Perceptual decisions require the brain to integrate sensory evidence over time, yet the temporal weighting of evidence can be flexibly adjusted according to task demands. How such flexibility emerges from interactions between sensory and decision circuits remains unclear. Here, we combined behavioral and neural measurements with recurrent network modeling to investigate the mechanisms underlying temporal reweighting of sensory evidence. Macaques performed a motion-discrimination task in which the temporal statistics of sensory evidence favored early, late or uniform integration. Behavioral psychophysical kernels revealed corresponding shifts in the influence of evidence across time, accompanied by systematic changes in motion discriminability and choice-related activity modulation in visual area MT. We developed a recurrent sensory–decision network incorporating reciprocal feedforward and feedback interactions and temporally structured modulatory inputs. The model reproduced the observed behavioral and neural signatures across temporal weighting conditions. Mechanistically, perturbations of feedforward coupling primarily altered stimulus-driven transmission and temporal evidence weighting, whereas feedback preferentially enhanced late choice-related activity. Moreover, shifting the onset and dynamics of modulatory inputs systematically reconfigured the temporal profile of evidence weighting without substantially altering sensory response dynamics. These findings suggest that flexible temporal integration can emerge from dynamic interactions between sensory transmission, recurrent decision circuits and temporally structured top-down modulation, providing a mechanistic framework for how neural systems adapt the computation of sensory evidence to changing task demands.

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