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Serial, parallel and hierarchical decision making in primates

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Figures and figure supplements

Serial, parallel and hierarchical decision making in primates

Ariel Zylberberg *et al*

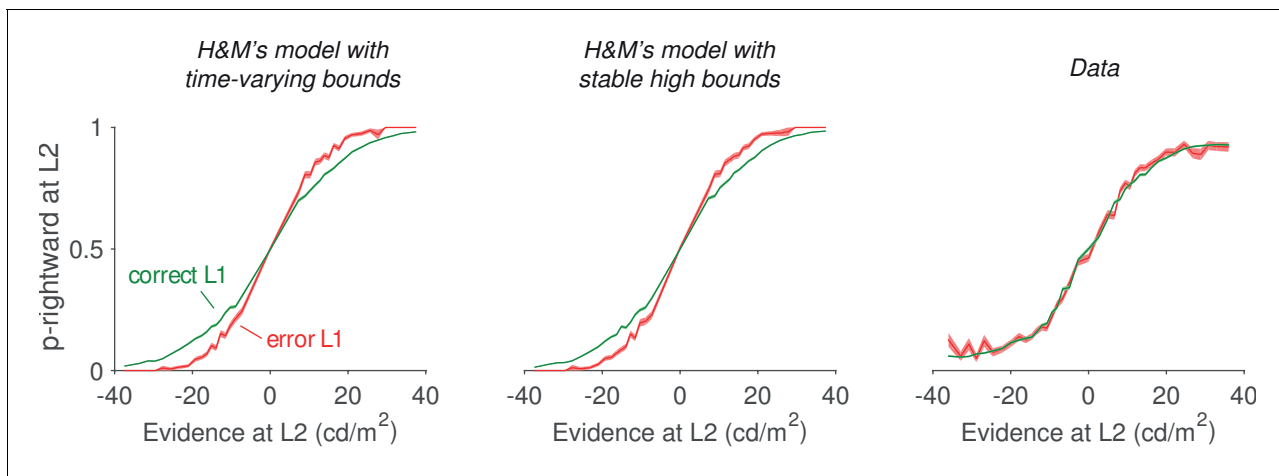


Figure 1. Interaction between the accuracies at L1 and L2. We computed the psychometric function for the L2 decision for trials with a correct (green traces) or erroneous (red) decision at L1. Left, H and M model with infinite bounds collapsing after 500 ms. Middle, H and M model with high bounds that are stable. Right, data of the monkeys in [Lorteije et al. \(2015\)](#). Green/red regions, s.e.m.

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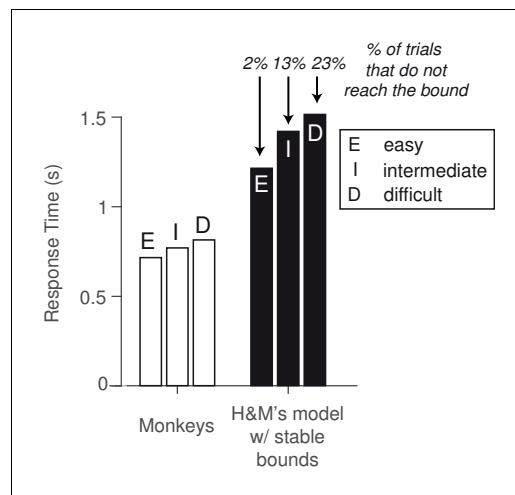


Figure 1—figure supplement 1. Reaction times for model and data. The monkeys' response times (white bars) exhibit a substantial increase with the difficulty of the stimulus, as expected from a decision process in which evidence is accumulated to a bound (see also Figure S1D in *Lorteije et al., 2015*). The model of Hyafil and Moreno-Bote with stable high bounds produces unrealistically long response times (black bars) and the decision variable does not reach the bound in a large fraction of the trials.

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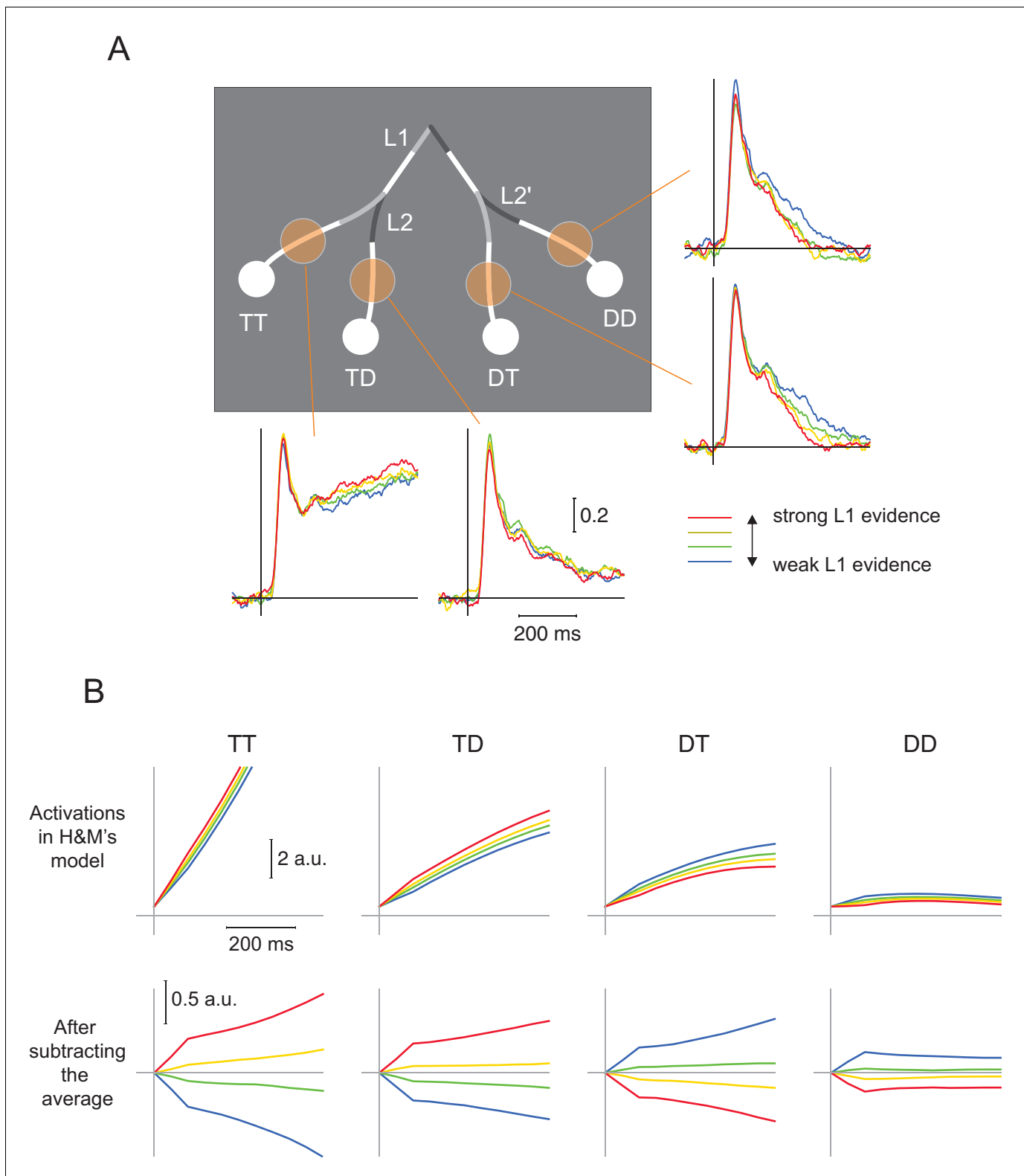


Figure 2. Influence of strength of evidence at L1 on V4 activity elicited by the L2 and L2' branches in V4 and in the model of H and M. **(A)** In the data, high L1 signal strength increases the representation of TT, suppresses the representations of DT and DD, but has little impact on TD. This finding is incompatible with flat models that include only one source of inhibition. **(B)** Upper panel, Same analysis conducted for the activity in the model of H and M. Note the steep rise in activity, which is very different from the neuronal activity in area V4. High L1 signal strength increased activity elicited by

Figure 2 continued on next page

Figure 2 continued

both TT and TD, and suppressed DT and DD. Because of the rectification (firing rates cannot take negative values), L1 evidence has the weakest influence on the DD branch. Lower panels, same data after the average activity was subtracted. Both models by H and M yielded similar results.

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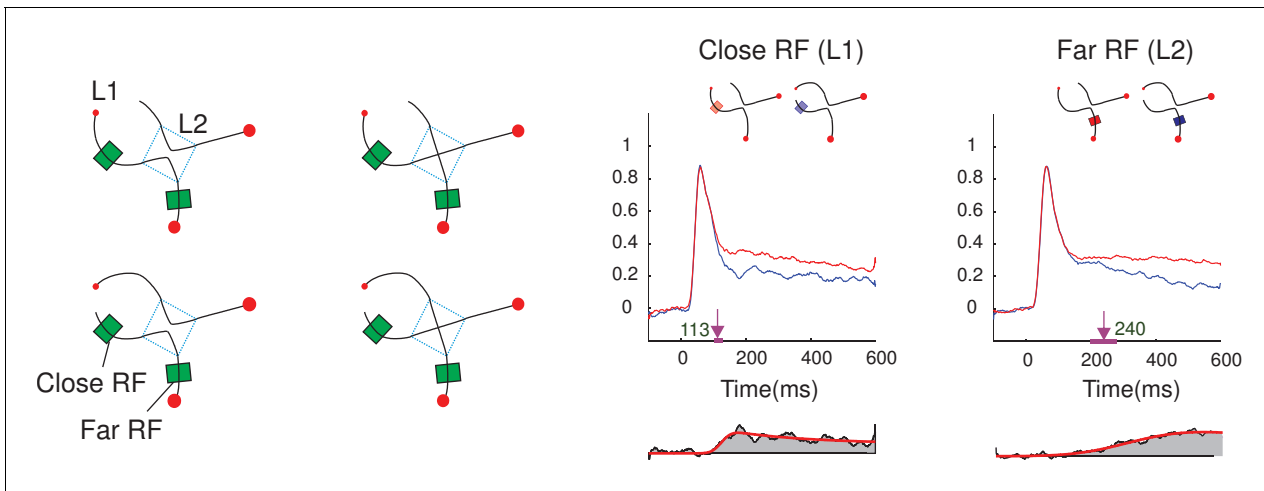


Figure 3. Curve-tracing task with possible intersections. V1 activity elicited by a target curve was stronger than that elicited by a distractor curve. The latency of this enhanced activity reveals a serial decision process, as the selection signal of neurons with a receptive field near the fixation point (close RF, L1-decision) preceded the selection signal of neurons with a receptive field beyond the crossing (far RF, L2-decision). The lower panels on the right represent the selection signals (target minus distractor response). Reprinted with permission from *Pooresmaeili and Roelfsema (2014)*¹⁸.

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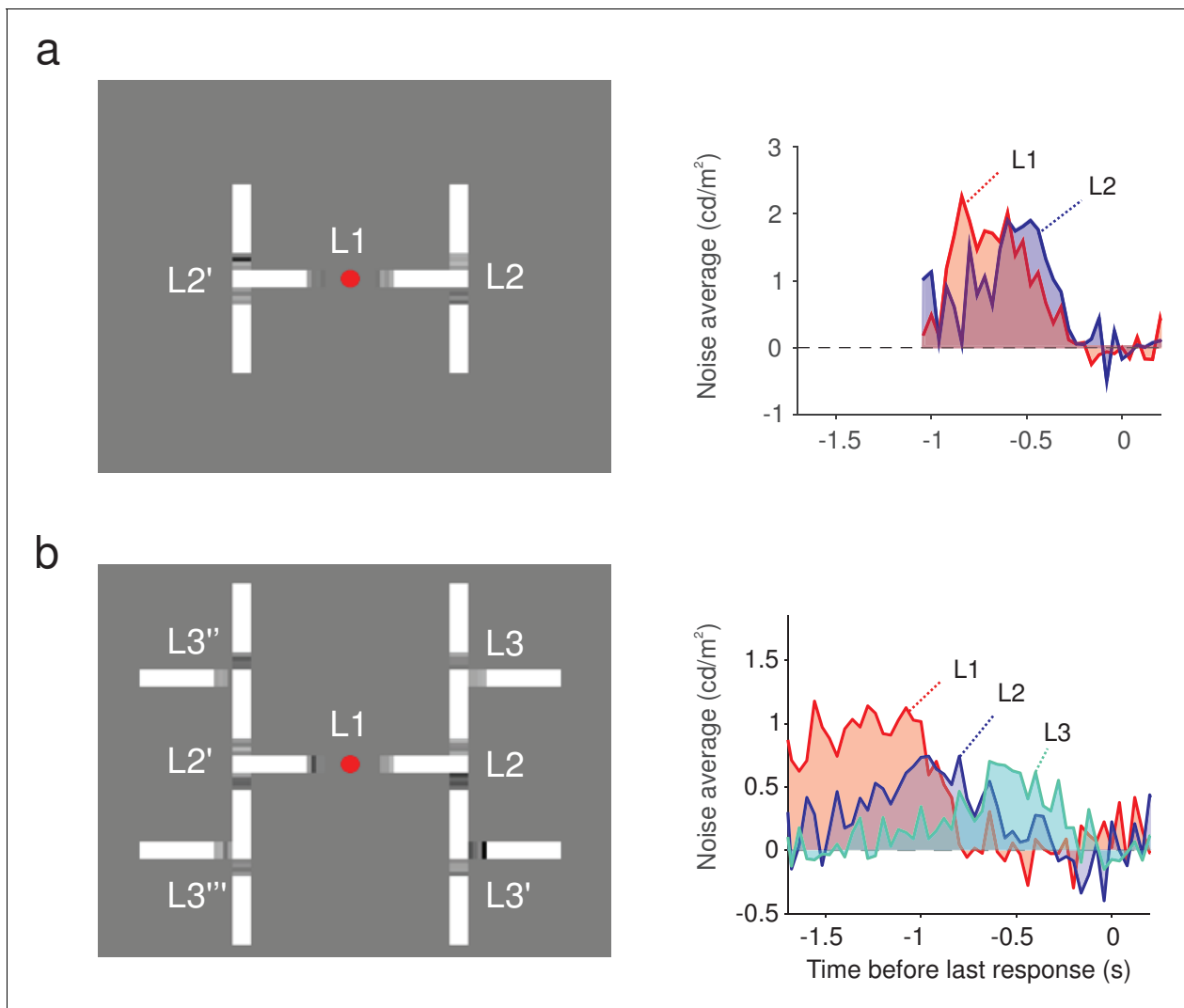


Figure 4. Integrating evidence in a hierarchical decision making task with two (a) and three levels (b). (a) Left, at every bifurcation, subjects had to choose the branch with the higher luminance. At L1 they chose left/right and at L2 they chose up/down. Right, the psychophysical kernel for L1 (red) and L2 (blue), which represents the influence of luminance fluctuations at different time points aligned to the second response. (b) Adding a L3 decision caused a more serial decision process and decreased the overlap between the kernels for the L1 and L2 decisions. Panel b was reproduced with permission from [Zylberberg et al. \(2012\)](#).

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