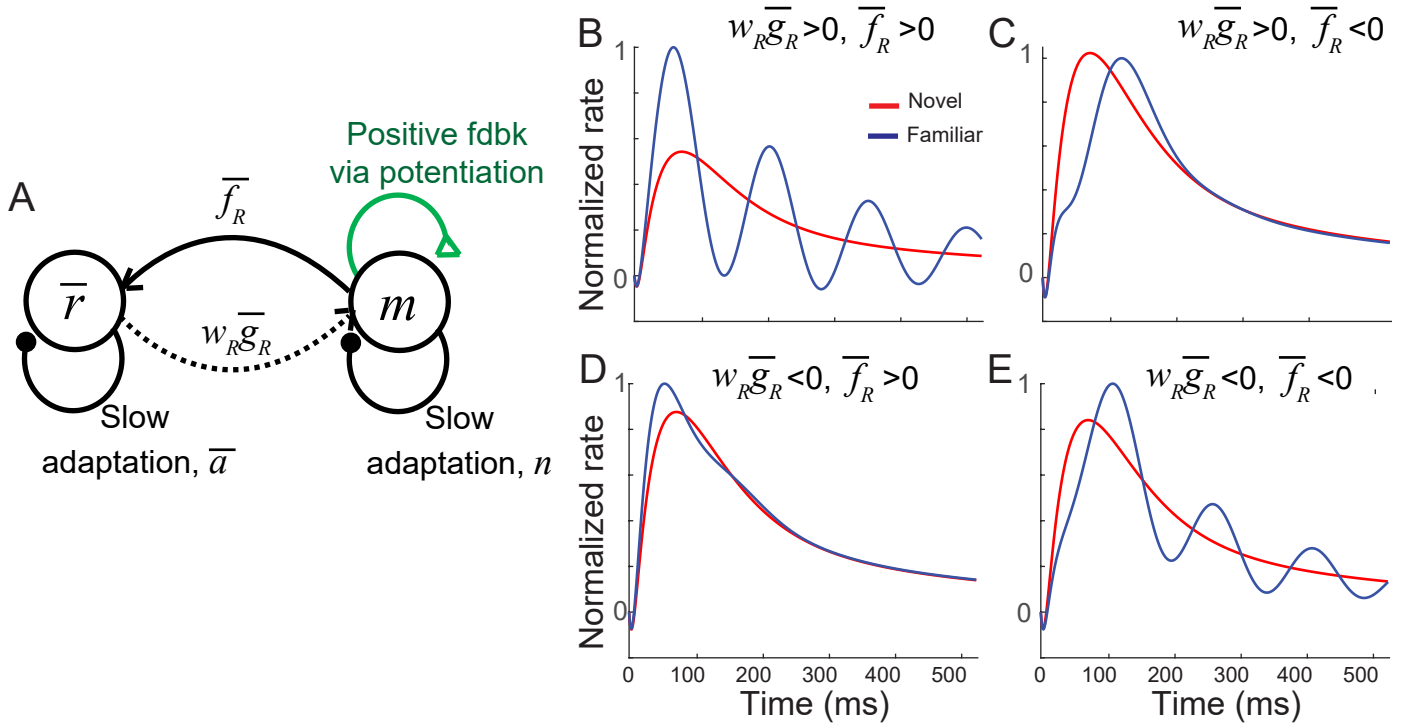


## Figure 3 - figure supplement 2



**Figure 3 – figure supplement 2.** Networks with synaptic plasticity only in recurrent connections without the constraint of the sum normalization of synaptic weights achieved by  $\sum g_k(\xi_j) = 0$ .

(A) Schematics of the mean-field dynamics after learning. The qualitative difference between the dynamics with or without the constraint is the feedback from  $\bar{r}$  to  $m$  (dotted curve). (B-E) Average response before (red) and after (blue) learning with different  $\bar{f}_R$  and  $w_R \bar{g}_R$ . As the case with the constraint, the oscillation can be generated by the strong positive feedback and slow negative feedback in the  $m$  dynamics, and the synchronous oscillations in  $\bar{r}$  and  $m$  are determined by the signs of  $\bar{f}_R$  and  $w_R \bar{g}_R$ . When  $\bar{f}_R$  and  $w_R \bar{g}_R$  have the same signs, a positive feedback loop through  $\bar{r}$  further boosts the oscillation in the  $m$  dynamics (B,E), while the opposite signs of  $\bar{f}_R$  and  $w_R \bar{g}_R$  suppress the oscillation (C,D). Synchrony oscillation between  $\bar{r}$  and  $m$  requires  $\bar{f}_R > 0$  (B,D), and  $w_R \bar{g}_R > 0$  further increase overall oscillation as well as average rates (B). On the other hand,  $w_R \bar{g}_R < 0$  diminishes the oscillation while decreasing average rates (D). None of these cases can reproduce the experimental observations, synchronous oscillations in  $\bar{r}$  and  $m$  with a decrease in the average rates. Thus, additional changes as the feedforward synaptic plasticity are still required without the constraint on the pre-synaptic dependence. The simulation of the mean-field dynamics is the same as in Figure 3-figure supplement 1 except  $w_R = -0.1$ ,  $a = -6.5$ ,  $b = 5.5$ ,  $t_0 = 400$  ms,  $t_l = 40$  ms,  $\bar{f}_R = \pm 0.1$  and  $w_R \bar{g}_R = \pm 1$ .