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Exercise #11

Question 10.1

Hidden Units	Input	PFC	Output
G	0.40 words	0.68 wr	0.99 gr
g	0.34 colors	0.43 cn	0.96 gr

Question 10.2
During the conflict condition of color naming, where red conflicts with the color green we are able to observe that both of the hidden units become activated. The result of this activation is heightened competition between these pathways which results in a longer settling time or response due to the cognitive effort that is required to resolve any conflict. This network in turn mirrors the human Stroop task experience where conflicted stimuli increase decision making times as the brain makes effort to prioritize the given conflicts.

Question 10.3
Reducing the PFC gain from 0.3 to 0.25 targets the network's ability to manage conflict by weakening the top-down control that usually suppresses the dominant word reading response which in turn results in slower response times, more specifically in situations including conflict. This mirrors cognitive deficits observed in frontal damage or schizophrenia which further emphasizes the PFC’s role in cognitive control. Conversely, increasing the DtVmTau affects all cognitive processes uniformly which leads to a general slowdown rather than the specific impairment that we see with the reduced PFC gain. Therefore, while general slowing affects all tasks, reducing the PFC gain targets conflict resolution which demonstrates the crucial role that PFC plays within the Stroop task.

Question 10.4
During the B trials in the network simulation the network initially exhibits strong activation patterns for the A location due to the recurrent activation from previous trials and the Hebbian learning that has strengthened the connections which are assimilated with A. This reflects the A not B error which was seen in Piaget studies where infants reach for the location A when the toy is at B. As the B trial goes on the network struggles to update its internal representations from A to B. If the recurrent weights are weak then the network will fail to maintain the new location of

B which will result in more reaches for A. This correctly resembles the infants who reach towards A despite the block being at location B due to the reinforced location memory.

Question 10.5

Increasing the RecurrentWt to 0.7 significantly enhances the network's active maintenance capabilities which mirror the development of better working memory or active maintenance abilities in older infants or toddlers. With stronger recurrent connections, the network can maintain newer information. The result of this is a more accurate update of internal representation and the output layers more reliably shifting to the B location during B trials. The increase in the recurrent weight effectively minimizes the A not B error as the network is now able to overcome the previously set preference for A. This in turn demonstrates the improvement in behavioral flexibility.

Question 10.6

With an increase in delay length and a recurrent weight of 0.7, the network's ability to maintain accurate representation over longer periods is tested. The longer delay creates a greater challenge for the network's maintenance capabilities. The extended delay can lead to a gradual decay of the current representation of the B location especially if the recurrent weights are not optimally tuned to handle such long delays. This decay will result in a renewal of the location of the A locations activation which leads to a higher chance of committing the A not B error. The delay effect illustrates the crucial role of the active maintenance in memory which in turn shows that even enhanced PFC abilities have limits when faced with prolonged delays.

Question 10.7

The pattern of AbsDa dopamine firing and the PctErr performance in the network are linked through the reinforcement learning mechanisms supporting the basal ganglia's control over gating in the prefrontal cortex. As the network goes through training, 'AbsDA' reflects the phase of dopamine signals that represent reward prediction errors. Initially when the network often guesses incorrectly, the error rate is high and 'AbsDA' shows substantial fluctuations reflecting significant dopamine bursts and dips. As learning progresses and the network becomes more proficient at the task, the PctErr Decreases, which indicates fewer errors and improved task performance. In the same way the 'AbsDA' signal diminishes over time, this implies that the dopamine responses are stabilizing. This stabilization occurs because the network's predictions about rewards become more accurate. Thus the difference between expected and actual outcomes decreases. The decreasing 'AbsDA' value indicates that the network is approaching a level where its predictions are more consistently aligned with the outcomes, which minimizes the prediction errors. Essentially, the basal ganglia and PFC learn to effectively gate and maintain the correct information, reducing the necessity for large corrective dopamine signals which optimize the network's gating strategy and allow it to perform the task with accuracy.

Question 10.8

The weights from the Store, ignore, and Recall inputs to the Matrix stripes reflect the learned gating policies that enable successful performance. Store weights contain high weights from the store input to specific matrix stripes, which are crucial because they determine when and where to gate information into the PFC. This network learns to strongly activate the GO pathway in the matrix when a store signal is received, which enables the corresponding PFC to update its content with the current input. Ignore weights typically learn to activate the NoGo pathway in the matrix. This ensures that the PFC stripes do not update their contents in response to inputs that should be ignored. The high weights to NoGo prevent disturbances in the maintained information, which is crucial for successful recall later. Recall weights Learn to activate the output gating stripes via Go signals in the matrix. This allows the networks to use the information maintained in the PFCmnt stripes to drive the appropriate responses in the output layer.