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A Brain-inspired Computational Model for Spatio-temporal Sequence Recognition

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Temporal sequence processing is fundamental in brain cognitive functions. Experimental data has indicated that the representations of ordinal information and contents of temporal sequences are disentangled in the brain, but the neural mechanism underlying this disentanglement remains largely unclear. We investigate how recurrent neural circuits learn to represent the abstract order structure of temporal sequences, and how the disentangled representation of order structure facilitates the processing of temporal sequences. We show that with an appropriate training protocol, a recurrent neural circuit can learn tree-structured attractor dynamics to encode the corresponding tree-structured orders of temporal sequences. This abstract temporal order template can then be bound with different contents, allowing for flexible and robust temporal sequence processing. Using a transfer learning task, we demonstrate that the reuse of a temporal order template facilitates the acquisition of new temporal sequences, if these sequences share the same or partial ordinal structure. Using a key-word spotting task, we demonstrate that the tree-structured attractor dynamics improves the robustness of temporal sequence discrimination, if the ordinal information is the key to differentiate these sequences.