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Behavior of hidden nodes in Artificial Neural Networks under increasing cognitive load

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Biological neural networks solve cognitive tasks with varying levels of complexity. However, it remains unclear how specific structural and functional features of these networks are related to increasing difficulty of the problems to be solved. How do network motifs change when the cognitive cost is increased? We address this question by evolving Artificial Neural Networks (ANNs) under the pressure of a functional goal of successfully playing the classic Atari game Pong with setups of increasing difficulty. These setups include deterministic modifications for varying degrees of ball velocities, different paddle sizes, and increasing levels of stochasticity in the system by varying angular velocity of the ball upon wall collisions. The resulting ensembles of ANNs contained an overrepresentation of the same motif: an excitatory and inhibitory edge of equal magnitude integrating the ball and paddle position into a single output node (hereafter M_1). This simple policy was successful for both deterministic and stochastic modifications. Further, stochastic modifications resulted also in different network motifs with M_1 embedded as part of the network, and, interestingly, with motifs that did not contain M_1 . We focused our analysis on this latter, non-standard network motifs, that exhibited hidden nodes and complex policies for successfully playing the game. By re-evaluating the non-standard network solutions with graded levels of unpredictability of ball behavior, we identify the role of hidden nodes. Using this framework, we present a fingerprint of the hidden node behavior in the complex policies emerging in ANNs evolved under functional goals with increasing levels of stochasticity.

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