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Proceedings of the Annual Meeting of the Cognitive Science Society

Title

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Permalink

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Journal

Proceedings of the Annual Meeting of the Cognitive Science Society, 43(43)

ISSN

1069-7977

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Publication Date

2021

Peer reviewed

Regression, encoding, control: an integrated approach to shared representations with distributed coding

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Abstract

Artificial systems currently outperform humans in diverse computational domains, but none has achieved parity in speed and overall versatility of mastering novel tasks. A critical component to human success, in this regard, is the ability to redeploy and redirect data passed between cognitive subsystems (via abstract feature representations) in response to changing task demands. However, analyzing shared representations is difficult in neural systems with distributed non-linear coding. This work presents a simple but effective approach to this problem. In experiments, the proposed model robustly predicts behavior and performance of multitasking networks on natural language data (MNIST) using common deep network architectures. Consistent with existing theory in cognitive control, representation structure varies in response to (a) environmental pressures for representation sharing, (b) demands for parallel processing capacity, and (c) tolerance for crosstalk. Implications for geometric (dimension, curvature), functional (automaticity, generalizability, modularity), and applied aspects of representation learning are discussed.