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Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 15(0)

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Publication Date
1993

Peer reviewed

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Abstract

The architectural properties of a neural network, such as its size, shape, and connectivity pattern, determine the network's functional properties. From an engineering viewpoint, discovering a suitable architecture for a given task is often the only way of achieving good performance on the task. From a cognitive science viewpoint, the study of structure-function relationships helps in understanding the "modular" aspects of the mind/brain. We present a multi-network, or modular, connectionist architecture in which tasks are not pre-assigned to networks. Instead networks compete for the "right" to learn different tasks. Results suggest that the structure of each network biases the competition such that networks tend to learn tasks for which their structure is well-suited.

Experimental findings suggest that the neural subsystem that encodes categorical spatial relations (e.g., on/off, above/below) is distinct from the one that encodes metric spatial relations (e.g., object A is 3.5 inches away from object B). Similarly, distinct subsystems seem to be responsible for recognizing a visual stimulus as a member of a category (e.g., dog) and for recognizing a stimulus as a specific exemplar (e.g., Fido). Furthermore, categorical spatial relations and category representations of shape are encoded more effectively in the left hemisphere, whereas coordinate spatial relations and exemplar representations of shape are encoded more effectively in the right cerebral hemisphere. We have used computer simulations of artificial neural network models to show that differences in receptive field sizes can promote such organization. When visual input was filtered through relatively small nonoverlapping receptive fields, networks learned to categorize shapes relatively quickly; in contrast, when input was filtered through relatively large overlapping receptive fields, networks learned to encode specific shape exemplars or metric spatial relations relatively quickly. In addition, using the modular architecture described above, networks with small inonoverlapping receptive fields tended to win the competition for categorical tasks whereas networks with large overlapping receptive fields tended to win the competition for exemplar/metric tasks.

References

Jacobs, R. A., Jordan, M. I., & Barto, A. G. (1991) Task decomposition through competition in a modular connectionist architecture: The what and where vision tasks. Cognitive Science, 15, 219-25

Jacobs, R. A., Jordan, M. I., Nowlan, S. J., & Hinton, G. E. (1991) Adaptive mixtures of local experts. Neural Computation, 3, 79-87.

Jacobs, R. A. & Kosslyn, S. M. (1993) Encoding Shape and Spatial Relations: The Role of Receptive Field Size in Coordinating Complementary Representations. Submitted for publication.