Computational principles in visual comprehension: Simulating neuropsychological deficits by lesioning attractor networks

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Abstract

A central challenge in cognitive neuroscience is to explain how disorders of brain function give rise to disorders of cognition. In this regard,connectionist modeling provides a useful computational formalism for relatingcognitive processes to their underlying neurological implementation. In the domain of visual comprehension of words and objects, I will show how two peculiar patterns of impairment observed after brain damage, deep dyslexia and optic aphasia, also arise in simulations embodying a set of general computational principles: (1) visual and semantic information is represented as distributed patterns of activity over separate groups of units such that the patterns exhibit the appropriate similarities within and between these domains; (2) the knowledge of the relationships between representations is encoded as weights on connections between units; and (3) the mapping between representations is accomplished by interactivity among units, forming "attractors" for familiar patterns of activity. Further assumptions are that short-term correlational information is useful in object recognition but not in word recognition, and that there is less structure in the mapping from visual to semantic representations for words than for objects. In a simulation of word reading, damage leads to the peculiar interactions of visual and semantic similarities in errors found in deep dyslexia. In a simulation of object naming, very few purely visual errors occur after damage but now semantic similarity interacts with perseverative effects from previous trials, as in optic aphasia. The replication of complex empirical phenomena concerning impaired visual comprehension of both words and objects provides evidence that the general principles underlying the simulations also apply to the semantic processing of visual information and its breakdown following brain damage in humans.

References

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