Dynamic Cognitive Modeling of Syntactic Language Processing

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We present Dynamic Cognitive Modeling [1] as a three tier top-down approach comprising the levels of (1) cognitive processes; (2) their state space representations; and (3) dynamical systems implementations that are guided by neuroscientific principles. These levels are passed through in a top-down fashion: (1) cognitive processes are described as algorithms sequentially operating on complex symbolic data structures that are decomposed using so-called filler/role bindings [1,2]; (2) data structures are mapped onto points in abstract vector spaces using tensor product representations [1,2]; (3) cognitive operations are implemented as dynamics of neural networks or neural/dynamic fields. The last step involves the solution of inverse problems, namely training the system's parameters to reproducing prescribed trajectories of cognitive operations in representation space. The method is illustrated by means of an instructive example from syntactic language processing [3]. We construct a functional representation [4] of a context-free left-corner parser over a three-dimensional feature space processing the well-formed sentence

(1) Die Gans wurde im Ofen gebraten

"The goose was grilled in the oven"

and the phrase structure violation

(2) Die Gans wurde im gebraten

"The goose was grilled in".

After training a neural field, the differences of neural activation exhibit some remarkable resemblance with the event-related brain potentials reported in [3].

References

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