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Recollection and imagination in a functional model of visual cortex

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In [1] we have presented a model of signal flow in functional cortical columns, across the six cortical layers and between several cortical areas. We showed how the columnar subsystems interact to predict and recognize stimuli in terms of locally stored knowledge. In this model, columnar communication integrated bottom-up signals with internally generated top-down signals to describe the stimulus consistently across all cortical areas. Here we extend this model to demonstrate that the same setup of intercommunicating columns can use the stored knowledge to integrate a pre-activation on the highest level with the bottom-up recognition process. Given only coarse or invariant top-down activation, the model can (i) guide and support the recognition of noisy or ambiguous stimuli, and (ii) recall known objects, at the highest level of detail, by creating specific neural activations across all cortical areas. The second process corresponds to recollection or mental imagery, in which the brain internally creates a percept without a physical stimulus.

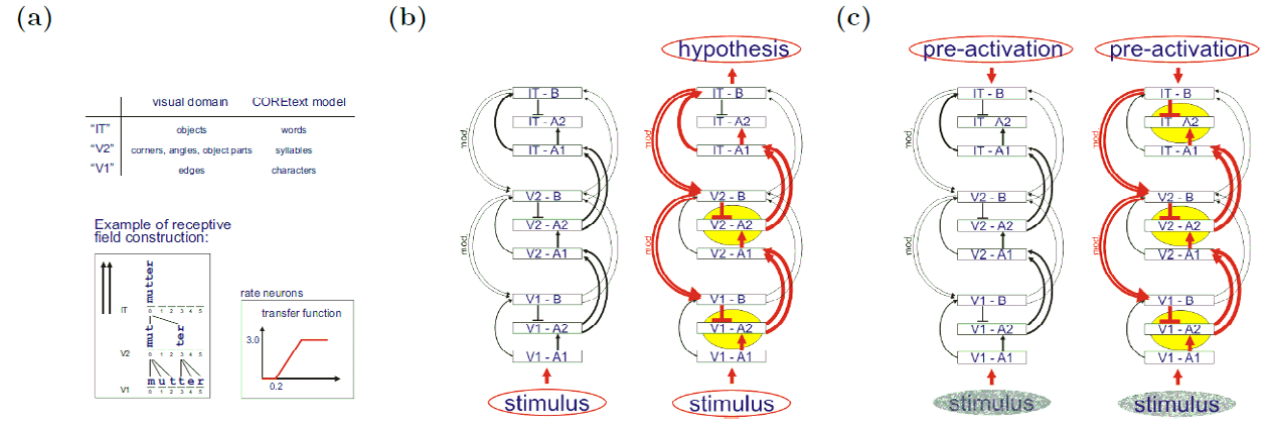

Figure 1
Recognition and recall in the COREtext model. (a), characters, syllables, and words in the COREtext model correspond to edges, parts, and objects in the visual system; (b), bottom-up mode (recognition); (c), top-down mode (recall).

The top-down pre-activation supports recognition of a stimulus in several ways. (1) If the stimulus is noisy and could not be recognized in the pure bottom-up-driven mode, the pre-activation of the highest area supports weak bottom-up activations that are consistent with the top-down signal, and stabilizes recognition of the stimulus. (2) If the stimulus is ambiguous and did not lead to a stable pattern of activity, because no consistent description across all levels could be found, pre-activation of one of the alternative objects (words) in the highest area stabilizes the recognition of this object, and marks the other parts of the stimulus as errors. In both cases, the dynamics of the interacting neural subsystems promotes the top-down influence across all model areas. (3) If the physical stimulus is unspecific or missing, the top-down activation shapes the diffuse bottom-up activation towards recognition of the respective object. Because the dynamics of the interacting neural subsystems strives towards consistent neural activity on all cortical levels, it (re-)creates a detailed and specific mental image of the recalled object.

References

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