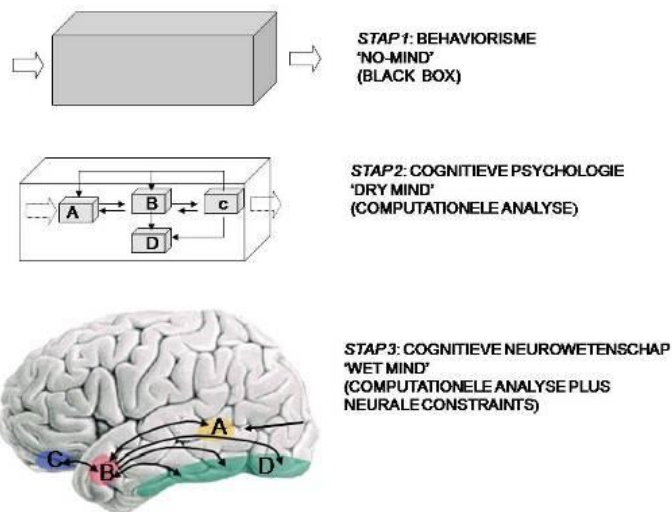


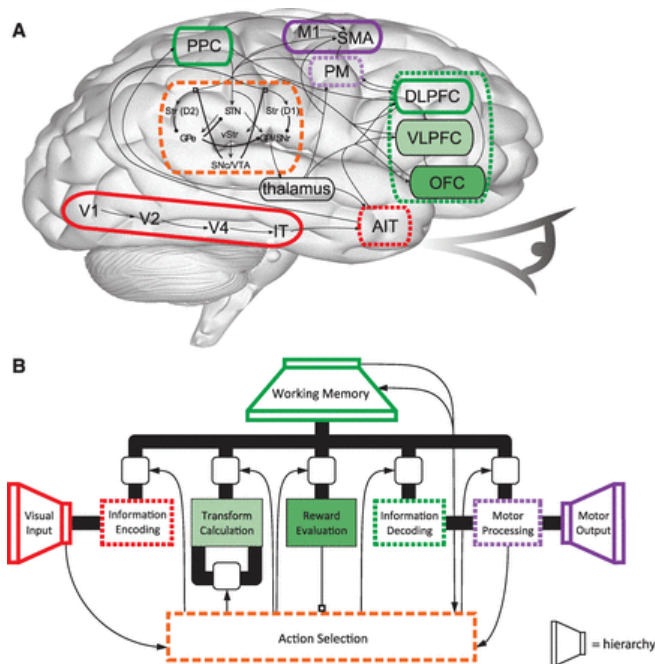
Stages in the brain

For many years I have used the slide below in my basic course on Cognitive Neuroscience (CN) in what was then still called the 'vakgroep Psychonomie'.



The slide was meant to elucidate three important phases or steps ('*stappen*' in Dutch) in CN, evolving from black box psychology, to computational analysis, sometimes referred to as the linear or "stages" approach, and finally the implementation of the 'dry' computational analysis in a 'wet' brain model.

Now, very recently (and for me rather surprisingly) Eliasmith and coworkers described in *Science* a simulation of what they refer to as a 2.5-million-neuron model 'Spaun' (*Semantic Pointer Architecture Unified Network*). Spaun is able to respond to visual images and emit responses by using a physical mode of the arm. Although simplified, the model captures many aspects of neuroanatomy, neurophysiology, and psychological behavior and can perform eight different tasks, involving recognition of images and a serial working memory task. So basically, Spaun is a refined elaboration of the simple stage model we used to guide our students on their first uncertain steps in Cognitive Neuroscience. One might also say that Spaun (see figure below taken from the recent *Science* paper) is of an upgrading of the serial 'Sternberg' or 'Sanders' models, now describing serial information processes on the computational as well as brain level.



Anatomical and functional architecture of Spaun. **(A)** The anatomical architecture of Spaun shows the major brain structures included in the model and their connectivity. Lines terminating in circles indicate GABAergic connections. Lines terminating in open squares indicate modulatory dopaminergic connections. Box styles and colors indicate the relationship with the functional architecture in (B). PPC, posterior parietal cortex; M1, primary motor cortex; SMA, supplementary motor area; PM, premotor cortex; VLPFC, ventrolateral prefrontal cortex; OFC, orbitofrontal cortex; AIT, anterior inferior temporal cortex; Str, striatum; vStr, ventral striatum; STN, subthalamic nucleus; GPe, globus pallidus externus; GPi, globus pallidus internus; SNr, substantia nigra pars reticulata; SNc, substantia nigra pars compacta; VTA, ventral tegmental area; V2, secondary visual cortex; V4, extrastriate visual cortex. **(B)** The functional architecture of Spaun. Thick black lines indicate communication between elements of the cortex; thin lines indicate communication between the action-selection mechanism (basal ganglia) and the cortex. Boxes with rounded edges indicate that the action-selection mechanism can use activity changes to manipulate the flow of information into a subsystem. The open-square end of the line connecting reward evaluation and action selection denotes that this connection modulates connection weights. See the full paper for more detailed definitions of abbreviations, a summary of the function to anatomy mapping, and references supporting Spaun's anatomical and functional assumptions.

References

- C. Eliasmith et al., *Science* 30 November 2012: Vol. 338 no. 6111 pp. 1202-1205. A large-scale model of the functioning brain
- <http://bigthink.com/neurobonkers/a-conversation-with-the-creators-of-the-worlds-largest-functioning-model-of-the-human-brain>

