The magic number 10 --- *Hertz, that is!*

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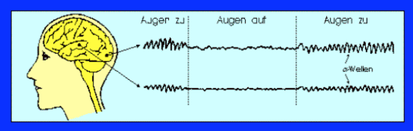
The ~10 Hz frequency domain



Near 100-ms periods are commonly observed in conscious sensory integration and consciously mediated reaction time tasks. (Baars, 1988).

Three brain rhythms oscillate near 10 Hz: alpha, theta and mu. Hughes (2005) argues that the same pacemaker cells in thalamus may generate mu and alpha. Theta may reflect similar pacemaker cells in hippocampus. For simplicity, we will treat near-10Hz rhythms as a class.

The amplitude of Event-Related Potentials and Evoked Synchrony in the same frequency range is also associated with conscious events, ranging from 100-600 ms, and may reflect multiple cycles of the same underlying mechanisms.

We propose that ~10Hz rhythms reflect a region-sampling cognitive cycle similar to the Cognitive Cycle of LIDA. (below) Each cycle may trigger a globally reentrant broadcasting burst of beta-gamma activity, consistent with Global Workspace Theory (GWT). Standard cognitive tasks require multiple cycles to complete.

In contrast, lower frequency rhythms (< 4 Hz) signal a general loss of consciousness under a wide variety of conditions. **Consciousness-related brain rhythms are therefore clearly bounded at the lower limit of their range. .**

~10 Hz rhythms may in turn pace "beta-gamma" oscillations, which are associated with specific conscious contents. (W. Singer, Fries, etc.)

The figure below shows how single neurons can b e grouped and paced by synchronized near-10 Hz rhythms.

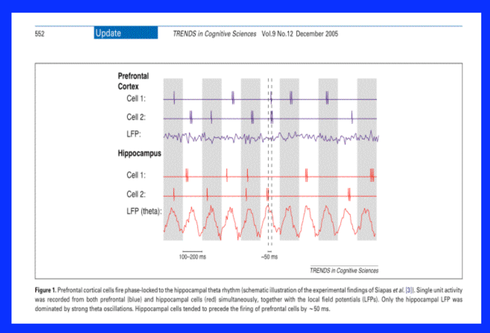
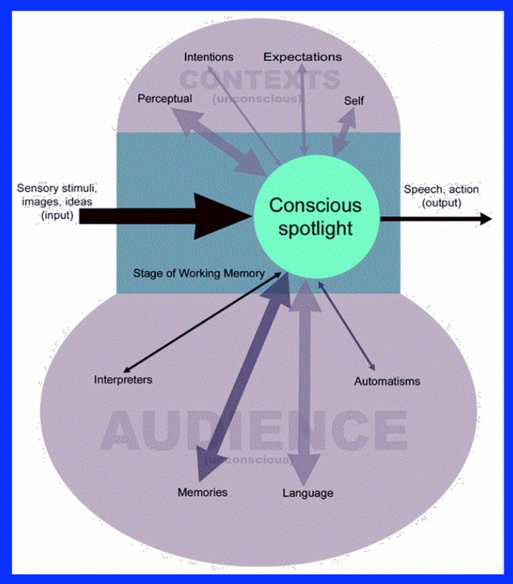
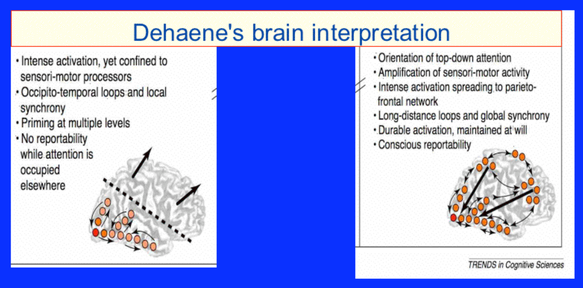


Figure 1. Prefrontal cortical cells fire phase-locked to the hippocampal theta rhythm (schematic illustration of the experimental findings of Siapas *et al.* [3]). Single unit activity was recorded from both prefrontal (blue) and hippocampal cells (red) simultaneously, together with the local field potentials (LFPs). Only the hippocampal LFP was dominated by strong theta oscillations. Hippocampal cells tended to precede the firing of prefrontal cells by ~50 ms.

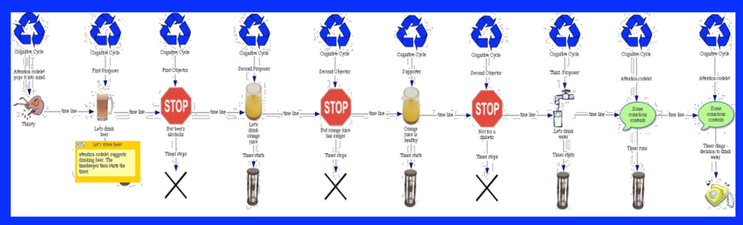
Global Workspace Theory





LIDA's Cognitive Cycle

--- in consciously-mediated decision-making and many other functions.

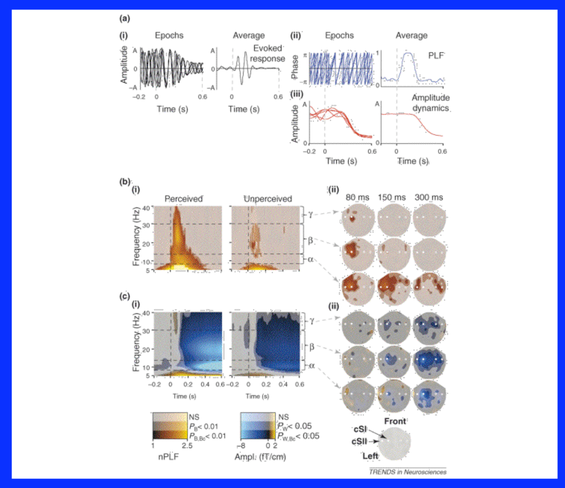


LIDA Cognitive Cycle – Threefold Decomposition

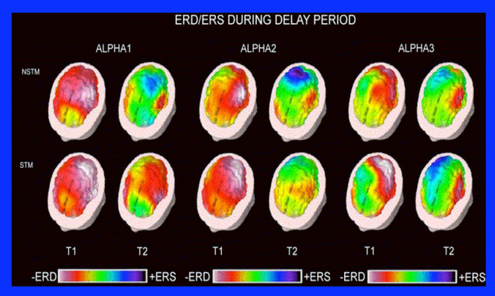
1. Understanding the current situation:
   a. Beginning with incoming sensory stimuli, both exogenous and endogenous
   b. Going back and forth through sensory memory, perceptual memory and the workspace
   c. Taking advantage of transient episodic memory and declarative memory
   d. The structural model in the workspace of the agent's picture of its situation is updated to reflect its current situation.
2. Consciousness:
   a. Coalitions of portions of this internal model compete for access to the global workspace on the basis of relevance, importance, urgency, novelty, etc.
   b. One such coalition wins. Its portion of the current internal model becomes that which will be attended to, the current contents of consciousness.
   c. These contents are then broadcast throughout the system to recruit needed internal resources and to implement learning in each of several modes.
3. Action selection and execution
   a. Possible action schemes activate themselves to the extent that their preferred context intersects the current, and recent, contents of consciousness.
   b. Those schemes with sufficiently high activations instantiate specifications of themselves using current, and recent, conscious contents.
   c. A single action is chosen from these, and earlier, instantiations.
   d. The action is executed

Evidence for ~10Hz pacing in conscious moments of cognition.

Sensory consciousness (Palva & Palva, 2007)

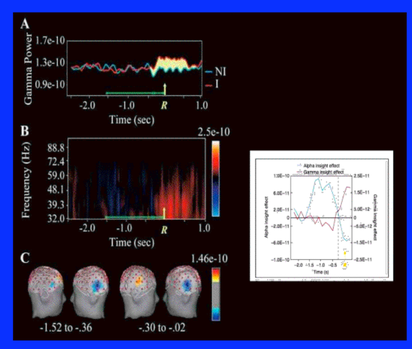


Short-term memory (C.Babiloni, 2004); Sauseng et al, 2004: X. Wu, et al, 2007)



Episodic (conscious) learning and retrieval: (See Doppelmayr et al, 1998; Klimesch et al, 2001)

Problem solving with conscious "insight": (Jung-Beeman et al, 2004)



"… an entrainment/gating mechanism in which multiple alpha networks (visual-, auditory-, and somatosensory-centered domains), typically producing rhythmic oscillations in a locally independent manner, become coupled and entrained. A global or 'diffuse and distributed alpha system' comes into existence when these independent sources of alpha become coherently engaged in transforming perception to action . (Pineda, 2005)

Summary and Conclusion: Near-10-Hz- rhythms may coordinate faster (beta-gamma) oscillations to perform the major functions of Global Workspace Theory and LIDA.