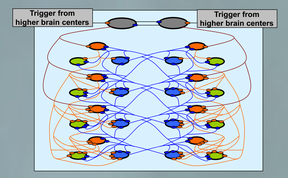
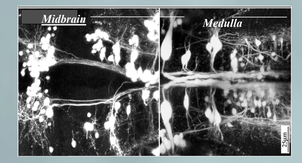


Conscious Record Memory: Thoughts on an Associative, Flash Memory System that Underlies Human Intelligence

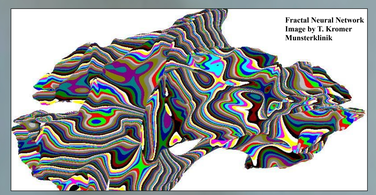
Valeria Gioioso and Donald M. O'Malley, Dept. Biology, NU Boston MA



92.22
EE19

What is CRM? Autonoetic Consciousness?

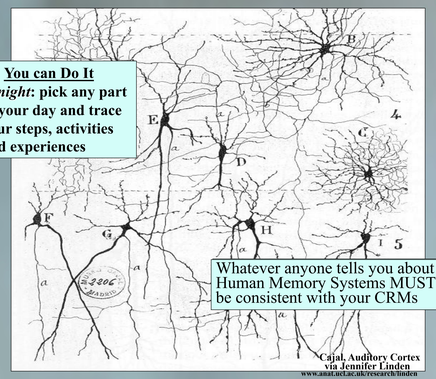
CRM = Conscious Record Memory
CRM refers to chronological **daily memory traces** that you can interrogate in great depth on the day of your experiences. The retrieval of CRM fragments is called "Autonoetic Consciousness" (Tulving, 2002). Classically-studied ***Episodic Memories*** (EM) can be viewed as remnants of daily CRM records although current studies of "EM" often focus on different (or overlapping) memory systems.



Attributes of CRM / Flash Memory

1. CRM is written <u>effortlessly</u> & chronologically.
2. CRM ***vastly exceeds*** our STM and WM stores' capacities (such as lists of 7 unrelated items).
3. CRM is a one-trial (**FLASH**) memory (and thus distinct from memories that require repeat-firing)
4. CRM is vast ***because of*** our prior experiences.
5. CRM reflects massive cortical interconnectivity.
6. **. Resident** CRM is probably used thru out the day

<u>You can Do It</u>
***Tonight*: pick any part of your day and trace your steps, activities and experiences**

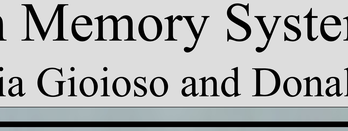


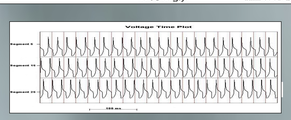
zzee.net/images/images/void1.jpg

CRM is Experiential in Nature

***Some Ideas About CRM*:**

1. Daily CRM vastly exceeds **short-term** and **working memory** buffers and is distinct from classic Hebbian LTP by virtue of being ***experience-dependent.***
2. CRM is ineffective in recording "alien" experiences in most people (e.g. 1000 new vocabulary words).
3. CRM is similarly limited in recording **the exact sequences** of words *heard* or *read* during the day.
4. CRM excels in recording the gist of experiences that are both salient and well-represented by prior experiences (**associations**), such as seminars.
5. CRM capacity = f(# prior associations) and depends upon massive interconnectivity of cortical neurons.
6. CRM thus constitutes a memory-resource that is largely distinct from "list learning" mechanisms.
7. These conclusions are based upon experiences that most individuals can examine via introspection.





Certain Savants and Calendar-Memory individuals have extensive musical, visual or other records. But the storage of such records may come at the expense of other kinds of records such as social interactions, facial expressions and myriad other features of the internal and external worlds. We expect that CRM has a finite capacity that depends upon experience and a young, healthy cortex

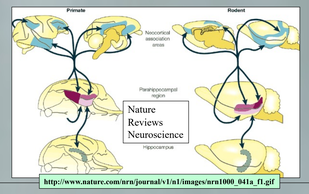
Conscious Experience is an *Excerpt* of the External and Internal Worlds and ..

… CRM = Excerpt of *Conscious Experiences*
<u>so:</u> CRM = a very, very tiny fraction of the total sensory and internal information flowing through the CNS [Franklin and Baars, 2005]
But still: CRM is massive in relation to STM / WM systems

STM, Hebbian Learning & <u>CRM Daily Records:</u> How do these things relate?

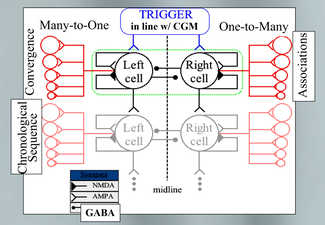
- **Hebbian Learning / LTP** involves paired, repeated stimuli and apparently is NOT dependent upon ***past associations***
- **Short-Term "list-learning"** memory stores are very limited [despite the effort applied to learning "new lists"]
- *Daily Memory Records* (DMRs) can exceed **1000 items**
- Storage of **Flash DMRs** requires no repetition or effort
- Storage of DMRs presumably involves activation of stored **prior experiences /** neural representations.
- CRM may be analogous to **genetic recombination** with *de novo* Hebbian learning akin to spontaneous mutations
- Both types of learning and memory may be important for achieving human-level intelligence

Please Fill Us In: The fewest # of action potentials needed to enable LTP is: _____



Associational CRM may utilize existing connections and bistable CPG states

- **Incoming stimuli** are proposed to trigger coherent, associated stored representations
- **CRM storage** may entail activation of linkages between stored representations by switching CPGs to ON state
- CRM may depend upon **cortical predictions** that occur ahead of experience (see Hawkins' *On Intelligence*)
- **Past temporal associations** [or a chronological buffer] enables recording of CRMs as chronological sequences

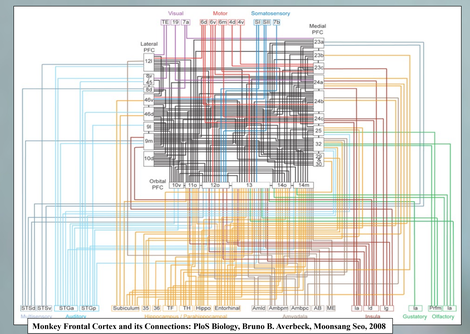


The key criterion enabling vast, immediate and effortless memory storage seems to be ***prior experience***: predictive (top-down) cortical patterns match or mesh with bottom up (i.e. sensory) patterns, thus e.g. registering a visual signal as a person (e.g. meter maid, heavyset woman, smiling). Some salient subset of items achieves a threshold value sufficient for instantly creating persistent activity patterns. One possibility is that local circuits and/or distributed networks with **bistable states** are flipped into the ON state and thereafter oscillate for as long as appropriate for those particular memories. Simple two-cell models of spinal oscillators show such bistable behavior (Knudsen et al., 2006); such may be implemented in cortical networks (Yuste et al. 2005).

<u>CRM Development:</u> Infants should have essentially zero CRM capability, but this will grow steadily with experience as guided by inductive bias (but see Baum, *What is Thought*?). By age 2, toddlers may have CRM at least to the limits conveyable by their limited vocabulary. The loss of early quasi-permanent episodic memories seems unrelated to our daily CRM records; only a very small subset of CRMs are consolidated into such enduring episodic memories.

CONCLUSIONS

Possible Mechanisms underlying CRM



Monkey Frontal Cortex and its Connections: PloS Biology, Bruno B. Averbeck, Mounsang Seo, 2008

<u>Several features likely contribute to or ensue from our model:</u>
1. The greater the sensory convergence onto an oscillator unit (e.g. 2-cell CPG), the greater the likelihood of the unit receiving sufficient summation to switch it into the ON state (also see **Singer 2009**).
2. This convergence is determined by prior learned associations and 10K-cortical connectivity, along with **one-to-many** network inputs.
3. Cortex is capable of sustaining millions of such mini-oscillator circuits simultaneously.
4. Central "timing" circuits ensure synchronization of related activities and are evident in macroscopic brain rhythms e.g. gamma, theta, beta. Cortical layers segregate oscillators (Roopun et al. 2008).
5. Because these neural activity patterns are tightly linked to sensory representations, they presumably reside in appropriate higher order sensory and/or associational cortices.
6. Subsequent (LTP-related) mechanisms extend CRM durations into medium and long-term memory as salience, determined by subsequent cortical analysis and other events, dictates.
7. Dopamine reward systems are involved in multiple steps.

Potential Utility of CRM

1. Consciousness is the sole domain of all Reflective Mental Activity and CRM is a major, primary record.
2. CRM is the neural representation of all that we hear, see, feel, think, know, say, like, hate, fight, etc.
3. Processing of the most SALIENT aspects of our world **is based upon the** processing of CRMs because CRMs –***ARE***– the MOST salient aspects of our world.
4. CRM is especially well-developed in humans and plays a major role in human intelligence.

References: See summary provided. Comments Welcome.

Various Notes on Above Poster

www.digital-maze.com
www.digital-entities.com

The key criterion enabling vast, immediate and associative memory storage seems to be ***prior experience***: predictive (top-down) cortical patterns match or mesh with bottom up (e.g. sensory) patterns, thus registering a visual signal as e.g. a person (e.g. meter maid, heavyset woman, smiling). Some salient subset of these items achieves a threshold value sufficient for instantly creating persistent activity patterns. One possibility is that local circuits and/or distributed networks with **bistable states** are flipped into the ON state and thereafter oscillate for as long as appropriate for those particular memories. Simple two-cell models of spinal oscillators are capable of such bistable behavior (Knudsen et al., 2006) and so it seems practical to implement this in cortical networks (Yuste, 2005?). Several features contribute to or ensue from this model:

(1) The greater the sensory convergence onto an oscillator unit (e.g. 2 cell CPG), the greater the likelihood of the unit receiving sufficient summation to switch it into the ON state (see Singer, 200X)..

(2) This convergence is determined directly by prior learned associations and 10K cortical connectivity.

(3) Cortex is capable of sustaining millions of such mini-oscillator circuits simultaneously.

(4) Central "timing" circuits ensure that these disparate activities are to some extent synchronized – thus contributing to macroscopic brain rhythms e.g. gamma, theta, etc.

(5) Because these patterns are tightly linked to sensory represen-tations, they presumably reside in appropriate higher order sensory and/or associational cortices.

(6) Subsequent (LTP-like) mechanisms extend CRM durations into medium and long-term memories as salience, determined by subsequent cortical analysis and other events dictate.

Note: Dopamine reward systems may be involved in multiple steps.