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Evolutionary Learning, Symbolic Operations and Cognitive Advancement: A Neuronal Perspective

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Her gentle spirit lingers in my mind . . . . always.

Sally-Anne

Neuro Questions for the Next 100 Years

How does the brain create and use symbols?
Where did symbols come from?
How do we manipulate symbols and construct thoughts?
and finally: is the ongoing symbol-manipulation in our brain done with ***words*** or sub-linguistic symbols?

SNOPs are Symbolic Neuronal Operations

When we plan a route or think about a problem or imagine a conversation we might have, we rely upon SNOPs. All brain operations rely upon groups of neurons performing specific tasks and many tasks are intrinsically symbolic, such as the flash of a firefly or the peacock's tail. But the ability to combine and manipulate symbols, that is a bird of a different feather and the subject of this essay.

Symbols According to Wikipedia

Symbols (in generic terms) are marks or signs. Wikipedia notes that "All communication (and data processing) is achieved through the use of symbols." While there are no physical marks or signs in neocortex, there are representations of such and there is massive, ongoing information processing and communication. Indeed, EVERY aspect of the world, that is represented such that it can be communicated to other brain regions for comparison, categorization or action, is in fact *symbolic* in its representation.

SCIP is Sub-Conscious Information Processing

Vast amounts of SCIP are the basis of ongoing learning, planning and decision-making. Consc. experiences actually reveal very little of what your 20 billion neocortical processors are doing. All of your words, sentences and thoughts emerge from the symbol-rich SCIP that assesses the world and any opportunities presented.

Symbolic Representations have DEEP roots:

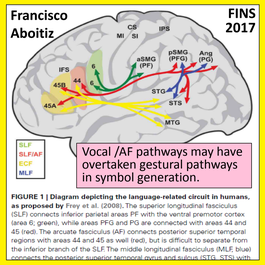
Neural Representations of Real World Items (RWIs) have evolved *since the first animals* and have shaped sensory, motor and decision processes. The innate ability of zebrafish to e.g. process visual info and enact motor programs constitutes evolutionary learning of the physics of the world including dangers, object-properties and myriad other RWIs.

SNOPS-L Linguistic Operations *Words are great Nodes*

Modern human language is an extreme symbol manipulation system that can create infinite expressions from a finite grammar. While much theory has been devoted to **context-free grammars** (CFGs), i.e. structures that are independent of meaning, *human sentence-generation* might be more closely related to **U.P.-based grammar**. Indeed, thought might be largely sub-linguistic, but be communicable only once transcribed into the linguistic domain. While CFGs might be appealing as formal, manageable approaches to NLP, if language actually derives from ancient SNOPs-nl mechanisms, those might be better suited to giving *Siri* her voice.

Arcuate Fasciculus (AF) and Dorsal Pathways

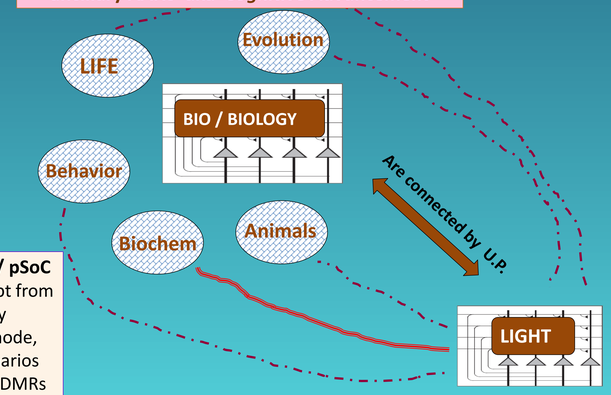
The AF has become more substantial and elaborate in humans vs. apes and monkeys (Rilling report). This greater bandwidth may have enhanced **packet routing** (CBA & DMO, 2017a; zfhindbrain.com) and concomitant analogical processes via U.P. structures, e.g. spatial layout, associated features, kin relations, object properties and more.



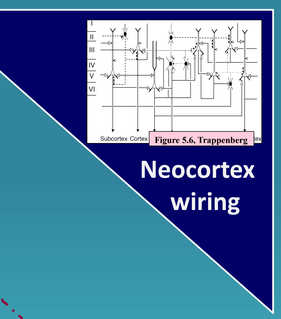
prospective Stream of Consciousness / pSoC

Our stream of consciousness is an excerpt from the flood of sensory inputs and internally generated signals. In Default Network mode, we tune out the world and play out scenarios in our mind via pSoC (this forms weaker DMRs than regular SoC). Like DMRs, pSoC can be largely derived from non-linguistic SNOPs. Might other animals have pSoC?

Co-Activation of AANs can lead to activation of ancillary AANs aka *Cognitive Advancement*

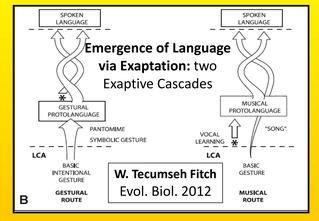


Did greater repertoire of AAN connections ➔ Human Language?



from Alarm Calls & Gestures to Language

Mirror Neurons and gestures may have paved the way to phone-dominated communication. Neocortex learned how to string items ala hippo and thus began the evolution of SNOP systems that later evolved into modern Language. Hominid specialists / cooperation / coalitional enforcement might have forced L. emergence.

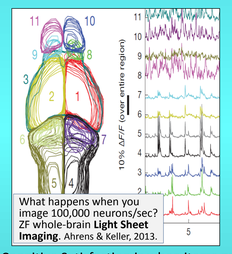


Human Grammar = Universal Physics aka U.P.

Single words = calls, but proto-syntax ups the ante, e.g. "red hot" "river frozen". Chomsky's archaic *Universal Grammar* can perhaps be resurrected by a *Universal Physics*, since every aspect of grammar is an evolution of physical relationships and THEY are already snoppian, i.e. manipulable: fresh meat, bear in cave, your child lost.

Proto-language: see Robbins Burling

for proto-word origins. But to get linguistic we needed SNOPs. Based upon an analogic-engine, we propose that U.P. relationships served as templates for linguistic relations (i.e. syntax/ grammar). AANs were initially bound pre-syntax and provided structural seeds from which all SNOPs emerged. In other words, linked AANs are the analogic engines.



Cognitive Satisfaction is when items gel

Neocortex uses *Neural Words* to communicate

Neural Words are proposed, compact representations of RWIs that can be used in neocortical computations. More compact than *Invariant Representations*, n-words (i) are not linguistic but (ii) are imbued with semantic info which provides a basis for connecting to other n-words, which when bound together can form DMR epochs and other constructs, leading to SNOPs.

see n-words on DMR page at zfhindbrain.com

SNOPS-nl aka Non-Linguistic SNOPs

If n-words can be broadcast to possible associated AANs, some of which are percolating, this can lead to binding and γ-band epochs, possibly including new sets of items not previously linked. This is a rudimentary type of SNOP. Based upon tile-speak and termite-probe tool use, primates might have SNOPS-nl abilities sequences, but in humans such AANs ultimately are tagged with actual words and appear in our minds as thoughts.

Learned Items are stored in synapses

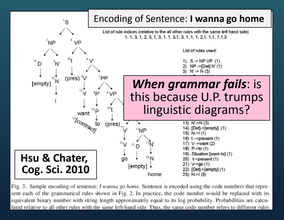
Animals learn many things, such as location of items in a maze or Dad's song. Such items are represented as patterns of action potentials in cell assemblies. The initial processing stages determine "what" is out there and can activate a stored/invariant representation. But for such items to be acted upon by other brain systems we need a compact / communicable "symbol".

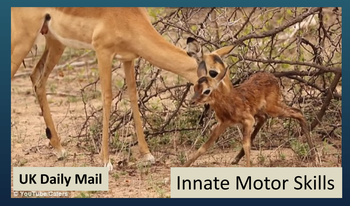
Mammals store Symbols in Neocortex

Sounds, shapes, colors, words, concepts are stored in distributed fashion amongst many specialized representational systems. Some items we can communicate to others but most are for internal CNS processing. At present we have limited insight into primate neural codes but there must be channels by which symbols are routed about.

Many Animals Communicate and Use Tools

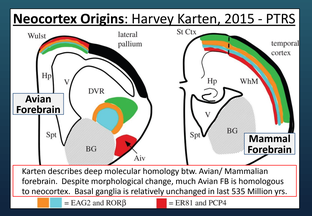
Vervets send alarm and social calls; others use gestures, scent marking and songs. Gestures are of note given its possible path to language. Tool use by primates, beavers, crows and others implies symbolic recognition of items that can be physically manipulated and may have been the impetus for human language.

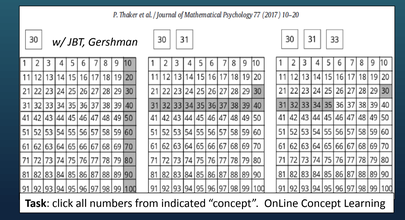




The Mind-Food Pyramid

Building a Cognitive Architecture from the Ground Up





Our mind works not on Psychological Principles but via the outputs of defined neuronal populations.

see notes