

From Symbolic Neuronal Operations to Universal Grammar: an NGG Primer

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ABSTRACT

Two seminal questions embody the core of modern neuro-linguistics: (1) the nature and pace of **Language Evolution** and (2) establishment of a neuron-centric answer to the **WDSCF** question, *Where do Sentences Come From?* These most challenging topics have remained refractory to consensus—by both neuro-technologists (for decades) and by linguists (for generations). This perspective takes an ancient-origins approach seeking common ground between early hominid behavior, neocortical expansion, and the necessary neuronal machinery to progress from proto-words and primitive syntax to fully modern language (FML). To best formulate candidate neuronal circuits, we rely upon **Auto-Associative Networks** as compact, operational devices that prove useful for different linguistic and semantic tasks. This fits with a digital symbolic core, the basis of two levels of **Symbolic Neuronal Operations** (SNOPs), specifically a linguistic layer and a sub-linguistic layer. Special emphasis is placed on the rapid emergence of a Natural Syntax, based upon the Universal Physics embedded within mammalian neocortical architectures. Natural Syntax builds upon ancestral Semantic Construction machinery: in hominids sublinguistic constructs are fed into a new linguistic layer via a **Neuro-Generative Grammar / NGG**. We suggest ancient origins for key elements of the NGG, namely **Tagging**, along with **Tag Sequence Readout** and **Pattern Recognition Machinery (TSR, PRM)**. While this framework is a substantial departure from classic Generative Grammar approaches, which still dominate neuro-linguistics today, there is much common cause with such linguistic staples as a genetically-encoded **Language Learning Organ** and a corresponding **Universal Grammar**. The neuronal-circuit details being revealed by MEG and intracranial electrophysiology (iCR) today comport nicely with the NGG model. [Future iCR Commentary Pending at Neuro3000]

1. INTRODUCTION

AANs are Digital Stores. This NGG Primer embodies **Digital Operations** in the brain, specifically Symbolic Neuronal Operations that enable both cognitive and linguistic computations. At the heart of these operations are **Auto-Associative Networks**: neuronal circuits that enable the storage, retrieval and manipulation of individual items, such as the words in these sentences. While physical evidence of widespread AANs in the brain are lacking (beyond CA3 hippocampus) either AANs or circuits that are functionally similar are crucial to our symbolic core (see CNS-2025 & NBOL-2025 poster-reviews: on **Neuro3000.com**). Of special note is that the **discrete, compact operations** considered herein are (1) conservative of neocortical wiring, which is a hard limit on what can be added to neocortex and (2) are increasingly supported by **intracranial studies** of language operations in epilepsy and other patients. We expect that efforts to explore this theoretical space in more granular detail might enable a better ground-truth understanding of the neuronal basis of hominid cognition.

We believe that *Cognitive Constructs drive Linguistic Decisions*, a claim that pre-dates Chomsky (ala Tomalin's pithy review of Formal Linguistics; 2006), and yet remains a stark departure today from both classic generative grammars (e.g. Chomsky's 1957 TGG) and much of modern neuro-linguistics. A neuron-centric version of the claim arises via a **Symbolic Neuronal Operations (SNOPs)** framework that is comprised of two layers: **SNOPs-L** and **SNOPs-sub**. Per this claim, the grammatical **SNOPs-Linguistic** layer, is not the source of sentences, but instead sentence-content arises from the **SNOPs-sublinguistic** layer, which is a vast cognitive-semantic enterprise in modern humans. This sublinguistic (semantic) capacity derives directly from the massively expanded hominid neocortex: only we humans

are able to generate the extraordinary diversity and complexity of semantic constructs that flow into all the world's text and speech [fits with Fedorenko et al., 2024c]. Herein we juxtapose modern grammatical approaches to language with a neuron-centric approach aka a **Neuro-Generative Grammar (NGG)** [no such phrase in Google Scholar-5/26/26]. The NGG framework offers, in our view, a computationally more economical approach to the production and comprehension of sentences and best explains a gradualist, evolutionary trajectory from ancient First Words and proto-syntax, through successively greater adaptive feats that in turn justified the vast expansion of neocortex over the past 2.5 million years. Of special note is an occult but dynamic interplay between NGG (part of SNOPs-L) and sublinguistic, semantic operations. Humans initially learn linguistic patterns which ultimately are stored as sublinguistic (meaning-laden) cognitive structures: it is via this hominid-specific neural machinery that we alone can generate modern sentences. This process utilizes a **Syntactic Translation System / STS**, whereby sublinguistic **Semantic Constructs (SemCon)** are converted into grammatical strings. Below we propose specific hominid-grade neuronal operations to enable this NGG model.

The Oldowan: From Rocks to Syntax. By virtue of our focus on symbolic layers, and a most pivotal question, *Where do Sentences Come From?* [WDSCF], this perspective must of necessity chart a path from the Dawn of Language (perhaps back in the Oldowan, 2.5 million years ago) up through **Fully Modern Language / FML**. This is estimated to have been attained by about 200,000 BC, when we had reached our full stature, control of fire, and diverse new technologies—in conjunction with our now full-sized Anatomically Modern Human brain (ala Murphy, 2019). This path is essential to the NGG story because we see no way to understand the necessary incremental advances in cognitive and linguistic capacity unless we begin at the beginning, i.e. with the ancestral chimpish brain guiding our bipedal ancestors such as Lucy (an Australopithecine) who showed the first, occasional fashioning of stone-tools roughly 4 million years ago. After that, neocortical expansion accelerated, along with hominid dominion, leading to a near quadrupling of neocortical size—an addition of roughly 15 billion neurons onto the chimp's 5 billion. Lithic technology became established in the Oldowan era (ala the Olduvai Gorge in Tanzania) and has fueled hominid growth and power ever since, as it spread regionally and generationally, with incremental genetic enhancements feeding neocortical expansion. While much of **Language Evolution / LEVO** is controversial and speculative, feasible advances in neuronal circuitry must have occurred to account for the new 15 billion. Of note is niche-construction theory, e.g. Bickerton and Szathmari (2011), where new hominid capabilities (e.g. bipedalism, stone throwing) could lead to further advances like communication and coordination. Given this context, a neuronal origins story is proposed here, to wit a *Neuro-Generative Grammar / NGG*. This NGG suggests early incremental steps and how they enabled further progress across many future billions of neurons to arrive at FML and *Fully Modern Cognition (FMC)*. We begin with a cognitive version of 'big foot' whose reality is curiously elusive.

2. SEMANTIC CONSTRUCTION and DMRs

Atlas – The Invisible 900 lb. Gorilla. The LEVO / WDSCF field has perhaps sputtered some because few seem to have noticed Atlas, the 900 lb Gorilla holding the World of *Linguistic SNOPs* upon her shoulder. Our modern cognitive world emerges from **Semantic Construction (SemCon)**, the essence of our friend **Atlas** because absent **reflective, experience-driven SemCon** we're just GPT: an empty, statistical trick played with meaningless symbols. A key argument, arising from our 2-layer system (SNOPs -L and -sub), is the claim that **grammars** describe only the cumulative *resultant products* of SemCons, i.e. their translation into sentences: said sentences are admittedly streams of meaningless symbols (think e.g. rows of Chinese characters—meaningless to me and perhaps another 70% of humanity). **Speech sounds and written words only seem meaningful** because (A) you've stored, within your private, neocortical processors, myriad associations between arbitrary symbols (like those on the Rosetta stone) and real-world items and constructs (like *The Cat in the Hat*), and because (B) you are at present a conscious being.

Research Topic-Commentary: How SemCon differs from Semantic Composition: HRL, Red Boats and Scrambled Sentences.

Our NGG is thus a two-layer (and two-part) story with the underlying SemCon (SNOPs-sublinguistic) layer being the bigger part of Fully Modern Cognition: a sub-linguistic engine that ultimately drives **Fully Modern Language**. Given LEVO considerations, if we backtrack way earlier to our initial ability to share items (Lion!) and constructs (*at water-hole*), we may better discern details of the Hominids' long march from the Oldowan to Total Dominion. **FML**

is sublime, as are some blazingly rich cross-layer dynamics: our **Syntactic Translation System / STS** converts SemCons into acceptable sentences, while an inverse process, featuring **Syntactic Discovery**, helps you to interpret the incessant chatter and writings in your world. Herein we are guilty of deploying some new terminology, but only because we want to mesh classic grammatical descriptions of English with the neocortical **Symbolic Neuronal Operations (SNOPs)** that generate both thoughts and sentences. We hew to extant terminology, whenever possible, in the course of fitting our neuronal-circuit needs to established bodies of literature. No matter if scant attention is yet paid to Atlas—she just shrugs.

“The essence of our humanity is our penchant to tell stories” *Horselover Fats*

Semantic Construction / SemCon. It seems there is a paucity of substantive literature with neuronal details on SemCon, i.e. on the neuronal mechanisms that give rise to thoughts, notions and other such nebulous constructs as one might like to convey: As one stares at a blank page, **Generative Grammars** cannot say which words to choose! In this regard, the surface and deep structures of linguistics (sentences, universals) are not generative, nor is Pieter Seuren’s wonderful book *Semantic Syntax*. SemCon is indeed a formidable challenge for the WDSCF industry given that, in general, we cannot see, hear or write down our internal semantic constructs. We are conscious mainly of the final work product: SemCon + STS = Sentences. Often we recognize our own words and sentences only at the moments they are flying from our mouths and fingers, i.e. when they achieve Phonological Reality (ala BBS commentary on RJ’s Foundations of Language; Molina, 2003). This largely relegates **SemCon** to the vast neocortical domain of **SCIP (sub-conscious information processing)** to which we have extremely limited access outside of intracranial recordings (mentioned in Ang and O’Malley, 2024; Zhang, Do and O’Malley, 2025). With attention, we can be conscious of **Real World Items / RWIs** around us, or stored in our memories, and we can deliberately construct sentences based on particular items, but even in such cases our sentences tend to pop out on their own as directed by the physics surrounding us: *That vicious brown dog is charging at us*. Neocortex has stored a wealth of such **RWI-driven experiences** and language is structured by a guiding **Universal Physics (U.P. - items, actions, properties, values, positions, relations, etc.)** that is innately understood by neocortical regions and their interconnections (more below and in *Chapter 9, Hominid Games*; Neuro3000.com).

What CAN we say about SemCon? As we move through space-time, the world is constantly telling a story, with the hippocampal-neocortical system promptly recording it in the form of **Daily Memory Records** (Ganz and O’Malley, 2012). This **DMR** is effectively a day-long, chronological SemCon. All the while, neocortex is rapidly assessing and predicting diverse aspects of many situations (how far away is that dog? is it looking at us? does it seem more playful or rabid?). Via recall, we are able to consciously recount situations and thus convert said RWI-data into UP-organized **semantic constructs** aka episodic memories, a feature of mammalian neocortex (they don’t become *memories* per se until we recall them). In hominids, epochs of these auto-stored constructs can be translated from the sublinguistic / semantic layer up to the linguistic layer, and thus into sentences. Today, of course, us hominids can get vastly more creative and write about technical, social, fictional and magical things. We previously outlined **evolutionary NGG-stages** that can tap into our neocortical database (CNS-2025; Do and O’Malley, 2025: Neuro3000 posters) and produce increasingly elaborate communiques as hominids made their way from the Oldowan up through modern times. This meant we began to share *more valuable cognitive-semantic constructs*, driving both adaptive advantage and linguistic competence. This required neuronal additions and new wiring which were enabled by iterative behavioral-genetic advances that propagated across friendly clans and generations. As such, neocortical **Semantic Construction** is the ultimate neuro/modern answer to the WDSCF question. This term (coupled with ‘neuronal’), however, barely exists today on Google Scholar [we explore Lion SemCon at Neuro3000: Zhang and Do, 2025 poster]. But it does lead to a rethinking of the amazing speed and power of linguistic production and comprehension. [*Note: Semantic Composition* is a bird of a very different feather and topic of a Future Commentary]. In summary, semantics reside in stored conscious experiences (excerpts of DMRs) and higher-order constructs such as consolidated knowledge. Sentences arise from sublinguistic, constructive recall, together with novel assemblies, as enabled by our neocortical stores and powered by STS/NGG machinery. **Research Topic:** What does ‘sentencizing’ a SemCon do to its structure, extent and endurance?

3. THE QUADRUPLING, LLO and U.P.

We initially presumed that the invention and elaboration of language (**SNOPs-L**) had to play a major role in the roughly 4x expansion of hominid neocortex, beginning with **Tagging**, the ability create and use iconic, symbolic proto-words. We now surmise that while grammatical advances played a substantial and essential role in expansion, the lion's share of new neurons and wiring went to advances in SemCon and associated cognitive circuitry (**SNOPs-sublinguistic**). [For general neuronal book-keeping we reckon that at most 10 billion of the new ~15 billion neurons went to cognition and language, with 5 billion going to house-keeping duties associated with larger body size and such]. Alas, the operations of SNOPs-sub are not so visible as grammar, vocabulary and other linguistic functions (e.g. analogies, writing, etc.). Also, at the outset, i.e. at the **proto-language** stage (pre-grammar), we could orally communicate only small tidbits of our cognitive world like *Lions Waterhole* or *Vultures Meat*! This meant that there was a substantial amount of time during which linguistic competence had to advance before it could catch up with our ancestral cognitive capabilities (thinking, planning, acting, decision-making, social skills, etc.). Along this timeline, with an evolving language-learning organ, we used up our iconic-word options (proto-lexicon) and then evolved combinatorial phonology and after that morphosyntax: these are aspects of our progression through a series of increasingly powerful grammatical language stages (BL, EML, FML: **HG, Chapter 7** and see upcoming HG Precis at Neuro3000). At some point, however, we evolved sublinguistic cognitive skills that exceeded the capabilities of our ancestral, chimpish SemCon. This is evident in the ability of us hominids today being able to create an endless variety of SemCons—far beyond the ken of any animal (nuclear fusion, exoplanets, molecular biology, parliaments, etc).

While the existence of a genetically-encoded **Language-Learning Organ (LLO)** is controversial, what is not is the existence of neocortical expansion, ancient tool-making, power-scavenging and dictionaries. It is also clear that **Nimals** (non-human animals) are incapable of any substantive grammatical-language production, ala Herbert Terrace (2019b), who nonetheless writes that “animals can think”. Nimals, however, cannot reflect upon Pharmacology, Thermodynamics or Theocracies. This fits with the fact that we hominids have about 10 billion additional neurons for cognitive-cultural needs. Their volume and metabolic expenses could have only been sustained by competitive advantages—both immediate and incremental. The most immediately feasible hypothesis might be a genetically-encoded LLO and a co-evolving **hominid Semantic Construction Organ (hSCO)**: the latter neuronal circuits extended our capabilities far beyond that of our ancestral, chimpish SemCon organ. This is not to deny Nimal intelligence: every mammal is quite intelligent in its own domain—my dog's olfactory world remains far beyond my ken, and the elephant's world is even greater. But would generic additions of hundreds of millions of neocortical neurons, for domain-general purposes, make adaptive sense?

Domain Generals and the Bland Billions: Let's suppose you add **100 million neurons** for Domain-General Operations. Where is the adaptive value that transcends the metabolic and wiring costs and potentially superfluous volume? The new hSCO-enabling neurons that we propose herein might seem domain-general, with lots of storage and computational space for U.P. like arrangements embodying relations, prepositions, pre-play, social moves, command/cooperation, ecological challenges and affordances. But could a generic, 100-million neuron retainer (neocortical addition) operate like a lackadaisical-Realtor, where they invite folks to come inside and live in available places for some undefined amount of time to see if they like it and then hope said squatters might later choose to give them money? Or is that a terrible idea? The term for the biological (neocortical) version of this story is extinction: Evolution is a harsh mistress! Sometimes bonus neurons might fall in just the right brain in just the right scenario and be leveraged into **enhanced functions** of one sort or another. Mammalian neocortices are riddled with specializations which tend to boost efficacy and efficiency, two things that Mother Nature adores. Some modular additions might start general but then become quickly specialized, as evidenced by stroke patients who often encounter particular, localized deficits due to modular disruptions. *Bottom Line*: Evolution did not add multiple **billions** of neurons to chimp brains just for extra, general-purpose computing power.

The **Universal Physics (U.P.)** of the world shaped mammalian neocortex with many specialized circuits (e.g. V1, A1, MTL, M1, SMA, PFC, Cingulate, etc.). In turn, hominid neocortex became massive, with many further enhancements, custom circuits adapted for our niche (look at any mammal). Social interactions were already highly-evolved in pre-hominids, so there is no quantifiable need for an additional 10 billion “social neurons”—especially in the absence of language. Moreover, *most every advance* by hominids over the past 3 million years would be better with language, so

denying early, genetically-encoded language circuits seems a flimsy branch to pursue (dissenting opinions welcome). U.P., in this context, drove an early natural syntax: our evolving **Neuro-Generative Grammar machinery** was, at every step, enhanced by pre-existing cognitive/U.P. circuitry. Syntactic advances merely had to capture what 6-layer neocortex already knew. A related consequence is that every successful language today has two indispensable features: efficacy and easy (automatic) learnability. As with the **LLO**, the related notion of a **Universal Grammar / UG** is controversial, especially if one interprets it as a genetic-encoding of particular grammatical constructs, which is clearly a non-starter since grammars can vary tremendously from language to language. But the original notion of *universal linguistic principles*, ala Riddle of the Rosetta, remains in force because all languages capture the U.P. of the world AND every language can be learned by every baby, no matter the world-region of its birth. We therefore endorse the notion that the **LLO and UG are two sides of the same coin**: the LLO is tailored to learn EVERY language, so long as they remain true to the underlying NGG and hSCO circuitry. This is what evolution and competitiveness dictate. We shall see that the proposed NGG machinery may finesse some “linguistic challenges” for GenGrams which can perhaps be overcome via less convoluted (but still genetically-encoded) neocortical, linguistic algorithms. This includes e.g. NGG machinery that can facilitate learning of all the schemas of a language (ala RJ’s *Texture*, 2020). [HG Chapter 9: to be posted at Neuro3000: WDSCF page]. **[see *Perp Report on Origins LLO*]**

When was the hSCO invented? Proto-Language, and perhaps Basic-Language as well, may have evolved for some time before there was need for SemCon capabilities that exceeded that of intelligent mammals like primates and large predators. As illustrated for a **Lion’s AAN-World** (CNS-2025; Zhang and Do, 2025: Neuro3000 posters) worldly representations (i.e. content-rich RWI constructs) can be quite elaborate with many dynamic, related moving parts like lionesses on the hunt seeing cubs, hyenas, antelopes, vultures, grass, water (maybe with alligators), while noting time of day, weather and traversed terrain. Based upon parietal/MTL records, these hunters could tell many diverse and granular stories, just by replaying small epochs of their day-long episodic memories (DMRs), but they would **need a lot of language** to share such stories. Early hominids did not, at the outset, have so much language and thus did not yet need an enhanced, **hominid SemCon Organ (hSCO)**, the sublinguistic partner to our LLO). It was only later, after our linguistic production had expanded greatly, first to match and then exceed our ancestral sublinguistic constructions (already quite powerful in chimps and lions), that parallel hSCO evolution was needed. In contrast to the hSCO, **our LLO was needed very early on**, essentially at the Dawn of Language, because we needed the impetus to grasp and produce short **Tag (word) Sequences**: *you talk good, you be clan chief and popular with ladies*. By HE-man days, and certainly with Heidi, neocortex was shockingly large, demanding many calories and dramatic adaptive efficacy. As new grammatical machinery (additions to NGG) came online, **LCAC** (advanced syntax) circuits might have become creatively profligate (amongst the more verbose of our clanfolk), which raises a different question: why build language circuits beyond what basic SemCon could do? There must have been ongoing co-evolution of **LLO, NGG and hSCO!** Presumably there was much iterative boot-strapping as our thoughts and words (SNOPs-sub, SNOPs-L) expanded together, far beyond the Nimal mind for whom our modern discourse on *gold standards* and *human-subject committees* will forever be incomprehensible mouth noises (in contrast to interesting sounds like: walk, treat, toy, bath and ride).

FROM HG8: Pinker and Jackendoff (2009a) reject the Evans-2009 thesis (p. 465) rebutting what they see as a misconstrual of UG and note: “We do...endorse a version of the Universal Grammar (UG) hypothesis: that the human brain is equipped with circuitry, partly specific to language, that makes language acquisition possible and that constrains human languages to a characteristic design”. Moreover, P&J describe many universals of language that E&L discount or ignore including: **discreteness, productivity, levels of structure, constituency and dependency**. They more pointedly note:

“These learning mechanisms are a black box for E&L, who suggest that they can be borrowed off the shelf from other domains of cognition.

But they do not cite any analysis showing that some independently motivated set of cognitive processes actually suffices to acquire the

detailed and complex structures mastered by children.” **[relates to LEVO-driven LCACs: Chaps. 16, 17, HG8]**

This is exactly our view of UG and why it should be equated with an innate LLO. As P&J point out, skills that evolved for language can do other things and it makes far more biological sense to explain deltaBV, our differences from animals, critical periods and constraints of languages as based upon genetic-encoding of capabilities as opposed to arguing “our brains just got bigger for no reason and now we are smart and we just invented language via culture”.

Cognitive Rules drive Linguistic Decisions: Neuronal Machinery. Progovac and colleagues (2018, FINS) describe a convoluted, GenGram-styled, linguistic mechanism to generate the sentence *Elena will grow tomatoes* [see Morphosyntax-AAN panel on NBOL-2025 poster]. But in the *Syntactic Translation System* framework, SemCon does the heavy lifting of generating a construct that accomplishes the central cognitive goals, in this instance, formulating details of a particular future event. Early on, eons before the invention of such linguistic terms as transitive and

intransitive, our basic (linguistic) pattern-recognition machinery (PRM) enabled such proto-sentences as *Grok make rocks* and *T hag kill lion*. With the advent of grammatical (i.e. category-driven) **Basic Language (BL)** and further cognitive advances, we evolved the ability to create more sophisticated communiques with time-dependencies, assessments and other cooperative strategies. However, in regards to the “hierarchy of layers” used in classical linguistics to create sentences, via a “generative syntax”, we, in contrast to most major players in neurolinguistics (see 6/26/26 Perp: on Resources page) suggest instead that sublinguistic Semantic Construction (SemCon) produces most of the structural elements from which sentences ultimately emerge. In brief, SemCon captures cognitive intent by working with **stored experiences** and an assortment of **hominid-specific linguistic and sublinguistic operations**, including the SMS, LCACs and PRM (*Key NGG Terms* summarized at bottom). This enables a wide range of constructs (enabled by a hominid-grade SemCon Organ) to be authored and then translated (via STS) into the correct language-specific patterns of the local language. Note that recurring word-patterns are recognized and stored by linguistic **Pattern Recognition Machinery (PRM)** that enables rapid acquisition, storage and reproduction of the variegated linguistic constructs that are culturally stored as accepted usage-patterns (Gramity) within the ancestral, local language. [AI Note: LLM failures in Gramity are noted by [Murphy, 2025](#)]. We consider here how the “emergence of such cultural rules” of English sentences, patterns really, depended upon the evolution of custom, genetically-defined, neuronal circuits. notes: WEGT/Progovac/morphosyntax = nice Commentary Topic: contrast w/ RJ:PA/RM/schemas. back: new Cyclops fueled cognition notes. ALSO: Do kill GPT (new refs): surface LLM formalisms utterly fail absent SemCon and SCFE/UP.

Morphosyntax Origins. “Grow” is a nice example by Progovac-2018 since one can write *grows*, *will grow*, *to grow* and *has grown*. It is helpful for the clan to know that Elena will grow tomatoes and if someone asks *what does she do*, you can just say *she grows tomatoes* and then further amplify that notion by saying *Elena likes to grow tomatoes*, as well as *she has grown very large tomatoes*. While children learn all this effortlessly, few adults can explain linguistic machinations such as the differences between transitive and intransitive verbs. All adults can, however, say why they use *grow* or *grown* as they do: these are the patterns they heard and learned (via our innate PRM). It is not linguistics that dictate usage, but rather the cognitive constructs: hominids had become increasingly adept at thinking about the future and the past—because our hSCO had evolved—in concert with our also communicating such thoughts. Nimals, to our knowledge, cannot generate communicative constructs that signal intent to communicate about past or future events. We can excitedly ask: *Are we going to go to the zoo?* Also, once we learn *Tammy has built houses* and *Chris has sewn clothing*, we (hominids) can automatically apply such word forms (morphology) when thinking about other past events: *Don has learned English!* Because English uses many simple, regular patterns we need nothing more than our cognitive notions/intents to implement actor, action, object, time and item. Moreover, ala Zuber-Phrases (next section), we can store a vast stock of phrases and subsequently utilize custom, high-speed linguistic machinery to retrieve phrases/idioms/etc. in the course of Syntactic Translation aka STS-ops. Adult humans can immediately, and without sentence-specific training, implement a great variety of communicative goals. This stems from our neocortical AAN-World and its innate organization (powered by mammalian Universal Physics): the marriage between new RWI-constructs and an increasingly powerful NGG led to a new kind of animal. Morphosyntax AAN: see Poster Figure, NBOL-2025.

4. NGG MACHINERY

AAN-Enabled TSR / PRM Machinery. Because an **Auto-Associative Network / AAN** with 1000 neurons can store ~1000 distinct patterns (items), the dedication of a billion neurons (out of the 10-billion new), to the **storage of words, novel RWIs, new concepts** and such, would enable massive, digital storage for a multitude of cognitive and linguistic tasks. Early on, implementation of clan-conventions, using **Tag-Sequence Readout / TSR**, had formalized a basic syntax (such that *Bear kill Thag* $\neq$ *Thag kill Bear*): hominids now had a match between word-patterns and underlying semantics--making these two communiques into quite opposite messages! Further genetic-progress and deltaBV (neocortical expansion) enabled linguistic **Pattern Recognition Machinery (PRM)**; missing in Nimals). This allowed cognitive-semantic decisions, e.g. sharing that *Thag is dead*, to be implemented via stored protowords and patterns. During the language-acquisition phase (via the early-hominid **LLO**; missing in Nimals) young clan members could learn meaning-pattern correlations for such proto-sentences as *Grok make Tools*, *Lions kill Hyena*, *BkT* and *TkB*. This first entailed learning the Tag-RWI correlations, as was easily done via LTP, ala Pavlov’s dog learning the bell-sound = steak language! Dogs, however, lack one crucial capacity: the ability to flexibly produce, on demand, semantically-

grounded **Tag Sequences**. Given that *Homo habilis* (**Habi**) was adding large chunks of neurons to neocortex, the ability to read out (aka produce) auditory sequences would have enabled a very primitive, proto-syntactic, communicative ability—one that is nonetheless beyond any **non-hominid animal** (**Nimal**).

Proto-Syntax. Habi language is best explained by a genetically-encoded (or enabled) **Tag Sequence Readout / TSR** neuronal circuit. In contrast, Ancestral Working Memory is limited to replay of extant *sequences*, e.g. if you remembered seeing *thag, bear, in cave, one killed*, your ancestral gamma-on-theta WM circuit can only report: Thag, Bear, Cave, Dead. This does not convey who is dead, but nonetheless boosts communicative bandwidth, especially with follow-ups. If asked “Thag Cave?” and you reply “Thag Cave Dead” that helps and could be followed by “Bear Angry”. **TSR, however, goes beyond such pre-syntactic auditory mimes: TSR provides open access** to our proto-words list (a proto-lexicon, stored in an AAN). Now, with open access, any desired, particular orderings like *Thag kill Bear* and *Bear kill Thag* become possible, with meaning ultimately determined by **clan convention** (the original, natural proto-syntax). While this appears straightforward, one encounters some complexities en route to this most fundamental step towards a grammatical syntax. But ultimately, Tagging + TSR (with enabled clan conventions) constitutes the first true (albeit still proto) language. It is still pre-grammatical as Tags/proto-words, per our staging, have not yet become true / grammatically-categorized Words with morphosyntactic and/or other features.

What can TSR *not* do?

Sequential Thoughts, Eloquent Articulation: a TSR Feature

When we go to create a new sentence, e.g. **Lions kill Antelope**, the 3 RWIs are already activated in PFC in ancestral working memory and each RWI, via language acquisition, had already been strongly connected to the three stored words. But our modern ease of word-playback is misleading: Nimals are quite incapable of flexibly generating 3-sign sequences in any modality: no phonological loop in pre-hominid brains! Back in Habi days, given a basic TSR, i.e. a genetic-ability to pluck mimetic words from the proto-lexicon bucket, we still did not have an easy route to clan conventions. But hominids certainly had expanding memory systems (PFC, MTL and tweener systems) and per Zuberbühler’s claim (2018, 2019) stating that our FML brains can store vast stocks of phrases, this may have been the path to evolving a rudimentary clan convention, perhaps a look-up table (inelegant, but effective as a starter circuit). With a small lexicon and simple patterns, clan conventions could be enforced by consensus and/or edict so we know to say *Lion kill Antelope* (not *Antelope kill Lion*). Individuals that could store and more eloquently play back phrases would project fitness to their clan mates, while also enhancing overall clan performance. With the benefit of phrase storage, and TSR’s facility to read out individual proto-words, we could now retrieve the preferred phrases (proto-sentences). This was an essential step towards **PRM (Pattern Recognition Machinery)**, i.e. circuits that could identify patterns and flexibly generate new cognitive patterns for translation into the SNOPs-L (proto-language) level.

Shortly after the Dawn of Language, individuals would have experimented with varied forms of word and phrase use. This would have occurred in parallel (over the generations) with new genes adding new neurons, wiring (e.g. Rilling fibers; Rilling et al. 2008) and thus new neocortical modules. Genetic implementation and/or boosting of most every language aspect would have proved advantageous to progeny and could spread laterally (via sharing of attractive clan members). Once the **TSR-Circuits** were instantiated into Habi culture/brains, any hominid could pick 3 or 4 or 5 words (more once the SMS had evolved), by simply storing and re-using sequences. Despite benefitting from U.P.-inspired organization, SNOPs-L was still operating as a look-up table, the least efficient form of computation. Later machinery drove **PRM emergence**: mammalian brains were already good at pattern recognition, but building regular phrase-structure capabilities required symbolic operations in the abstract realms of non-RWI symbols, using abstract patterns e.g. subject-verb-object like structures. We reckon this took a bit of time along with some new genes, neurons, circuits and wiring. While TSR was a communicative game-changer, **PRM abilities** would more strongly accelerate communicative powers and inventions by enabling use of conventional ordering and additional linguistic features designating numbers, time and relationships. This would go hand-in-hand with emergence of *de facto* grammatical categories (with custom AANs), and would thus be connected to our achieving **Basic Language / BL**, the first true grammatical language.

RWI-SVO-BL: a Just So Story. Great Rift Valley, 2,229,000 BC: **Thag heard loud rustling** in the brush. Not far away he saw Tuck racing through the grass. Was he hunting? (*Not his forte*) Then Thag saw 3 snarling hyenas racing towards where Tuck had just run to. WM-STORE DETAILS: Tuck, running, hyenas. ANALYSIS/SemCon: Hyenas chasing Tuck. ARTICULATED Proto Sentence: *Hyenas chasing Tuck!* Note that the Working Memory sequence (T, r, H) differs from Thag’s neocortical gestalt of the scene (HcT). This gestalt, however, is not a linguistic construct (especially if language started in 70,000 BC). HcT is a set of **Real World Items**. But with **TSR and clan convention**, this ordered set of RWIs (SemCon) can be directly translated into a clan-ordained proto-sentence: HcT! By virtue of physical understanding (U.P.) i.e. predators chasing prey, and a word sequence that naturally reflects salient worldly elements, this clan had stumbled on the **Subject-Verb-Object** pattern, a Natural Syntax-driven

extension of sublinguistic meaning, based upon neocortical understanding of actors, actions and targets. The clan now had *de facto* grammatical categories that, in effect, captured the essence of **Basic Language (BL)**, despite an absence of any explicit grammatical considerations (*Hominid Games: Chap. 7*, on Neuro3000, describes the PL/BL/EML/FML language stages). Moreover, the SVO pattern could now be implemented for a broad range of sentences, that expanded in concert with the growing BL lexicon.

Grammatical PRM: the Next Game Changer. At present, it is uncertain which came first: **Pattern Recognition Machinery or BL**. But over time, words began to coalesce into natural categories (e.g. actions, objects, agents, properties, spatial relation words, social relations) which fits with the U.P. strictures of neocortex: such regularization of language (aka BL) opened up new realms of linguistic inventions. In contrast to TSR, **PRM abilities** would greatly accelerate communicative inventions, with the regular grammatical ordering inviting additional linguistic conventions like prepositions (see **HG8**). By organizing *de facto* grammatical categories into custom AANs, the neocortical bedrock is laid for future inventions of diverse languages: rising up from common NGG machinery, a nascent computational (UG) core. With PRM, once we know certain patterns, we can just pick words from functional buckets, including newly-evolved grammatical buckets (using newly evolved, custom AANs). Whatever forms the local language uses, PRM machinery can just sequence them per clan convention, e.g. Vultures Flying Water No Lions (if that is the clan's preferred syntax / word order). **Research Topic:** Generalize SVO to future sentences. Mesh w/ Russian, Chinese Syntax (see BSN). **Tech Note:** there is evidence for functional word buckets in FML brains from iCR recordings that show word-category responses before the meaning of the word is known! See e.g. Murphy et al., 2024; with Rollo, Tandon. Topic of Future DINOC commentary.

Most crucially, with PRM, the correct sequence would be created by allowing the sublinguistic (cognitive/semantic) construct to identify words and push useful word-order sequences into the TSR buffer: a replicated WM circuit that was exapted specifically for linguistic sequences and was subsequently tapped by PRM circuitry to reproduce syntactic and morphosyntactic structures as these circuits continued to evolve. Feasibility is key to such arguments, with deltaBV contributing. Mammals can learn many kinds of patterns but not semantic-driven production of Tag Sequences: all this new machinery was indeed far beyond the mammalian castle walls: Nimals are not teachable in such matters. In hominids, instructional genetic changes specifically added many neurons to hominid neocortex (deltaBV) and the *TSR-PRM conjunction would be an early advantage* to parlay into future adaptations, along with many new kinds of custom AANs and AAN-clusters. Further paleogenetic and natural-selection mechanism research should be directed towards feasibility and adaptive advantage of these hypothesized new cognitive-linguistic units. This might be accomplished by adding new modules, perhaps many modules, in each new 100-million neuron addition during The Quadrupling—and for which evidence in iCR recordings might already exist. [Classic pad: NEW FIGURE with PRM Evolution]. Still need to say if PRM uses the WORDS pattern or the RWIs pattern, and also how this works.

RESEARCH: Need to script neuronal circuits for phrase storage. [Every mammal has a story, some more elaborate than others.]

For Future Commentary: No Nimal TSR: The dog producing *water-outside* when the 'beach' button was broken ≠ human TSR, since dogs cannot flexibly play back diverse items from their stored lexicons. Still, they may get closer than other Nimals. It is more likely they are simply using ancestral WM, thinking of the beach which has water to play in and you first get outside by punching the outside button. With many trials, rewards, patience, and intelligent (human) training-program design, the executive functioning suite of mammalian PFC can learn a great variety of things. But this is the antithesis of immediate, innate, effortless human language learning via our LLO.] **For AAN World:** *Neural Words* are digital constructs representing RWIs. NWs might be similar to, or compact versions of, Invariant Representations (NLM book chapter: TBP at Neuro3000). [**Note:** The phrase *Neural Words* phrase was independently used by Buzsaki for distinct, but complementary research]. Because any given NW/RWI can have 1000 different inputs, they represent a high-D space (a Piantadosian Vector; Piantadosi et al., 2024) which makes them both compact (singular AAN storage) and expansive (given all their inputs; and all their direct and further-downstream targets). These elemental AAN-W items are amplified by dynamic assemblies of both enduring and transient constructs likely assisted by consolidation-circuits that determine which memories/dimensions live and which die (get erased) from our DMR. Such convolutions posed challenges for folks like Poeppel and Idsardi, 2020 (and us) who seek The Grail: How and Where words are stored in the brain. Things are even more problematic for iCR researchers who are slogging into this high-D monstrosity; MEG helps but the dimensionality makes further fMRI forays perhaps largely toothless. As Wise Barry once said, "Everything is more complicated than it seems".

Perhaps most crucial today is our innate drive to learn phonemes, words and phrases. How this is genetically encoded, and how neocortex is directed to undertake these specific tasks, while ignoring a plethora of other possibilities, is a tad above our paygrade, but Deep Mind might offer some paths to explore (nicely introduced by *The Infinity Machine*; Mallaby, 2026).

The preceding foreshadows our assertion that **Cognitive Operations drive Linguistic Decisions**. The early SNOs-L were parlayed by the many additional neurons and adaptive behaviors to come. Early sentences like "*throw rocks*

NOW” embodied a nice touch of command and pragmatics, thus helping power-scavenging Habi’s to fend off a charging male lion. Clans that got this right survived and their genes prospered: the stages noted above have been explored in a series of Neuro3000 posters [WDSF page; also see Chap-7:HG on Neuro3000]. This includes custom **Sentence Memory Systems (SMSs)** which are WM-like buffers tailored to either sentence production (SMSp) or sentence interpretation/comprehension (SMSc). **Language Chunk Assembly Circuits** constitute a further advance enabling higher-order constructs as we invented new grammatical categories and functions, including eventually **Morphosyntax** which is a variation on the earliest PRM circuits discussed above. Today’s quite sophisticated PRM circuits, within FML, can accept a great range of patterns, i.e. they can implement many of the Relational Morphology schemas explored in Jackendoff’s *Texture-2020*. The same applies to generating a sentence like *Elena will grow tomatoes*: AANs, PRM and NGG machinery may perhaps streamline the Chomskyian formal-linguistic operations conveyed in Progovac-2018 (see NBOL-2025 poster). **NOTE**: SVO was the first Schema! $\leftarrow$ more to come.

From SMS to LCACs. Longer word-sequences, beyond WM’s 7+/-2 items, became more adaptive once PRM was well established, perhaps in the Acheulean times (1.5 MYA). This made evolution of the SMS and a bevy of accompanying circuits (including peripherals for articulation and phonological processing) all the more pressing, enabling hominids to face the challenges of new worlds, given the Euro-Asian diaspora of *Homo erectus*. Better cooperation and coordination would allow clans and individuals both to access resources and to out-compete their rivals as befits the greatest acceleration of neocortical expansion in life on Earth, i.e. the Habi to Homo erectus to Heidi epoch (from 2.5 to 0.5 MYA: a cognitive arms race). The convolution of PRM with the new cognitive-layer SemCons facilitated more complex structure building, which an expanding SMS accommodated by (1) storing candidate constructs and (2) allowing the movement of sentence-parts around: this was the dawn of **Language Chunk Assembly Circuits**. LCACs were built on top of the earlier machinery, but had to remain local-language neutral and so the overall **Syntactic Translation System**, in conjunction with a co-evolving LLO, can to this day generate every acceptable sentence of every world language. The LLO thus manifests as a **Universal Grammar**. Further developments included more elaborate and dynamic **Cross-Layer Operations** (SNOPs-L $\leftrightarrow$ SNOPs-nl), dubbed **Cyclops**, which is a topic for future consideration (NeuroBoston25 / OMalley Gang Poster). These machinations fall well outside the iterative (and minimalist) MERGE operations of GenGrams—at least because they relegate the essence of sentence construction to the sublinguistic, largely SCIP, semantic layer (**SNOPs-sub**).

Throw the Rock, Sew the Skin are near to proto-language, i.e. to our pre-grammar stage, but *She threw the rock* and *He sewed the skin* required more formal clan conventions (in accord with truly grammatical syntax) and boosted clan efficacy / administration: you want your best throwers throwing and best sewers sewing! Nimals can, in theory, understand and possibly produce two-word linguistic sequences like the first two (omitting *the*), but would have great difficulty learning and generalizing the past tense ala Terrace-2019. Chimps, given 10,000 training trials, can learn all kinds of things that nature never intended—but this may lead to spurious interpretations: such results say little about WHY modern infants and toddlers so effortlessly *learn* language. Our **hSCO** and **LLO** tell us a lot more. Each Billion neurons added a lot, first by genetically enhancing receptive and productive **Tagging** capacity, i.e. boosting our usage and invention of Tags, ideally getting most clan members roughly on par with the best and the brightest. This included a genetically encoded **TSR** system (beyond Nimal capabilities) and was eventually followed by a likely replication of PFC-WM circuits to initiate a language-specific **SMS** (sentence-memory system) as evidenced by the longer sentential streams we can store/recall in our **linguistic Working Memory**. But in our *early-language days*, we hominids quickly ran into a **cognitive wall**. Generating communiques about future activities, analyzing past events and outcomes, adjusting clan-plans: this seems beyond a chimp’s cognitive capacity, presuming they cannot elaborate upon chimp-troop organizational plans. There might be some innate admin in beaver-dam building, but they ain’t discussing future options to enact in case water levels rise! Bortolato et al. (2023) offers an exhaustive summary of chimp communiques, which seem to lack the digital granularity of hominid first words. By the time of the Habi era (from ~ 2.8 to 1.8 million years ago), the first billion-neuron addition to neocortex likely enabled many operations that were well beyond the ancestral, chimpish brain (and are impossible for modern chimps). Within the NGG framework, **co-evolution of the LLO and hSCO** is the only way to explain the steady yet dramatic expansion of hominid neocortex and the increasing dominance of Savannah hominids: from Hyena food to Apex Scavenger to Global Dominion.

5. SURFACE STRUCTURE and SUBLINGUISTIC CONSTRUCTS

Did Language teach Neocortex to Think Better Thoughts? Exactly what each **SNOPs** layer does remains rather uncertain but PRM patterns (~schemas; see Jackendoff and Audring, 2020a,b) can map (via analogical machinery) down to the SemCon level, so we now conclude that lurking in neocortex is some sublinguistic **SemCon-PMM (Pattern-Matching Machinery)** extending patterned-constructs like ‘I will drive’ to ‘I will run / buy / see / leave a tip / and so on. **To be clear:** we are not speaking of word-streams, we are contemplating **meaning** streams that might operate separately from words and linguistic algorithms. This goes beyond the hominid’s initially-evolved hSCO circuitry, which is logically limited (we suspect) to putting basal thoughts together (i.e. not pattern-matching) as e.g. if one is thinking about how different RNA molecules might interact with proteins in a cell’s ribosomes, or something more apropos to cave or savannah life. It’s presently uncertain if the **advantage of economy** that digital word-manipulations have, vs. sublinguistic juggling of meanings or concepts, might obviate any need for sublinguistic PMM machinery. But we expect that analogical thinking, which is a more abstract kind of PMM / pattern-matching machinery, might be dominated by sublinguistic operations, aka **SNOPS-sub** (ala *The Analogical Mind*, Gentner et al., 2001). To go a step further, **LCACs** (Language Chunk Assembly Circuits) might also map down to the SemCon level, thus yielding **SCACs: Semantic Chunk Assembly Circuits** (coined 9/3/25). In theory, this might relegate the **STS** (Syntactic Translation System) to simply reading out advanced SemCons that were already pre-mapped into the structures that emulate learned, local-language grammars. As such, the many maturational steps to linguistic neuronal circuits via our LLO, that automatically produce language acquisition, might be accompanied by yet more extensive modifications of our SemCon machinery. Alternatively, such “**SCAC circuits**” are perhaps a bridge too far. But if such operations do exist, said operations might be evident in brain imaging and electrophysiological/iCR data.

Gestaltation. How is it that neocortex puts together large sentences and gestalts their essence? This occurs in the context of both linguistic *Production* and language *Comprehension*. Meaning is crucial, as approached from both the P and C sides. Brennan and Martin (2020) have reported that oscillatory patterns, specifically phase synchronization, “varies systematically with linguistic structure composition”. Within the STS framework this suggests a computational device for doing sublinguistic PRM-like processes (and analogical operations) in concert with a variety of SNOPs-L algorithms (despite our knowing rather little of how subconscious neocortex actually works). In concert with LCACs (or other mechanisms) it’s likely that SCIP operations can assemble long, complex sentences via an internal memory buffer (SMSp) and that individual constructions might be one-and-done if the initial assembly of words comes out nicely or as intended, thus achieving ‘Gramity’ (more below). Such production requires some initial notions / SemCon, since **Generative Grammars cannot operate on a blank page**. It also needs the STS (in some form) to generate the first pass sentence. Of necessity, this invokes a grammaticality check: us humans are unable to “not assess” sentence-cohesion--it just happens. As such, there must be feedback (aka efference copy) from the -L layer back to the sublinguistic layer for a meaning check: even *Colorless Green Ideas Sleep Furiously* means *something* to my neocortex. In contrast, our brain screams NO when we read Colbert’s book title: **I am America and So Can You!** Most folks cannot say exactly how the ‘rules’ of grammar have been so pointedly violated by Colbert, but we know at some level that it’s not grammatical. This sense of grammaticality, aka **Gramity**, further implies an operation that involves the SemCon level (since it’s the meaning of the book title that hurts), so this cross layer *feedback pathway* seems obligatory. This also fits with a higher-order (perhaps oscillatory) binding operation to achieve Gramity, aka the sensation of particular sentences being nicely grammatical. Brennan and Martin (2020), in describing the binding by different oscillatory patterns, go beyond basic gamma-on-theta rhythms in regards to compositionality, but at present, the machinery of Gramity seems out of reach.

Research Topic: How might neural oscillators contribute to Gramity, LCACs and Cyclops?

Production: SemCon + STS is required to generate grammatical sentences. The proposed oscillatory integration of such information (see ROSE, Murphy, 2025) would, via the NGG framework, involve both SNOPs levels, in particular SemCon which crystallizes notions to the point where meaning-constructs can be routed (translated) into the LCACs stream for proper grammatization. Because this is mostly or entirely happening at the SCIP level, most everything but the final assembly (such as these lines flying from my fingers) is invisible to us. It seems plausible that just within production there are two dynamic, powerful **Sentence Memory Systems** working in parallel, the **SMSp** store, which acts as a readout store, yielding speech or text. This might be complemented by an underlying *SemCon Stream Store*

(SCSS, sorry). As each notional goal is proffered or puffed into existence (by some trans-dimensional creature), we expect follow-on ops and dynamic trans-layer interactions as each notional goal is achieved with just the right tone, clarity and Gramity (thanks to Wise Barry). While nearly all of this is occult and speculative, we do know that it's fast and as automatic as a newborn antelope standing up: it has to be genetically-encoded because the African Savannah has little patience for unnecessary trial and error: **The Savannah is a Harsh Mistress.**

Note: There is a loose analogy between the SNOPs layers (-L, -sub) and the Surface/Deep language layers of GenGrams, but in generative grammars both layers are linguistic, even within the Generative Semantics and Semantic Syntax traditions.

Research Topic: The hSCO was not needed until (1) language had already progressed substantially, from proto-language to basic-language or higher and (2) hominid neocortex was ready to exceed what primate SemCon could do. This was the Rubicon of **hSCO / LLO co-evolution**. This new cognitive-linguistic capacity is a *candidate threshold* for **EML / Early Modern Language** (proposed 9/10/25). As occult as the proposed PMM (and possibly SCACs) lurking in SCIP are, we know hominid neocortex can do high-level cognitive-linguistic things, by some algorithm or other, and so it would be of interest to **deploy iCR, MEG** and other approaches to help us detect and study such computational machinery.

Morphosyntax and Digital Operations: Twins Sons of Different Mothers. While AAN-World is explicitly **Digital** (because AANs are winner-take-all devices), **Morphosyntax** is a bird of a different feather: a center of classical linguistics, including its more recent, modern forms (Progovac, 2016; Everett, 2017; Zywickzynski et al., 2017; Jackendoff and Audring, 2020a). The symbolic beauty of mammalian neocortex, especially linguistic (hominid) neocortical operations, emanates from its Digital Core: digital operations on a multitude of symbols (**SNOPs**), including words and real-world items (**RWIs**). To an antelope, a Lion is a digital thing: large male, hunting females, cubs, a pride lounging in the sun: they're all lions and readily distinguished from cheetahs and hyenas. Circumstances dictate an antelope's responses—a whiff of lion scent in nearby grasses, for example, and the Antelope's prelinguistic, AAN symbol for lion is strongly activated, along with all manner of stored, connected experiences and general knowledge of predators—this is no time to be scrolling on your smart phone! Modern word variants, and their role in syntactic structures (morphosyntax), are **equally digital**: *hunt, hunting, hunted, hunter* are all distinct, discrete digital entries in the AAN-World that powers FML. Because of 10kCon (10,000-fold connectivity of neocortical pyramidal cells) each linguistic AAN-item is connected to many other words and to many sublinguistic items as well. Nimals are prelinguistic, lacking SNOPs-L, so they have only ancestral, sublinguistic-like SNOPs. We humans, in effect, come to learn words as groupings (e.g. variants of hunt above), and also as patterns (hunter, singer, writer; hunting, singing, writing), building upon evolved PRM-machinery and modern LCACs (see Neuro3000.com posters), *but each word is nonetheless stored as a stand-alone, discretely deployable item*. They work in conjunction with stand-alone semantic, sublinguistic symbols. This is an existential matter since (e.g.) the meanings of hunter and hunted are very different: confusing them would be a most dangerous game! Such developments enabled stream-lined, digital morphosyntactic operations, building upon a quite evolved PRM foundation, as enhanced by LLO, hSCO and other NGG-related machinery. Digital SNOPs, including analogical and morphosyntactic operations, will be explored further ala RJ's schemas in *Texture of the Lexicon* (Jackendoff and Audring, 2020a,b).

NEXT PAGE: Summary of Key Terms

6. NGG SUMMARY

- - With Key Terms in BOLD - -

Our Neocortical Tool-Kit. Herein we briefly recap the **NGG** and **sublinguistic** devices introduced in the course of the evolutionary neuronal-circuit design work above. To implement the variety of acceptable English sentences, and sentences more generally (ala **Universal Grammar** principles), we suggest a set of ancient hominid circuits that might accomplish this: a **Neuro-Generative Grammar**. [Murphy's ROSE architecture (2025) offers a higher-order complement to NGG]. Beginning with **Tagging** (iconic mimesis of salient niche sounds), hominids evolved **Tag-Sequence Readout**, a SNOPs-L neocortical resource sufficient for the evolution of clan-conventions, aka **Proto-Syntax**. Together with Tagging, this constituted Proto-Language, which was followed by three grammatical stages: **Basic Language**, **Early Modern Language** and **Fully Modern Language**. This included a custom **Sentence Memory System**, a derivative/expansion of TSR, which in turn arose from duplication/exaptation of an ancestral, non-linguistic Working Memory circuit. Capping this, for sentence production, are the **Pattern Recognition Machinery** and **Language Chunk Assembly Circuits**. Collectively, these elements constitute the linguistic components of our **Syntactic Translation System**, which translates nebulous notions into syntactic structures, aka language. Underlying all this is the **Universal Physics** of ancestral but expanding neocortex, which leads to an early **Natural Syntax** that continuously and incrementally expanded up through **FML**. Of course, none of this happens without the ancestral, underlying **Semantic Construction** machinery: it is the sublinguistic / **SCIP** layer (SNOPs-sub) that feeds nebulous notions into the **STS**. As neocortex (and thus hominid cognitive-linguistic capabilities) expanded, we needed hominid-grade SemCon, aka our **hominid Semantic Construction Organ** (a co-evolving companion to our **Language Learning Organ**). Our primary focus has been on the **Where do Sentences Come From** question, but for language reception we also endorse a Reverse Translation system which relies upon **Syntactic Discovery** to achieve modern-language comprehension. These elements evolved directly from ancestral neocortical / MTL machinery and offer many gradual enhancements to help account for the volume-elements of **The Quadrupling** of hominid neocortex. A future commentary will explore more advanced aspects of the **hSCO** system including **Cyclops**, a pseudo-acronym for the **Cross Layer Operations** needed in FML brains. This latter topic entails a deeper dive into our extraordinary **Sub-Conscious Information Processing** machinery.

Defined Above: NGG, LEVO, UG, TSR, BL, EML, FML, SMS, PRM, LCACs, STS, U.P., SemCon, hSCO, LLO, WDSCF, SynDisc, Cyclops, SCIP. For further exploration at Neuro3000.com, the **WDSCF / Posters Page** provides useful visuals/ppts; DINOC hosts recent research and a custom DINOC Glossary and Bibliography. Last Paragraph = PiB = Primer in Brief: **Post on DINOC**.

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