Scribbles: The missing link in a theory of human language in which mothers and children play major roles

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Abstract (word count 398)

No one knows how hominid voice apparati and brain changed to accommodate speech. Some adaptive pre-conditions for language are explored below, focusing on interactions between mothers and children.

Babbling, scribbling, and motherese are recognized as robust, universal behaviors. This paper identifies all three behaviors as links in a continuist theory of human language as both speech and literacy, with an emphasis on scribbles.

What's missing from an evolutionary theory of human language is the influence of literacy on speech. Children babble and scribble within the first two years' of life. Hands and mouths are proximal on the sensory-motor cortex. Gesturing is part of speech. The work of the hands and the mouth are connected. Illiterate brains mis-pronounce nonsense sounds. Literate brains do not. Written language (work of the hands) affects spoken language (work of the mouth). It is not speech which drove literacy as a transcription of sound, but literacy which drove the elaboration of speech, semantically and syntactically.

By including the influence of children's scribbles and mothers' notations on hominid language development, we can flesh out a theory of marks and mind:

1) babbling, motherese and scribbling emerged from the song-like gestural/vocalizations of primates whose bipedal locomotion made possible a cascade of interrelated physical and mental changes around mothers' freed-up hands, and dependent babies.

2) babbling, motherese, and scribbling functioned in the hominid brain as neural organizers for spoken and written languages.

3) humankind's earliest marks placed adaptive pressure on speech, creating the neural substrates for phoneme-grapheme (or sound-to-mark) correspondance, as well as for multiple literacies (art, literature, mathematics, music).
4) scribbling is an artifact of the evolutionary connections between speech and literacy.
5) the biological role of human language is the self-regulation of a system which tends to over-heat on three levels: emotional, linguistic, and quantum.
6) The human brain invented two cooling systems:

- a better vascular system, making larger language areas possible
- marks-based systems for thinking which helped brains resolve emotional conflicts, synchronize activity in multiple layers of brain tissue for language processing, and act as coolants or energy pumps in biomolecules

It seems likely that the biological goal of both brain systems (the vascular and the linguistic) was and is the same: the conservation of energy in a dynamic biological system which subscribes to the three basic rules: move, connect, and communicate.

Toward a theory of human language as primate vocalizations driven by the visual-attentional provocation of intelligible marks in the context of mother/child interactions

Word Count 6,426 exclusive of research questions, Coda, and bibliography.

Two Broad Categories: primates who make marks to think, and those who don't

Research with children's scribbling and drawing (1,2), including mappability onto deeply significant designs in art history (3), attests to their status as important invariant behavior. At this point, only one paper connects children's scribbles with brain development, with implications for quantum brain states (4). One of the aims of this paper is to add to the neurological hypotheses connected with human mark-making.

An evaluation of brain endocasts (5), as well as a re-interpretation of pre-Ice-Age marks incised in bone (6), brings into sharp relief two broad categories of brains: primate brains with increased vascular/cooling systems, which use meaningful marks to think, and primate brains which lack such systems, and do not.

Primates who think using meaningful marks (artistic, literary, mathematical, musical) process information using energy-costly modes, with potentials for over-heating the brain (5, Charlton). Improved meaning-making systems and improved cooling systems apparently go hand in hand in evolutionary biology (5).

Literate brains *learn* phonological processing from alphabetic written language. Auditory-verbal and written language interact. Literate and illiterate brains differ in attention, working memory, and articulatory organization of verbal output (7,8). These are significant, non-trivial differences (7). How did the verbal, literate human brain evolve? What drove the connections between marks and mind?

Information from brain science, anthropology, research with the deaf and the blind provide clues.

The Sensory-Motor Cortex: closely connected hands and mouths

The contiguity of the hand and the mouth on the sensory-motor human cortex supports a synergistic relationship between the action of the hands and speech (9). Hand and mouth areas on brain cortices are close, too, in other primates (10). Still, some confluence of behavior and environmental pressures connected the work of the hands with work of the mouth in the service of human language. A special, synergistic relationship between hands and mouth persists in the life of child whether sighted or blind, hearing or deaf (11). Gestures, signing, and speech are connected activities neurologically.

It is this paper's position that not only gestures and speech (12), but speech, scribbling and drawing are neurologically linked in the human brain as multi-modal extensions of the dopaminergic SEEK and PLAY mammalian survival systems (13). It can be argued that the evolutionary rationale for such a linkage is not language *per se*, but emotionally-driven, energy-conserving *understanding*.

In a marks-based (as opposed to a speech-based) theory of language, scribbling and drawing may act like thermostats, heating/speeding up brain frequencies for easy word-retrieval in speech, as well as for reading and writing, then cooling/slowing down brain frequencies to achieve efficient resting states via marks-based resolution/understanding.

Exactly how the praxis and practice of speech and literacy and emotional self-regulation co-evolved in hominid history and continues to unfold in today's child is unclear, but research with children and mothers engaged in play and conversations around scribbles and drawing should extend the existing research connecting speaking mouths and gesturing hands. Until that time, we can consider the following information.

Vision and Attention

Vision and attention are connected operations (14). Sustained visual attention is necessary for speaking, as well as for drawing, reading, writing, and other marks-based information gathering and expression. We can hypothesize that the work of the hands *as marks* extended the attentional capabilities of the visual cortex for language. In this regard, it is useful to review the first four tenets of The Scribble Hypothesis (15):

• One: Very young children's scribbling trains the brain to pay attention and to sustain attention, setting up a self-organizing, dyadic feedback loop between the eye/hand and the interhemispheric brain.

• Two: Very young children's scribbling stimulates individual cells and clusters of cells in the visual cortex for line and shape.

• Three: Very young children's scribbles help them practice and organize the shapes or patterns of thought.

• Four: Very young children's scribbling encourages an affinity, or love for marks, preparing the mind for its determining behavior: literacy.

To explore these tenets, some background information from anthropology, brain science, and human and primate development is useful.

Anthropological missing links: brain-casts and scribbles.

Research with hominid brain-casts (5) produced a "radiator theory" of vascular cooling in the upright hominid brain. By examining the pattern of surface veins on brain casts as well as the number of holes, or foramina, through which major blood vessels penetrated brain tissue, some important conclusions were drawn about certain prehistoric primate skulls.

Skull fossils of bipedal hominins showed that blood started to leave the skull in ways that differed from the way blood circulates in ape brains. By counting the numbers of holes in the skull which allowed major vessels to dump their coolant (blood) all over the surface of the brain, it became clear that the special placement and increased number of foramina increased dramatically in *Homo* (5, page 25). Brains and veins evolved together (5, page 26). Cooler brains became bigger brains.

Endocasts provided evidence that Broca's area - one of the two we associate with language- was present in the brains of hominins that lived about 1.9 million years ago. It is still present in chimpanzee brains today, while Wernicke's area is not. This means that language was being selected for and lateralized 2 million years ago (5, page 27). As the dividing and sharing of mental tasks into two general categories, the spatial and the linguistic, lateralization was a huge jump forward in hominid brain morphology and capabilities. Still, the question remains: why did some primates develop spoken and written languages while others did not?

The Motherese Thesis and other Physical Conundra of Speech

Bipedal, upright posture selected for smaller pelvises. Smaller maternal pelvises selected for immature neonates. Immature neonates put pressure on mothers' vocalizations for reassuring sounds (5, page 28).

Bipedalism, improved brain-cooling systems, smaller pelvises, premature births, infant dependence eliciting maternal comforting and admonishing sounds, helped increase mother-child interactions, generating, over time, the slower, more carefully articulated, higher-pitched speech called "motherese" (5, 16). This "motherese;" the probable fine-motor effects of "pincer/pencil finger" grooming (18) accompanied by gossip (5, 16, 17a, 19); the growing signal functions of crying in infants separated from their mothers (20); and, as here hypothesized, changes in *breathing and swallowing* brought about by extended infant separation-crying, a horizontal, sling-position for nursing, infant outbursts of spontaneous laughter and mothers' answering chortles, admonitory "shushing" by mothers trying to get babies in arms and toddlers on the ground to be quiet while the mothers stalked small game (18), plus the solitary *marks-based* play of the hominid toddler set down in the dust, are components in a constellation of pre-adaptive conditions for human speech. It was not the descent of the hyoid bone that did it. The hyoid bone descends in the organization of the throats in modern day chimps as they mature (21). Arguably, it was the complex interactions between mothers and children around sounds and signs that proved pre-adaptive for speech, with *literacy* as the key to the sophisticated oro/facial controls as well as to the neural networks necessary to transform vocalizations (22) into elaborated speech beyond simple (as opposed to complex)sentences.

Primates and Language: the great debate

Linguists do not believe primates can acquire language as humans do (23, 24) Some primatologists believe they can (25, 26). After eighty years of research with apes and chimpanzees, it is unclear whether highly trained primates understand the *meaning* of the signs and symbols they use, let alone grammar or sequencing rules (27, 28, 29). Because they tend to interrupt their trainers, failing to take turns conversationally or to provide new information, never lengthening their sentences past 6 or 7 signs, chimpanzees' use of human language is very different from the child's (30).

The major difference between human children and chimpanzees as language-users is that children invent new sentences, while chimpanzees sign the sentences they've learned from their trainers (with a few reported exceptions). Another major difference between child and chimpanzees is that chimpanzees use language to ask for things, rarely, if ever, to "chat" (31, 32)

It remains unclear, whether apes can actually speak using distinct noises that attempt to imitate human speech (33) or by using a computer and a voice synthesizer (34).

To date, research shows that primates can learn to use more than 200 signs. It looks as if the more signs chimpanzees know, the greater their chance of responding to a novel demand, if not to making a novel statement (Sue Savage-Rumbaugh's research with Kanzi). Still Kanzi made this statement about a stuffed dog and a syringe, "Give the dog a shot," a sentence which Kanzi had never heard.

One researcher suggests that primate research should focus on gesture rather than speech to see if primates have something like a natural sign language (33, 12). If this were so, then some of the conditions for language as speech *as gesture* if not as sound would have been met before hominids split off from the rest of the primate groups. Since chimpanzees will scribble with trainers, another line of research might focus on whether chimpanzees in the wild make marks. For instance, when gorillas drag branches to indicate that the group is going to move to a new nesting site (16, 57), does the rest of the group follow the branch-dragger or the marks the branches make on the ground? Is the function of branch-dragging creating an attentional, noisy visual display or a map? If the marks are followed by members of the troop who follow at a distance, out of sight and hearing of the branch-dragger, then this might be where scribbling, drawing and literacy began.

Instead of asking whether chimps can speak or sign grammatically, with understanding, it might be more fruitful to ask if chimps can learn to draw, and then try to "bootstrap" (24) signed speech onto drawing. This approach would place the emphasis on learning visual literacy before verbal literacy, which makes sense developmentally, at least from a human child's point of view.

The question still goes begging: *exactly how* did our CA (common ancestor), the one who bridged the gap between great apes and humans, map spoken language onto existing gestural/vocalization communication systems?

Putting the Baby Down: Exploring infant solitude in connection with scribbling and drawing and the lateralization of human brain.

"Infant parking " was rare in anthropoids because predators were everywhere (16). Still, bipedal mothers occasionally put their dependent toddlers down upon the ground, freeing up their hands for survival tasks like gathering, gardening, and hunting small game. Presumably, as hominid society became more organized, child care-like support was provided by allomothers (35), allowing supervised infant parking to become more common.

Brain casts suggest that hominid mothers' gestural and vocal repertoires would have been sufficient to comfort and control babies who were too immature to cling to their mothers' bodies (16), while pre-toddlers' communicative gestural/vocal skills would have been sufficient to making their needs known to caregivers who were not actively holding them (16). Hominid mother/child communication became multi-modal (16, 36).

It is this paper's position that maternal notations and toddler scribbling followed a parallel course, achieving multi-modal marks-based (as contrasted with gestural- and sound-based) communication, encouraging the evolution of the abstract aspects of speech, as well as literacy (as literacy would ultimately include drawing, writing, mathematics, and musical notation). This parallel developmental course for marks provided powerful additions to the dyad's communicative repertoire.

It is probable that the prosody of motherese (which babbling reflects), is reflected, too, in the "prosody" of scribbling, increasing the influence of low-frequency organizers on the young brain. It is also probable that the "social syntax" (37), or learned call-and-response behavior in mother/child communication(also called turn-taking) was reinforced by scribbling and drawing, encouraging hemispheric turn-taking in a newly lateralized brain. Theoretically, this bihemispheric turn-taking created the neural circuitry necessary for translating verbal information into visual information, and visual to verbal information, making possible the multiple literacies humankind currently uses to communicate, including media technology.

Ambiguity, mimicry and the solitary independence of the "parked" child: more conditions for speech and literacy: The Period of Individual Propagation.

If manual gestures exchanged by mothers and children were often ambiguous (16), requiring the invention of words to make communication clearer, and if our hominid mothers taught us to copy her images (which is likely, given the instructional nature of mothers and the imitative nature of children), then both speech and drawing would have been dividends of mother/child interaction, making hominid mothers humankind's first, best speech *and* literacy teachers. Contrary to one scholar's position that maternal linguistic influence including "motherese" is "folklore" (24, p.39), modern mothers and children continue to co-invent language and literacy.

Just as it is possible to argue backward from how children currently learn to talk with their mothers, to how hominid infants must have learned to talk via exchanges with their mothers featuring the special prosody of "motherese," (17a), so it is possible to argue backward --- not from modern mothers' marketing lists --- but from the fact that modern toddlers scribble, to the position that marks of meaning must have been part of the process of the acquisition of spoken as well as of written language in young hominids, perhaps from the time of *Homo habilis*. In fact, the mental move from *Homo habilis* to *Homo sapiens* may relate to mark-making as much as to anything else.

One theory of how novel behaviors are transmitted maintains that children do it, youngster to youngster, with the novel behavior trickling up to older females and siblings, and last of all, as fixed behavior, to adult males (38). The theory rests on two periods, The Period of Individual Propagation (38) comes first, as described above. In the context of the "parked hominid child," the ability not only to understand the mother's comforting /admonishing utterances, but to stay put and stay quiet through self-amusement would have been strongly selected for. Scribbling and drawing are strongly self-amusing behaviors. This paper proposes that hominid toddlers and three and four year-olds invented mark-making in response to their mothers' needs for them to stop crying, be quiet, stay still, and not wander off.

If the Period of Individual Propagation does apply to an evolutionary theory of literacy, this meals that adult males learned to incise bone with lunar notations and to paint monumental cave paintings from toddlers.

This paper proposes that not only the sharing of utterances between youngsters, but the sharing of marks between youngsters, provided adaptive pre-conditions not just for speech, but for literacy, providing an ancillary example of "how ontogeny formulates new phylogeny" (39).

The Second Period of Pre cultural Propagation occurs when new generations of infants and children learn the behavior from their mothers, with the behavior passing on, in this way, to future generations (17a). So, at that point, mothers would have learned to use marks of meaning from their youngsters, becoming humankind's speech, art and literacy instructors.

Mothers and Marketing Lists: The Second Period of Pre cultural Propagation.

When hominid mothers, inspired by toddlers' scribbles and youngsters' drawings, began to make their own notes, drawings, lists and maps, labeling certain caches of leaves and seeds for medicinal properties, others for cooking, that's when literacy took off. This kind of everyday mark-making, like the scribbles and drawings of hominid youngsters, would have been impermanent ---charcoal and ochre on leaves or bark or hide---and thus lost to us, unlike the heroic murals painted deep in caves, most probably by shamanic males at a far later time, say 1.7 million years later.

Representational drawing, writing, mathematics and musical notation surely began far earlier than the murals in the caves at Lascaux. If speech sprang from a highly charged emotional/survival dialogue between mother and child, inquirer and answerer, mentor and mentored, between master gatherer, gardener, trapper, healer, and the younger children and other women who did, as they do now, the work around a home (feeding, clothing, general education, health care), then surely literacy sprang from such familial dynamics too.

Babies' babbles and toddlers' scribbles, as well as evidence of simultaneous neural activity in speech areas and in sensory motor areas for the hands (9), support the neurological interdependence of speech and literacy in terms of *timing* in modern humans. It can be argued that this interdependence in timing between speech and literacy began about 1.9 million years ago (5).

Exhaustive research with Ice Age notational markings on bone and stone (6), as well as definitive work with children's scribbles (3) support the importance of marks to the development of the human mind, including speech and literacy. Is there support for literacy as an embedded capability?

Innate Numeracy: Support for Embedded Literacy

The issue of numeracy in connection with child thought sheds light on the question of embedded literacy, supporting the innateness of mark-making as an attribute of the human language system.

Research with infants' innate sense of numeracy (40) supports a theory of embedded mathematics (41) , just as research with children's object recognition (42) supports a theory of embedded shapes or "geons"(43). These geons are both innate (44) *and* emergent, developing very early in childhood (45).

If attention to shape and naming are related developmentally (45), we can infer that the geometry of scribbling influences the elaboration of speech. The developmental closeness in time of speech and scribbling suggests inter-influence, if not interdependence. The fact that more advanced object name categories allow children to recognize stylized, abstracted, or "caricatured" shapes (45) means that a sense for shapes as well as skill with abstraction are interdependent. The important point to note is that, between the ages of 18 months and 24 months, naming and abstract shape recognition influence each other (45).

It is this paper's position that --- as they are accessed and expressed in toddlers' scribbles--- geometric shapes are both innate *and* emergent, and that therefore, what we call literacy ---visual and verbal, including art, literature, mathematics and music --- is also innate and emergent, springing from an embedded instinct for meaningful shapes, which children show us in scribbles.

If perception is inseparable from top-down processes and category learning (46), perception is also non separable from bottom-up processes, specifically the neural dynamics of a biological system in which notation has become a major strategy for motion, connection, and communication (15). Like the combined, embedded wave-particle theory of light (47), and because of some non-strictly reducible neural agency like Douglas Hofstadter's Strange Loops (1979), it is likely that the human abilities described as speech and literacy are embedded, emergent, interdependent, *and* learned phenomena.

The dots, lines, and minimalist geometric shapes in children's scribbles are where literacy begins. As abstract representations of form, toddlers' scribbles are logical correlates of infants' innate numeracy, or sense for objects as one, two, three, or even four *in number*. As neurobiological behavior, literacy distinguishes human brains and behavior from other mammals, including other primates---who can also count. Other creatures have numeracy, but they do not have literacy.

Compendia of children's scribbles and drawings (3) underscore the importance of Euclidean and non-Euclidean geometry to very young children's graphic expressions of thought. Since the child and the abstract artist share abstract representational strategies, research into abstract art as responsive to basic neural requirements and abilities in the human visual cortex (48) should help us to understand the child's developing visual system in connection with form recognition.

Learning to construct internal representations adapted not only to the external world (49, 45), but to the internal world of *non-world-related* brain activity makes the human brain different, presumably, from other creaturely brains. The human brain/body construct achieves its outer and inner connections using spoken words and written marks. Other mammals including other primates do not use spoken words and written marks.

Extending the capabilities of multi-modal brain tissue with clues from the deaf and the blind.

The instinct to communicate using any available mode is innate; if a child can see but is deaf it uses signs; if a child is blind but can hear, it uses sounds. Still, all children babble and scribble *at first.* Their brains, despite their disabilities, are organized to communicate verbally *and* visually, in systematic parts-to-wholes ways using a combinatorial mechanism much deeper than language. Children instinctively build up words with sounds, sentences with words; children instinctively build up images and text with lines and dots, curves, spirals, and other geometric shapes.

Brain tissue dedicated to communication is open to environmental influence; it has multi-modal potential (36). This multi-modal potential owes a debt to the interactions between hominid mothers and children around gesture, vocalization (5,17a, 17b), and marks of meaning. As significantly, mirror neurons in the brain most probably owe a debt to the affective exchanges between mothers and offspring across species.

Infant Decentration and mirror neurons

A theory of Infant Decentration (17a) suggests that, once infants no longer clung to the tummies or backs of their mothers, the mother/child unit was split. Mothers' and the infants' points of views about everything diverged. The infant had to learn to read its mother via her gestures, sounds, facial expressions: ditto, the mother vis a vis the infant. Since mirror neurons form substrates for understanding motor actions in others, it is likely that another pre-adaptive condition for language was an increased number of mirror neurons in sensory-motor, emotional, and language areas as additional contributions from hominid mother/child interaction.

How affective neuroscience connect emotions with a theory of language: the strategies SEEK and PLAY. Toward a Quantum Theory of Scribbling.

By connecting a marks-based evolutionary theory of literacy with the SEEK and PLAY strategies described by affective neuroscience (50), strategies which we share with other mammals, including primates, literacy becomes a downstream ramification of ancient emotional circuitry associated with strongly positive motivational neurotransmitters designed to encourage humans to seek and play ---- in this case, with meaning, rather than exclusively for food, shelter or social and/or sexual advantages.

Seeking and playing with meaning makes human brains unique. Meaning is, of course, invisible. Meaningful marks are not. SEEKing and PLAYing inside the brain for the fun of it, and for the need of it, became a possibility and a priority for literate mammals. It is in this connection that it is useful to review tenets #5 and #6 of The Scribble Hypothesis, proposing a Quantum Theory of Scribbling:

- Five: Marks of meaning operate like "super-radiant surfaces," or mirrors, encouraging self-reflection, capable of producing consciousness states describable as self-induced transparency, or epiphanic consciousness (including understanding, wisdom, peace, transcendent at-oneness), rewarding the brain emotionally and neurochemically for its hard-won self-clarification (51), while, at the same time, allowing the brain to settle into minimal, coherent energy states (52, 53, 54). This resolution across emotional/neural levels is energy-efficient, a highly desirable state in dynamic systems.

- Six: Marks of meaning including scribbling are not only critical to the neural development of visual, verbal, and emotional thinking in the child, but instrumental in the maintenance of healthy neurophysiology, including the visual, verbal, emotional, and memory/learning circuitry in the adult brain.

It is on these tenets that a theory of marks as transcendent consciousness designed to help the brain settle into energy-conserving states depends.

Linguistic thinking in humans can be described as a mapped map, a space-phase sandwich, an over-layering of kinds of information processing, from the sensory to the linguistic, with a major goal: settling into minimal energy states (52). In a brain which uses symbolic meaning to achieve equilibrium, there must be motivation for cooled-down states. It is arguable that the terms "self-induced transparency" and "super-radiance" associated with quantum microtubular consciousness states (54) have relevance for the *emotional* motivation of special, higher-order "transcendent" brain states responsible for neural resolution, and, that, in fact, these terms provide apt descriptors for how such clarified higher-level mental states *feel.* A brain that has worked hard to figure out a major problem in life feels lightened (in the sense of being filled with light), even ecstatically clear. Multiple literacies, including art, literature, music and mathematics, are major tools for resolving life's problems from journals and doodles to more formal marks-based "understandings."

The putative biomolecular specifics of a quantum theory of scribbling are attached as a Coda.

Shifting Paradigms

The stock psychological male model for fear and stress as a two-response, fight-or-flight system, is making room for a female, tend-or-befriend stress-model (55); the position that men are "cool under fire" while women panic has been overturned by research proving that motherhood produces a braver, more resilient and adaptable brain (56, 57): the anthropological paradigm for a sudden flowering of Paleolithic art and human consciousness is giving way to a more gradual pre-Ice Age model based on notational systems engraved on bone (6). The periodic lunar model for notational systems useful to male hunters is ripe for a shift to the gestational/seasonal roles of women gatherers and their children in hominid brain evolution in connection with a continuist position on language and consciousness (58), focusing on the quotidian importance of mothers' care-giving, children's play, and shared speech around marks of meaning.

By far the most powerful argument for the effect of marks on the human mind is research with adult illiterates. These illiterates mispronounce nonsense words, while literate adults do not. The research shows that learning a written alphabet in childhood changes the brain for a lifetime of *speech,* not just for literacy (7,8). *Seeing* the letters of the alphabet, learning to *read* them, teaches the brain to *say* them, even when the word is *nonsense*.

It would be quibbling to say that early hominins had to actually represent a sound using writing to learn the sound. Early hominins had to *invent* writing and reading. A look at the evolution of written languages, say Egyptian, shows us that pictographic writing paved the way for phonetic writing. A picture of a hawk came to stand for the sound that started the word "hawk." A picture of a thing became a picture of a sound. The brain *invented* consonants and vowels by *drawing* them. No one taught the solitary toddler in the dust to write and read consonants and vowels. Children and mothers invented them, along with vocabulary and grammar by drawing, and then by *talking about* drawings. Marks *changed* minds. Literacy changed, and still changes *speech*.

Humans did not invent speech first and then write it down. They invented rudimentary speech, drew what they could not otherwise communicate (which was almost everything), and invented new sounds, new words, new organizations of words from looking at their drawings.

If we use children's drawings as a model, then early hominins scribbled first, drew schematically second, then developed observational/representational drawing. Speech mirrored this trajectory, developing from babbled sounds to the barebones of noun-verb sentences to more full developed *verbal* sentences representing more fully developed *visual* thought.

Since humans still use images to express thought, and, in fact, require images to understand their most complicated, abstract thoughts, it is clear that words have not replaced the power of drawings to express meaning, and, most probably, never will.

Recognition of the effect of the visual on the verbal is the keystone of to a new paradigm for human language.

Fleshing out an evolutionary theory of language

Bipedalism and upright posture created reverse blood flow, which cooled the brain allowing for a larger brain. Thereafter, marks of meaning --- beginning with doodling in the dust by solitary toddlers as well as notational systems invented by hunter/gatherers(6), both male and female, to keep track of natural cycles and periodic events and processes --- placed substantial visual/attentional pressure on the proto-hominid visual cortex, the dexterous, expressive hands, and the vocalizing mouth, as well as on the motivational/emotional limbic system, driving brain growth in terms of:

- brain lateralization, allowing increased specialization, and thus, increased efficiency for spatial and linguistic tasks
- brain de-lateralization, or *de novo* unification via the agency of scribbling and drawing, re-introducing spatial input (as visualization, imagination, plus the visual complexities of spatial relationships of drawn marks which contributed to verbal grammatical complexities) to spoken and, eventually, written language.
- bihemispheric, corpus callosal transfer, making it possible for the human brain to use drawn and written "alphabets" or marks-based literacies to modify speech in connection with attention, memory, articulation, semantics and grammar, as well as to translate meaning across systems of representation (or marks-based literacies), for instance, changing a drawing into words, words into music, music into mathematics.
- the creation of awareness as attention in connection with a growing working memory (58), appreciably expanded by new representations created by children's drawings and mothers' notational systems
- emotional (endocrine-driven) motivation for thinking using symbols, off-setting the metabolically costly effect of brains which require so much information about humans and their doings (58)
- cognitive motivation for inventing words to describe the range of marks early hominins produced to communicate around and beyond speech

This brain growth, in turn, created:

- adaptive pressure for increased prefrontal lobe capabilities with symbols
- the possibility of increased synchronization via dyadic, call and response exchanges not only between mother and child, but between visual and verbal thinking (including the far-reaching effects of callosal transfer described above)

- increased levels of synchronization, which, in turn, increased levels of positive emotion, while conserving energy, which, in turn, made extra processing reserves available for images and words and other complex symbol systems
- "mom-binding" and "time-binding" (6), as well as a "theory of mind" (58) as additional dividends of the highly adaptive "displaced" capabilities of long-distance communication (58) including infant crying (20), motherese (17a & b),and youngsters' scribbling and drawing, along with other mark-making systems invented by hominid children and their mothers to work with the seasons of their lives, as well as with the seasons of the plants and animals on which they depended.

Language: an "instinct" or a strategy?

Our DNA is derived in an unbroken sequence from the same molecules in the earliest cells that formed at the edges of the first, warm, shallow oceans. Our bodies, like those of all life, preserve the environment of an earlier Earth" -
Lynn Margulis and Dorian Sage, *Microcosmos: Four Billion Years of Microbial Evolution,* 1986, p. 34.

"The cell remembers: the information of life is intrinsic to its cellular structure."
Margulis, *Symbiotic Planet:* a new look at evolution, 1998, page 47.

Insert image of cell extending pseudopod, or "Spirochetes become undulipodia, figure 3," Margulis,1998, get permission

Rules of the Pseudopod

"Pseudo" means false, and "pod" means foot. A pseudopod is a foot that reaches out like a hand. Nucleated cells in ancient oceans have passed on the memory of the pseudopod. We inherited it, like a ring from a grandmother, and use it for language.

On our Earth, a very long time ago (three billion years), pressure, temperature, and gravity created structural divisions between pockets of ocean water. We've named these structural divisions "membranes." Membranes allowed nutrients from the outside in, without letting the "inside" out. Then, something extraordinary happened, and this event (according to evolutionary biologist Lynn Margulis) may be the only discontinuous event in biological history (along with literacy, although literacy, too, has a cellular history).

A cell without a nucleus became a cell with a nucleus. One cell moved into another cell for mutually beneficial reasons. The cell on the outside remained the body and the bacterium on the inside became the brain. The name for this biological cooperation is symbiosis (59).

As soon as the single-celled organism had an inhabiting bacterium, it had a proto-brain. It could tell itself what to do, including how to bundle up information necessary to copying itself, and send that bundled-up information through a little tube called a microtubule. The nucleated unit could extend the resources of its membrane. It had figured out how to warp its shape for the purposes of transduction --- or the leading across of information --- in several ways:

- it could extend itself as a wriggling tail (cilia, flagella), achieving motility or **motion**. Sperms are DNA with tails.
- it could extend itself as a tube (a pseudopod reaches out like a "false foot" but acts like a straw), passing packets of information to new cells via a sticky process called adhesion, or **connection. (**Connection *is* communication of relevant information.)
- or, as a brain cell, transduction means the kind of adhesion we call synapsing, which creates the signaling pathways, or hard- wiring for the brain's **communication** system.

These three rules of cellular biology --- move, connect, and communicate --- mean that language isn't so much an instinct as a strategy. Logically, the basic rules of organic life which constitute "instinct" are the basic operations (move, connect, communicate), while *how* an organism moves, connects, and communicates, is strategy. Language is a pseudopodial outreach strategy, a search engine, which uses gestures, facial expressions, body language, sounds, signs, and marks to communicate .

An argument for language as a search strategy makes grammar a strategy, too, for combinatorial systems around sounds and marks. If language is a strategy for moving, connecting and communicating, then the mammalian emotions (panic, fear, rage, seek and play), which antedate language systems by millennia, are motivational strategies, too, for moving, connecting, and communicating with the environment. If the environment is not good for you, you need to avoid it or destroy it. If the environment is good for you, you need to approach it, and take advantage of it.

Most linguistic theory is hard to penetrate. But, try listening to a child babble and talk or watch a child scribble and draw --- and you'll experience the acquisition of human language, first-hand. You'll notice that it's gradual, but inexorable, like the crawling child who will clamber over anything in its way. There are two kinds of babbling (11). At first babbling is a timing mechanism. It gets the brain ready for the cadences, rhythms, *speeds* of speech. Speech itself begins when babbling becomes practice with sounds, commencing to one-word, then to two-word sentences, and then to three. Then, from the declarative ("doggy bark"), a child's speech moves to metaphor (like those invented by a three year-old I know: "rainbow noodles" for macaroni, and "zebra trees" for birch trees).

On the other hand, on a parallel course, there must be two kinds of scribbling, the scribbling that acts as a timing mechanism, getting the brain's speeds right for literacy, and scribbling as practice with the units of literacy: straight lines and dots, curved lines, and spirals, circles and other geometric shapes, then to schematic drawing, on to representational drawing. Speech and literacy are timing issues. As process, they are cumulative and combinatorial. As one thing - a sound, a sign - may stand for another, language is entirely metaphorical, all analogical (60).

Brain tissue for communicative outreach is multi-modal and pluripotential (36), and so are its strategies: marks can become anything: pictures, words, mathematics, music (15).

Conclusion:

In non-spectacular, everyday ways, mothers and children drove the co-evolution of marks and the human mind in connection with speech and literacy. Women's lunar procreative cycles, and children's developmental needs placed adaptive pressure on mothers' brains to anticipate and record biological events. The importance of recording the cycles of the plants and animals on which mothers and children depended, as well as remembering their locations and the way to get back from them in time to care for their dependent infants, placed additional pressure on the maternal brain. Research with rats shows that pregnancy has dramatic and long-lasting brain effects, These include improved spatial memory, and a reduced stress/fear response (55, 56). A bolder, braver, more exploratory mother who had to forage afar to feed her children would have been selected for neurochemically. An improved spatial memory plus a kind of ingenious courage in brains changed for increased plasticity by pregnancy, the built-in flexibility of the mind of the very young child, coupled with pressures for notational time-factoring systems and solitary self-amusement might have been the right mix for creating a new kind of mother and child: mother the notational time-and-space-binder; child, the world-drawer; *Mark-Makers of Significance*.

The long history of the role of the mother/child dyad as that dyad contributed to the development of symbolic thought, including speech and literacy, is recapitulated every time a mother engages a child in conversation about its marks or Scotch-tapes its scribbles to the fridge.

Still, that role in the evolution of human symbolic consciousness has gone largely unnoticed. Until fMRI's or some other non-invasive, *in vivo* brain scan technology (like infrared spectroscopy used by Laura-Ann Petitto at Dartmouth to study babbling infants) make it possible to image the developmental/neurological links between gesture, speech, marks and the human maternal and child mind, including research with literate and illiterate children's brain scans longitudinally to evaluate long-term differences in adult brains (8) the evolutionary pressure of marks on especially flexible maternal and child brain tissue that occurred 1.9 million years ago remains theoretical, including language's links to cellular biology's earliest cilial and pseudopodial outreach systems (61, 62).

Until we have fMRI's of mark-making versus non-mark-making toddlers and young children as they acquire speech, we can only hypothesize about the neurological differences, while noting the observable differences which, until they are codified in a data base, remain anecdotal.

Still, observations of children, and clues from research in art history, anthropology, biology, cellular biology, developmental child psychology, and gender-related neurobiology strongly suggest that speech, gestures, literacy co-evolved in the context of mother/child interactions (16).

New insights on hominid brain evolution in connection with language, emotion, and literacy, will, in time, underscore the importance of notational systems to human consciousness and well-being. A model of human language requires a theory of intelligible marks, including scribbling as significant neuro-bio-evolutionary behavior, practiced in the context of maternal/caregiving.

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Research Questions:

1) Were marks of meaning found preserved near hominid footprints in lava dust? Especially beyond sight-lines for lakes, springs or groves where the mights would have been directional indicators and/or locators (maps) for water or more abundant food sources?

2) Did the sling-nursing position (which would have been horizontal in immature hominid neonates as opposed to vertical baby chimps' posture)in immature hominid infants create a swallowing challenge, helping to modify the organization of the throat, larynx, hyoid bone for speech? How do primate and human vocal apparati differ in childhood *and* in adulthood? (For instance, the hyoid bone descends in chimps as they mature, as it does in humans, 21).

3) Did hoot-pant primate laughter (16)---in hominins--- increased through mother/child exchanges in response to the extended childhood of dependent, vulnerable offspring, modify the lungs and breathing appartus to accommodate the explosive sounds necessary to consonants in human speech? How do the lungs and other breathing apparati of primates and humans differ today?

4) What discontinunities do fMRI's identify in brain waves/oscillations/locations in primate and human brains when we focus on the first two to three years of life when very young primates (including humans) start to vocalize, gesture, scribble?

fMRI's of mother/child vocalizations among primates, and verbal exchanges between human mothers and children around scribbles and drawings should provide information on differences in the locations of neural substrates dedicated to language-use in primates and humans, as well as their metabolic profiles, electical frequencies, wave sines.

5) In young children who scribble and talk at the same time,

what happens to the neural substrates examined in the Illiteracy /literacy studies (7,8)? Do scribbling and drawing organize the child's brain for attention, memory, and articulation, and are the first four tenets of The Scribble Hypothesis valid, as well?

6) Controling for contrast, luminosity and spatial arrangement, design experiments *with infants*, rather than with adults, using human faces, ape faces, and objects, and extend these experiments by presenting *abstract* versus representational art to infants: how does their N170 response differ when they look at Mondrian's "Boogie Woogie" versus his earlier painting of a willow tree? Do infants look longer at Picasso's "Demoiselles D'Avignon" than a "more realistic" blue period painting of acrobats? How about a Cezanne still-life versus a Dutch still-life? Like mature abstract artists (48) and toddlers (15), do newborns show a preference for abstract geometric shapes? What might this mean for embedded geometric systems? And, if all notational systems derive from a child's earliest marks, for literacy?

7) If infants are shown geometric shapes in two-dimensional arrays, say the triangle and the square as objects with 3 and with 4 sides, do infants associate 3 sounds or 4 sounds with such shapes, extending the research with the counting of objects in conjunction with hearing a similar number of sounds? (49). If so, such research might suggest that not only is numeracy but number-of-sides-sense, or appreciation for the two-dimensional arrays we call geometry, exists as an additional category in an embedded mathematical system in the human brain. The fact that toddlers scribble 3- and 4-sided shapes spontaneously (3), using the same basic line invented by Ice Age notational carvers to describe the lunar-based passage of time on bone and stone (6), might help to extend the notion of embedded systems in children's brains to include marks of meaning as embedded systems in humankind.

8) What happens to speech and language in a baby's whose limbs, especially the hands, are restrained from birth?
(A thalidomide-type baby who is born without hands and feet would provide data.) Is the acquisition of speech impaired? Delayed?

9) If a child is prevented from doing any kind of mark-making throughout early childhood, is there any effect on its brain patterns for speech or on its capacity for emotion? Would such a child exhibit some of the symptoms of autism? Attention deficits? Learning disabilities? Acting out? Oppositional behavior? Inability to make human contact?

10) Laura-Ann Petitto's research with babbling infants (Holowka, Siobhan & Petitto, Laura- Ann 2002 Left Hemisphere Cerebral Specialization for Babies While Babbling, *Science*, Vol 297, 30 August, 2002 pp. 1515) distinguishes between two kinds of babbling, which can be identified by infant mouth position or infrared spectroscopy.

When infants babble in a non-speech-directed manner, there is bilateral hemispheric activity, indicating that this kind of babbling is motoric - that is, an oro-facial organizer. On the other hand, when infants are practicing the sounds of language, or doing speech-directed babbling, the right sides of their mouths are more open, indicating left hemisphere activity, that is, linguistic activity.

Logically, scribbling should mirror these two distinctions. That is, there should be motoric scribbling, and notation-directed, left hemisphere scribbling.

Because scribbling turns into both drawing and numbers and the letters of the alphabet in youngsters, scribbling may not be as easy to compartmentalize.

Early scribbling activity (which would correspond with Stage 1 scribbling as described in the book *The Scribble Hypothesis: How Marks Change Minds. Toward an evolutionary theory of literacy and a science of parenting*, in process)may indeed be motoric, and bilateral. Scribbling destined to turn into drawing might correspond with mouths more open on the left, indicating right hemisphere activity, while notation-directed scribbling, or "pretend-writing" might correspond to a more open mouth on the right, indicating left hemisphere excitation.

If however, scribbles initially represent the shapes of thought (as theorized in the paper "The Neurological Significance of Young Children's Drawings" 2001) way before they are proto-drawings or proto-writing or proto numbers, then we actually do not know what to expect from mouth positions or from infrared spectroscopy. Just because the area on the sensory-motor cortex dedicated to hands is engaged in speech does not necessarily mean that the area on the sensory-motor cortex dedicated to the mouth is involved in mark-making, although anyone watching a child draw or do other challenging manual activity knows that changing mouth positions seem to help the hands. Adults who sew know that the mouth helps the hands to thread a needle.

The truth is that we have no idea what happens in the child's brain or with its mouth when it scribbles because the research does not exist. The field is open.

11) Can scribbling and drawing be used diagnostically with language delayed children, and remedially with children identified as Specific Language Impaired?

Susan Goldin-Meadow's research with deaf children provides powerful openings for the importance of marks to the development of spoken language. As you read the following passage, substitute the word "marks" for "gestures." Goldin-Meadow writes, " Gesture can be an excellent predictor of later langauge development in children who are delayed language-learners. Late talkers who performed poorly on gesture tasks, and who made little use of gesture for thepurposes of communiction, continued to exhibit delays in langauge development one year later" (The Resilience of Language, 2003, p. 229). Does the same hold true for scribbling and drawing as predictors? Only research with mark-making will tell us.

Goldin-Meadow adds, "Children diagnosed as Specific Language Impaired (i.e. children who fail to acquire age appropriate langauge skills yet have no other identifiable problems) are able to express in gesture ideas that they are unable to express in speech. Gesture is a medium within which children can display their linguistic knowledge. It is therefore an ideal lace to look for skills that children have but may have difficulty expressing in the veral modality. I am suggesting that, in certain cases, we can use gesture to discover linguistic capabilities that, for whatever reason, a child is unable to display in speech" (ibid). Again, only research with scribbling and drawing will tell us whether mark-making helps children develop expressive skills intrinsic to language in other modalities, in this case, the visual modality.

12) Since primates will scribble, can they be trained to draw, and if so, might they then be able to "bootstrap" signed language onto drawings in such a way that they acquire a large enough vocabulary for original statements, plus an organizational grammar, along with a demonstrable understanding of the signs they use, as expressed by the drawings they make to accompany them?

It is my opinion that other primates do not scribble spontaneously as part of their normal develomental unfolding, and that they can not draw, nor learn to draw, and that therein lies the critical deficit in connection with the acquisition of human language. Since apes and chimpanzees do not need human language to flourish, this should not matter *to them*.

Coda

Toward a quantum theory of Scribbling.

Based on tenets #5 and #5 of the Scribble Hypothesis, it is possible to propose the adaptive advantages of SIT's (consciousness states described as Self-Induced Transparency) for the literate human brain as follows:

- *sustained visual attention* (analagous to the self-focusing optical phenomena that occurs when photons propate inside microtubules)achieved by marks of meaning has quantum effects within the noisy, thermal and chaotic intercellular milieu of the thinking brain.
- marks of meaning act as coolants (Bose-Einstein condensates) or like energy pumps (Frohlich model), exciting biomolecules coherently, reducing to a common frequency code... This common frequency mode regulates a brain synchronicity *as focus*, increasing non-linear soliton waves (to maximum tolerance --- like the crest of a foaming wave), initiating self-collapse on non-quantum levels in response to mental break-throughs (the solved drawing, the resolved symphonic line, the elegant mathematical proof). This self-collapse, or resolution is experienced emotionally as heightened consciousness, achieved via self-clarifying shifts in visual phenomenal experience. The quantum phrase "self-induced transparency" (or SIT) aptly describes such self-induced, marks-based "aha!" experiences.
- the possible quantuam mechanics of an SIT are as follows: marks of meaning cause neural microtubular dephosphorylation releasing sodium, calcium and magnesium ions whose radii are smaller than H2O, and so do not disturb the dynamical geometry of sheltered quantum neural states. This means that children who can not work comfortably with marks of meaning (dyslexic children, attention deficit children, autistic children) or who have problems with speech (including stuttering), suffer "decohere Type 2 phenomena" through chloride fluxes in axons which means that ions with too big radii disrupt the dynamically structured layers of water in bio-cytoplasm in the human brain's neural systems at levels which affect conscious emotion, producing sad and discouraged feelings. The brain is then at risk for a cascade of negative emotions, including desperation and depression, as it senses that it is failing to operate effectively. The blockage of calcium,

sodium and magnesium by choloride must feel lousy to the brain, much like an engine might feel (if it could feel) when oil, gas, oxygen, and spark are cut off. Combustion engines are not equipped with feelings. Humans are.

- Microtubule associated protein (MAP-2) "is essential for strengthening synaptic pathways. .. MAP-2 consumes a large proportion of brain biochemical energy, and acts to reconfigure the sub-synaptic cytoskeleton...by connecting with smaller cytoskeletal proteins directly involved in neurotramsmitter release...This release has a probabilistic component....and may reflect some unrecognized quantum influence" (Penrose and Hameroff, 1999). It is arguable that drawing and writing and mathematical notation and musical notation have the possibility of exerting a quantum influence on neurotransmitter release through major phosporylation.

Every mark of meaning is a poised, anticipatory event, leading the hand and the eye onward. As skill levels grow, the coordination of hand and eye achieve automaticity, conserving energy, while allowing the brain to think as long as its biochemical energy supply allows. Marks of meaning make more energy available to the thinking brain (Sheridan 1990) by affecting the "seemingly random" probabilistic component in neural activity, increasing the number of axonal depolarizations which result in vesicle release of neurotransmitters (Penrose and Hameroff, page 10), thereby, in turn, increasing or sustaining the non-linear soliton waves (Chou et al, 1994; Sataric et al, 1992) that signal brain sychronicity, or oscillations with zero time lags. Conservation of energy on quantum levels and marks-based break-throughs on consciousness levels are symbiotic interations. It is mutually advantageous for the brain to operate at peak efficiency at quantum levels *and* to feel enlightened on mental/emotional levels. Enlightenment can be achieved by meditation or through extreme physical exercise, including challenging "flow" experiences (Csikszentmihalyi, 1993), as well as by mark-making: painting, drawing, writing, calculating, and composing.

Feelings of wholeness or at-oneness is consciousness's way of experiencing a global PNS/CNS (peripheral and central nervous system) synchronous event, describable as global collapsed wave function, which is what happens when millions of simultaneously occurring or cascading mini-cytoskeletal superposition states coincide. When this occurs, super-radiance at the level of the neural cytoskeleton is experienced as self-induced transparency at the level of the brain, or a state of hyper- or super -consciousness (response to page 14, P and H, 1999).

The mind that is in a state of heightened consciousness feels exceedingly bright and clear to itself. That self is illuminated, refined, clarified by its own agency, clarified the way butter is clarified by heat in a pan on a stove. Cooks know all about clarification. Evidently, microtubules do, too.

The Advantage to the Brain of Minimal Energy States

The interesting point about quantum states from microtubules to consciousness is that they protect the brain from its own disruptive thermal energy. As here proposed, "quantum consciousness" is a super-coolant, allowing the brain to settle into states of minimal energy, lattices intact, coherent superposition in hyrodphobic pockets stabilized. It is in the ability to be wholly focussed as mind/body that the child and the artist/writer/mathematician/composer align in unified consciousness states. In fact, mark-making allows the adult mind, surrounded by distractions. to achieve the single-minded focus of the child so evident in play, including the play of scribbling and drawing when entity and environment exist in a harmonious, synchronous relationship.

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