Scribbles: The Missing Link in a Bio-Evolutionary Theory of Human Language with Implications for Human Consciousness

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Abstract: Bipedal locomotion in australopithecines exerted a cascade effect on primate body and brain evolution. Endocasts of primate skulls reveal some of the brain changes necessary for speech, while we can only infer the prehistorical sources of literacy from pre-Ice-Age notational bone-carvings.

If a pre-Ice Age precedence for men's notational systems can be inferred from the archeological record, the same can be inferred for women and children; the ethno-neuro-biological scene for notation-based brain changes was set by the entire species identified as early *Homo*. Just because thousands and maybe millions of years of children's scribbles and mothers' notations are unavailable for scrutiny because they appeared on impermanent surfaces - dust, unbaked clay, mud, skin, leaves - does not mean that children's and mothers' mark-making did not occur.

As part of the natural unfolding of normal developmental mental/motor behavior, children scribble and draw; meaningful marks are intrinsic to human neurobiology. Sensory motor maps support a neurological link between manual dexterity and speech. It is this paper's position that it was manual dexterity applied to mark-making (notational, pictorial, symbolic and decorative) that contributed to the elaboration of speech via literacy in a synergistic gestural/vocal/notational enterprise.

Hominid brains diverged from other primate brains around marks of meaning. Human behavior, human brain morphology, and, presumably, human brain waves became discontinuous around marks of meaning.

One tenet of human neurobiology is that brains capable of language are energy-hogs, requiring substantial cooling systems. It is this paper's position that endocasts revealing increased vascular networks are only part of the big brain/hot brain bio-evolutionary story; marks of meaning, including the multiple literacies we identify as art, literature, mathematics and music, played important neuro-evolutionary roles in

connection with cooling across quantum/cognitive levels. In fact, a quantum theory of scribbling can be proposed based on the system-wide benefits of special "SIT"consciousness states of self-induced transparency induced by marks of meaning.

Paradigms shift. 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; the position that men are "cool under fire" while women panic has been overturned by research proving that motherhood produces a braver, more resilient brain: 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.

A shift in attention to the quotidien effect of mothers' care-giving, children's play, and shared speech around marks of meaning provides new insights on hominid brain evolution in connection with language, emotion, and literacy, underscoring 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, as well as the importance of maternal support for children's scribbles and drawings, including speech around scribbles and drawings.

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FIGURE ONE: Chinese Scribbles, BMA, 2 years old.

Introduction

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. Brain tissue devoted to hands and mouths is proximal on the sensory-motor cortex, and disproportionately large. The work of the hands and the mouth are connected, and important. This paper proposes that ---as an extension of the human gestural system ---meaningful marks, or literacy was responsible for appreciable adaptive pressures on early hominid vocalizations, including proto-speech.

Illiterate brains mis-pronounce nonsense sounds. Literate brains do not. The written alphabet (work of the hands) affects spoken language (work of the mouth) in terms of the range of sounds it can pronounce and recognize (7, 8). Rather than holding to the position that human speech drove literacy as a transcription of sound, it makes sense, given the robust behavior we call scribbling, as well as brain research with manual, oral and visual communicative capabilities, to explore the influence of literacy on speech.

No single line of inquiry provides a full explanation for how and why human speech evolved. Even a synthesis of existing theories (anthropological, archeological, art historical, biological, neurological, linguistic, developmental) leaves unanswered questions.

As soon as we make the switch to the importance of marks of meaning to spoken language, focusing on the contribution of mothers and children to the evolution of human language, a new evolutionary/developmental theory of marks and the human mind becomes possible, including the following propositions:

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/independent babies.[1]

2) babbling, motherese, and scribbling functioned in the hominid brain as neural organizers and timing devices for oscillation rates and wave functions necessary 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) correspondence. [2]

4) 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.

5) The human brain invented two cooling systems to achieve this self-regulation:
- a better vascular system, making larger language areas possible
- a marks-based symbolic system to resolve conflicts on emotional levels, while acting as coolants or energy pumps on biomolecular levels.

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 system which subscribes to the basic rules of all biological life: move, connect, and communicate, and which depends, in large part, on the strategy/liability of language to follow these rules.

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[1]Babbling, scribbling, and motherese are recognized as robust, nearly universal behaviors. Motherese is used by roughly half of the human population currently. This paper proposes that when human language was evolving, motherese was used by all the mothers in that particular CA (common ancestor) primate group. This paper identifies all three behaviors as linked behaviors.

[2] As will be seen, research with blind and deaf children, as well as with children and adults with intact aural and visual systems support the importance of the work of the hands to the work of the mouth.

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

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

Research with children's scribbling and drawing (1,2), FIGURE TWO including mappability onto deeply significant designs in art history (3), FIGURE THREE 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), FIGURE FOUR as well as a re-interpretation of pre-Ice-Age marks incised in bone (6), FIGURE FIVE 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.FIGURE SIX.

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 neuro-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?

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). FIGURE SEVEN. Disproportionately large areas are devoted specifically to the thumb and tongue on the human sensory-motor cortex. If propinquity on the motor cortex means mutual influence, and if relative amounts of brain tissue are significant, then the ways human use the tongues in their mouths relates to how they use their thumbs on their hands. FIGURE EIGHT. Logically, flexibility/dexterity is the issue. Hand and mouth areas on brain cortices are close, too, in other primates (10). Some special confluence of behavior and environmental pressures must have connected the hands and the mouth in the service of human language.

A 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. It is this paper's position that not only gestures and speech (12), but scribbling and drawing are neurologically linked in the human brain as multi-modal extensions of the hand-mouth system. It is also this paper's position that spoken and written language serve the dopaminergic emotional mammalian survival system (13), and 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 act like thermostats, heating/speeding up brain frequencies for easy word-retrieval in speech, as well as for word-retrieval and recognition in 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 brain scans of mothers and young children interacting around scribbling, drawing and speech provide support for the theory of marks and mind presented in this paper, we can consider the following information, culled from a range of disciplines.

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 hominid visual cortex for language, powerfully affecting the scope of human consciousness. 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 neural shapes or patterns of human thought.

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

Anthropological missing links: brain-casts.

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. FIGURE NINE.

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 Conditions that may have been necessary for Speech

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

Bipedalism, improved brain-cooling systems, smaller pelvises, premature births, and 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). It will be argued below that the function of motherese was to tune-up infant brain waves for language, as well as to set a strongly position emotional tone for communicative exchanges. This paper hypothesizes that all of the mothers in the first CA group (common to humans and to the great apes) used motherese, even though, now, only about half of the population does, as noted earlier in footnote #1.

To the effect of motherese on hominid language capabilities, we can add the following influences that may have advanced spoken and written language: the 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); changes in breathing and swallowing brought about by extended infant separation-crying, as well as by 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); the solitary marks-based play of the hominid toddler set down in the dust.

Many behaviors must have contributed to the pre-adaptive conditions for human speech. It wasn't the descent of the hyoid bone, as was once thought, that caused human speech. The hyoid bone descends in the organization of the throats in modern day chimps as they mature (21). FIGURE TEN. This paper supports the position that the complex interactions between mothers and children around sounds and signs, including the actual physical act of scribbling and drawing, helped engender speech, and that proto-literacy (scribbling, notational marks, drawing) provide the key to the sophisticated oro/facial controls necessary for speech as well as for the neural networks necessary to transform vocalizations (22) into speech beyond simple noun-verb sentences. Brain research should eventually provide support for this eyes/ears/hand/mouth continuist position.

What is Babbling? Scribbling? Motherese? Which side of the brain? Timing issues?

Consecutive frames from video recordings of babies from 5 to 12 months old when they first enter the syllabic babbling stage were used to examine three types of oral activity: babbles, non-babbles, and smiling. FIGURE ELEVEN. Babbles were defined as a reduced set of sounds found in spoken language, repeated in consonant-vowell alternations, apparently without meaning. Nonsense sounds, or "non-babbles," contained none of these. When smiling and doing what could be termed Stage One Non-Lingustic Babbling, the left side of the baby's mouth opens, indicating right hemispheric processing. On the other thand, the right side of a baby's mouth opens when it is babbling pre-linguistically. Since the left side of the brain controls the right side of the body, speech-related babbling must be lateralized on the left side the the brain, the language side. If babbling were simply a motor program for the mouth, like chewing, both sides of the brain would be involved, and both sides of the infant's mouth would be equally open. Pre-linguistic babbling is not just a motor program for the mouth. It shows babies' sensitivity to language patterns, and readiness to produce such patterns (Holowka & Petitto, 2002).

If the neurological function of nonsense babbling is motoric as opposed to linguistic, what can we say about Stage One Scribbling (those very first marks an infant makes on paper)? What can we say about Early Motherese (those first cooing sounds mothers make with their newborns) ? It is this paper's position that "nonsense" babbling, Stage One Scribbling, and Early Motherese not only establish and support basic motor programs for speech, but act as timing mechanisms. Since the infant body/brain does not do anything it has not been programmed to do, nonsense babbling must be part of the maturational preparation for something. Logically, it is analagous to baby birds' tuneless early twitterings that act as preparations for the motor programs *and* the timing of song. Since Stage One Scribbling, and Early Motherese (in at least half of the modern maternal population) are also robust behaviors, they're important to the maturation of the child's brain in terms of motor programs and timing mechanisms. This paper proposes that all three behaviors are designed to organize the infant brain for speech and for literacy, in brains where speech and literacy are connected enterprises in an optimally functioning human linguistic system.

There's controversy over the neural basis for babbling, and thus for the origins of human language (Holowka & Petitto, 2002). If heart beat arises in heart tissue, language beat must arise in "language" tissue. Where might that tissue be located?

Implications of the frequencies of gesturing, babbling, and motherese.

Dartmouth neuroscientist Laura-Ann Petitto has observed that babies love to shake their right hand when they babble (Mary Duenwald, "The Power of Babble," *Discover*, 2003, p. 32). The right hand is controlled by the left side of the brain. Sensory-motor brain tissue dedicated to the right hand is part of the motor input for babbling, providing additional support for the role human hands played, and still play in connection with speech as communicative gestures.

Petitto has studied the hand movements of babies learning to speak and to sign. Both groups make hand gestures at about 3 hertz in frequency. Babies exposed to sign language make a second kind of hand gesture at about 1 hertz. Speech-directed babbling occurs at 1 hertz, too. The fact that babies are attracted to such frequencies and create them as they babble and gesture in what we could call the linguistic mode supports the idea that tissue in the left hemisphere is not only sensitive to, but produces these frequencies as a pattern, or cue. Petitto has her sights set "on the planum temporale, a piece of the superior temporal gyrus, a chunk of the brain about the size and shape of an index finger that curves over the top of the ear" (p. 32)" as the place where the rhythms of language arise in connection with gesture, signing, and speech. "Hearing and deaf adults use the planum temporale to process syllables, whether signing or speaking aloud" (p. 32). FIGURE TEN.

Because it allows her to measure brain activity in babies who are awake and learning to talk, Petitto uses infrared spectroscopy to find out where the brain is using the most oxygen. When the infant Rebecca (not yet five months old) watches "a hand held palm up flat like a traffic cop, then rhythmically rotated it - palm, back of the hand, palm, back of the hand- every second and a half," her planum temporale is activated. The same held true for 10 other babies (p. 32).

Babies under five months find the sight of a hand moving at 1 hertz "delicious," and "powerfully attractive" (p. 32). It is not the sight of the hand that is attractive. It is the speed at which the hand is rotating back and forth that attracts the child. The back and forth frequency is the attractor. If the 1 hertz frequency is a "Strange Attractor" in the mathematical sense for the child's brain, then a frequency of 1 hertz must organize chaotic neural patterns in the infant brain for some reason; it looks like the reason is language.FIGURE TWELVE.

Do Early Motherese and Stage One Scribbling share a common frequency? Is that frequency initially 1 hertz? Do motherese and scribbling register in the planum temporale? If they do, then we'd have more reasons to connect babbling, motherese and scribbling as neural organizers for language, as we'd have more evidence that the planum temporale is the bit of neural tissue where the "heart beat" of both speech and literacy arise.

A baby's heart beats at about 120 times per minute, or 2.00 Hz. A man's heart beats about 72 times per minute, or 1.20 Hz. The normal heart rate at rest is usually between 60 and 100 beats per minute, or 1.00 to 1.67 Hz. Babies suck while nursing at between 40-60 times per minute, at 1 Hz or under. Motherese has an average pitch of 238.5

Hz. Motherese occurs at about 4.2 syllables per second (Fernald & Simon, 1984) or 15 Hz. Babbling, the adult resting heart beat, nursing rhythms all occur at about 1 Hz. Motherese, on the other hand, occurs at 15 times that speed. No figures for the hertz of toddlers' scribbles exist. It is plausible that the hertz of Stage Two and Stage Three Scribbling (when toddlers start drawing curves, spirals, mazes, meanders, mandalas, Euclidean and non-Euclidean shapes) matches that of motherese or exceeds it.

The logic is that the speech activity of the mother helps tune the brain of the child for the frequencies of normal speech, or about 20 Hz, and that scribbling and drawing perform the same functions in connection with literate speech, or how humans are able to speak who are able to read and write.

This paper proposes that the "beat" of language established by the planum temporale is evident not only in Stage One Babbling, but in Stage One Scribbling, and that Later Motherese and Stage Two and Stage Three Scribbling and Early Drawing push that hertz rate from 1 to 15-20 at least for the sake of organizing a language-using brain (both verbal and literate).

The mother of the newborn pours out maternal love using sound in a special way. Her speech frequencies are tuned to the child's brain frequencies by the neurochemistry of pregnancy (Kinsley et al, 1990: Wartella et al, 2004; Keyser-Marcus et al, 2001).

Logically, that's the function of Stage One of scribbling, too; it's not writing-directed, just as "nonsense" babbling is not speech-directed. But scribbling's neurological function is the coordination of the actions of hands and eyes for literacy, as the neurological function of motherese is to coordinate the infant's eyes and ears for speech. A synchrony between eyes, ears, hands and mouth is evidently necessary for human language. The interesting part is that the child, at a very young age, takes over its own brain organization for language not only by babbling, but by scribbling.

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). FIGURE THIRTEEN. 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 200-500 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 for 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 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 for making their needs known to caregivers who were not actively holding them (16). Hominid mother/child communication was already multi-modal (16, 36).

It is this paper's position that maternal notations and toddlers' scribbling followed a parallel course, achieving multi-modal marks-based (as contrasted to 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 would have greatly extended the mother/child communicative repertoire, forcing spoken vocabulary and grammatical constructions to keep up with the growing visual content and spatial complication of mothers' and children's mark-making systems.

It is probable that the prosody of motherese finds echoes in the "prosody" of scribbling, increasing the influence of low-frequency organizers in 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, giving rise to 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 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 every day.

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, the period of the "parked hominid child" when 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-old hominid children 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 means 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 Precultural 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). Applying this theory of propagation to human language development, following generations of hominid mothers would have assumed the role of humankind's speech, art and literacy teachers, while the earliest generators speech, art and literacy would have been children themselves.

Mothers and Marketing Lists: The Second Period of Precultural 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 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 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 in adult speakers and readers (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), archeological research, research with babbling, compendia of children's scribbles (3) as they are invariant,and as they map onto the most signficant designs in art history, support the importance of marks to the development of the human mind. Is there support for literacy as an embedded capability?

Innate Numeracy: Support for Embedded Literacy as part of the dynamic of elaborated speech.

Support for embedded numeracy in child thought suggests the possibility of embedded literacy, supporting mark-making as an innate attribute of the human brain.

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). FIGURE FOURTEEN.

If attention to shape and naming of shapes 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). Being able to name a thing and being able to recognzie a thing are connected. If you do not know the word "dentition," how likely are you to recognize that architectural detail?

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. FIGURE FIFTEEN. 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.

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) FIGURE SIXTEEN, it is likely that the human abilities described as speech and literacy are embedded, emergent, interdependent, *and* learned phenomena.

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 --- 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.

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 to construct their outer or inner worlds. This is an observable fact. What it means for brain differences, that's the question this paper explores.

How research with the deaf and the blind provide clues to the general linguistic capabilities of multi-modal human brain tissue.

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*. 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. Children's brains, despite disabilities, are organized to communicate verbally *and* visually, using systematic parts-to-wholes strategies, tapping into a combinatorial system much deeper than language. Because deaf and blind children babble and scribble initially, it is clear that human communication is designed to be multi-modal, including sound and sight to communicate. How the human brain learns to use sound and sight depends upon influences in early childhood.

Brain tissue dedicated to communication is open to environmental influence; it has multi-modal potential (36). It can be argued that 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. Additionally, it can be argued that mirror neurons in the brain owe a debt to the communicative/affective exchanges between mothers and their offspring.

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; it was de-centered. Mothers' and the infants' points of views were no longer literally the same; as their points of view diverged, so did their thinking. 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 required by decentered, distanced mother/child interactions.

How affective neuroscience connects the SEEK and PLAY survival emotions with a theory of marks and mind: Toward a Quantum Theory of Scribbling.

By connecting a marks-based evolutionary theory of literacy outlined above with the SEEK and PLAY strategies suggested by affective neuroscience (50) FIGURE SEVENTEEN , literacy becomes part of the dynamic of the ancient emotional mammalian survival circuitry. According to affective neuroscience, strongly positive, motivational neurotransmitters encourage creatures to seek and play. This paper proposes that speech and literacy are extensions of the mammalian seek and play systems, extended to meaning. Rather than seeking exclusively for food, shelter or social and/or sexual advantages, the human brain seeks meaning, understanding, enlightenment. Rather than engaging in RAT, or rough and tumble play to learn how to get along socially, the human brain engages in RAT with ideas for the sheer fun of it.

Seeking and playing with meaning makes human brains different from other mammalian brains. SEEKing for meaning and PLAYing with ideas inside the brain became a possibility and then a priority for literate mammals. It is in connection with searching for meaning 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, and are capable of producing consciousness states describable as self-induced transparency, or epiphanic consciousness (including understanding, wisdom, peace, transcendent at-oneness), for which the brain is rewarded emotionally and neurochemically for such self-clarification (51) because such clarification allows 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 are important to the maintenance of healthy neurophysiology, including the visual, verbal, emotional, and memory/learning circuitry in the adult brain.

Linguistic thinking in humans can be described as a "space-phase sandwich," FIGURE EIGHTEEN, or an over-layering of kinds of information 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 such equilibrium, there must be motivation for such 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 solutions.

The biomolecular dynamics of a quantum theory of scribbling is proposed in this paper's coda, heavily dependent upon the Penrose and Hammeroth 1995 paper, "What Gaps?"

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 quotidien importance of mothers' care-giving (including motherese), children's play (including babbling, scribbling and drawing), 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* speech *and* 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 a vocabulary and grammar of language by drawing pictures of the vocabulary and grammar of visual ideas, and then by *talking about* these drawn ideas, or ideograms.

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 *syntactic* organizations of words from looking at spatial arrangement and content in their drawings. If the rabbit is drawn behind the rock, and the brain has yet to devise a word for "behind," then the spatial arrangement of rock and rabbit provides the visual cue for a new kind of word, a preposition. Prepositions then made more complicated grammatical constructions possible.

If we use the developmental unfolding of children's scribblings and drawings as a model for how human literacy evolved, then early hominins scribbled first, drew schematically and conceptually second, developing observational/representational drawing last. Logically, speech mirrored this trajectory, developing from babbled nonsense sounds to pre-linguistic babbling, to the barebones of noun-verb sentences to more fully 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 images to express meaning, and, most probably, never will.

Recognition of the effect of the visual on the verbal is key to a new paradigm for human language as evolution and acquisition.

Fleshing out an evolutionary theory of language as speech and literacy.

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 dextrous, 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, 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 (endochrine-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 (emotion-driven) 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 in individual brains (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 communciation (58) around infant signal 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.

Rules of the Pseudopod

"Pseudo" means false, and "pod" means foot. A pseudopod is a foot that reaches out like a hand. FIGURE NINETEEN. 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. The paper proposes that the opposed thumb and the language-using tongue are two of nature's pseudopods, or outreach systems, which developed over the millenia. Here's the scenario.

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 its 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, sending 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 made of microtubules (a pseudopod reaches out like a "false foot" but acts like a straw), FIGURE TWENTY 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.

From single cells with nucleoles, to us, the three basic rules of biology MOVE, CONNECT, COMMUNICATE hold true, only, in the case of human beings, we depend in large part on language to help us move, connect, and communicate. This means that language isn't so much an instinct as a strategy. The basic rules of organic life constitute "instinct," while *how* an organism moves, connects, and communicates, is a 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 this suggests that 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.

Linguistic theory can be 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. FIGURE TWENTY-ONE. You'll notice that it can be gradual or sudden, 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 the units of sounds, commencing to words, and then to one-word, then to two-word sentences, and then to three. From the declarative ("doggy bark"), a child's speech quickly accomModates fifteen word sentences (my grandson at age three is capable of very complicated, in fact, torturous sentences). A little child may even move to metaphor (like a three year-old I know who invented "rainbow noodles" to describe macaroni, and "zebra trees" to describe birch trees). FIGURE TWENTY-TWO.On a parallel course, this paper proposes two kinds of scribbling, the scribbling that acts as a timing mechanism, getting the brain's speeds ready for literacy, and the scribbling that provides practice with the units of literacy: straight lines and dots, curved lines, and spirals, circles and other geometric shapes which eventually become the visual metaphors in our lives.

Speech and literacy are timing issues.

As process, speech and literacy are cumulative and combinatorial.

As one item - 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, for instance, 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, including 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 the brain plasticity necessary to exploring new food-providing environments, combined with the extreme flexibility of the brain of the young child, created a dynamic mother/child duo capable of responding to pressures for notational time-factoring systems as well as for solitary self-amusement. Hominid neurology achieved the right mix for a new kind of mother and child: the notational time-and-space-binding mother; the Mom-and- world-binding child. Ecco, *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.

The influence of the mother/child unit on 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, as do 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 behavioral 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, and literacy co-evolved in the context of mother/child interactions (16). FIGURE EIGHTEEN.

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.

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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 marks 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 apparatus 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 discontinuities 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, electrical 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) Controlling 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) 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 developmental 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*.

11) How do mother to child vocalizations among bonobo apes compare with the pitch and cadence of human motherese? How do the rates of delivery of sound, or the hertz, compare? Matrilineal DNA suggests that only one mother had to speak a motherese at 20 Hertz to tune up infant primate brains for language.

12) How do sensory-motor maps on humans and apes compare in amount of tissue dedicated to hands/thumbs/feet and mouths/tongues? What inferences can be drawn from differences (if such differences exist) in these sensory-motor maps?

Coda

Toward a quantum theory of Scribbling.

Based on tenets #5 and #5 of the Scribble Hypothesis, it is possible to propose the following neuro-molecular advantages/scenario of SIT's (consciousness states described as Self-Induced Transparency) in the literate human brain:

- sustained visual attention (analogous to the self-focusing optical phenomena that occurs when photons propagate 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 brain synchronicity *as focus*, increasing non-linear soliton waves (to maximum tolerance --- like the crest of a foaming wave) FIGURE TWENTY-THREE, 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 quantum 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 H20, 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 chloride 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 neurotransmitter release...This release has a <u>probabilistic c</u>omponent....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. That this, when marks of meaning achieve a break-through in understanding, they increase some probabilistic component for neurotransmitter release necessary for maintaining healthy cells operating in synchronicity.

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). They may do so 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, may occur, in the literate human brain, interdependently. 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). This paper adds to the "flow" list the kind of epiphanies achieved by mark-making: painting, drawing, writing, mathematical calculations, and musical compositions.

Feelings of wholeness or at-oneness may be consciousness's way of experiencing a global PNS/CNS (peripheral and central nervous system) synchronous event, or global collapsed wave function, which occurs when millions of simultaneous, cascading mini-cytoskeletal superposition states coincide. This paper proposes that super-radiance at the level of the neural cytoskeleton can be experienced as self-induced transparency at the level of the brain, via states 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, the way butter is clarified by heat in a pan on a stove. Cooks know all about clarification. Evidently, microtubules and consciousness states 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" as SITs act as a super-coolant, helping the brain to settle into states of minimal energy, lattices intact, coherent superposition in hydrophobic pockets stabilized.

It is in the ability to be wholly focused 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 the organism and the environment exist in harmonious synchrony.

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