Symbolic Behavior (Palaeoart) at Two Million Years Ago: The Olduvai Gorge FLK North Pecked Cobble

The Earliest Artwork in Human Evolution

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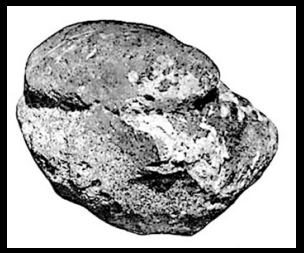
A New Paradigm

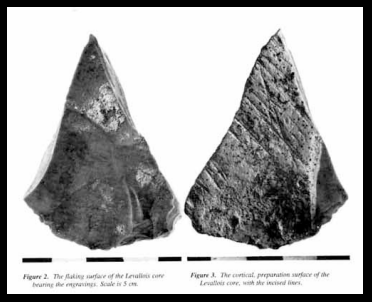
- Wave I: Dispersal of *Homo rudolfensis/habilis*, with classic Oldowan pebble-core tool tradition, out-of-Africa, ~2.0 Ma to 1.7 Ma

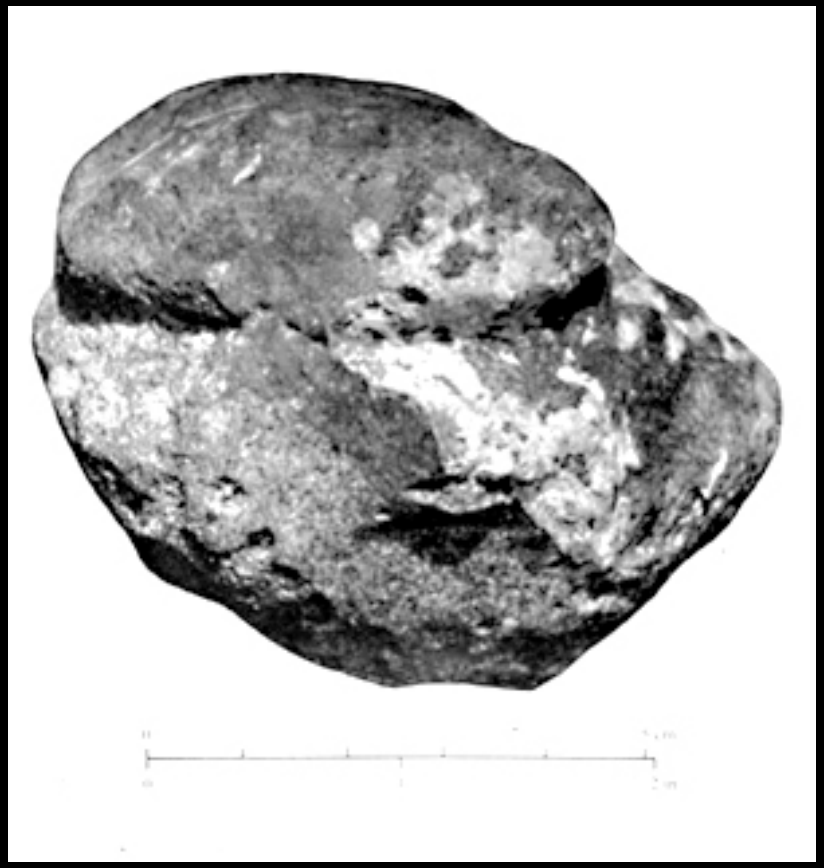
- Wave II: Dispersal of *Homo erectus*, with Middle Acheulian or Developed Oldowan-like tool tradition, out-of-Africa, ~1.0 Ma to 800 ka

- Wave III: Dispersal of *Homo sapiens sapiens* out-of-Africa or SW Asia with Mid-Middle Paleolithic technology, ~150 to 60 ka

- Wave IV: Upper Paleolithic → 60 ka Global Rock Art Heritage







Oldowan, grooved and pecked cobble

Olduvai Gorge, FLK North, Upper Bed I, 1.75 to 1.76 Ma

~8x5x5cm, artificially grooved and pecked phonolite cobble, cortex fully removed, pecked with four pits in row, 3-4mm deep + 2 pits 0.5mm deep on lower side and linear groove, varying 9 to 18 mm deep, encircling the cobble, sufficient for suspending by thong; overall shape 'unlikely a tool, resembles a primate / baboon-head' *(LM1971: 84, 269; LM1976;* 'apparent cupules on either side' *(BR2003)*. Photo Mary Leakey (1971: pl. 18)

In search of a method

In search of a 'scientific' method

to make hypotheses about the evolution of human symbolic behavior, including palaeoart, during the Lower and Middle Paleolithic

1. Look at phylogeny. Review general trends of primate evolution and cultural innovations and speculate about stages of human evolution over the last 2 million years. Few such studies cite known lower palaeolithic art, which would support or reject their speculations.

2. Look at ontogeny. Define stages of child development in one or more domains (e.g., cognition, planning, learning and imitation, vocalization and language, play, child tool use, child drawing) and suggest that early hominin capacities correlate to some stage of childhood. Setting aside the disparaging aspects of this approach, few such studies mention any palaeoart artifacts prior to UP art or MP 'symbolic behavior', e.g., Blombos. Again, artifactual evidence is rarely presented to support or reject these hypotheses.

3. **Carefully examine tools to identify typical visuospatial features and extrapolate competencies. I used this method in my paper examining an Oldowan 'found art' artifact from Koobi Fora (~ 1.8 mya) (Harrod 1992).**

Wynn, Thomas. 1989. *The evolution of spatial competence*. Chicago: University of Illinois.

and from this I initially deduced

Eight (8) Oldowan visuospatial features

4. Use neuroscience brain imaging studies of present-day *Homo sapiens sapiens* to make inferences about the cognitive abilities of prior species. To date there are only the three imaging studies (Stout, Toth, Schick and Chaminade 2008; Stout and Chaminade 2007; Stout, Toth and Schick 2000) on the making of Oldowan or Acheulian tools. There are no imaging studies on subjects making palaeoart markings; nor have the Stout studies been used to clarify anything about the evolution of human symbolic behavior.

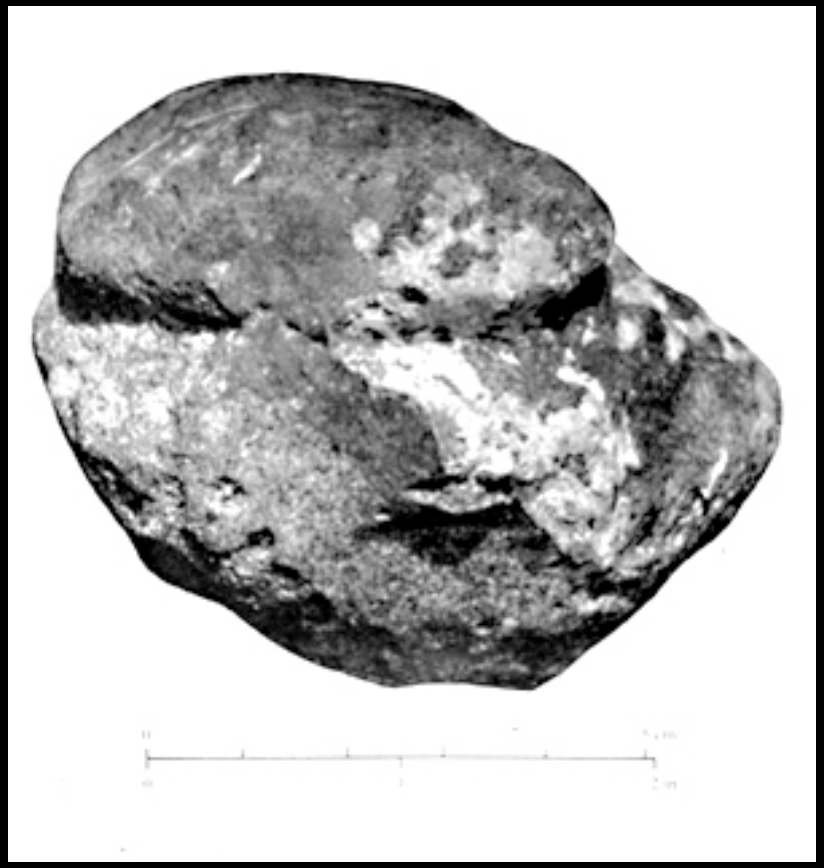
In the present study I aim to bridge art and science
and do so with respect to the Olduvai grooved and pecked cobble.
To accomplish this task I develop and apply two methods.

Method #1

I extend Wynn's method (Wynn 1989) for looking at visuospatial features in Oldowan tools to looking at Oldowan palaeoart. I expand this by identifying Oldowan 'body techniques or elementary actions on matter' (Joulian 2005; Leroi-Gourhan 1971, 1965) and showing how they imply a conceptual worldview for the palaeoartist, and extrapolating further I reconstruct Oldowan a basic phonological-lexical-semantics corresponding to both the Oldowan visuospatial features and Oldowan body techniques. Here I build on the phememe theory of Mary LeCron Foster 1996, 1994, 1992, 1990, 1983, 1978) and her reconstruction of two Oldowan phememes.

Method #2

From the opposite direction I develop and apply an art-theoretic approach to the artifact looking for the artist's application of basic design principles. First I review neuroscience brain imaging studies on Oldowan toolmaking and identify functions for the full range of nodes in these studies. Next I develop a comprehensive list of design principles and their corresponding neural substrates. I synthesize correlations between design principles posited by Macnab (2012) and the Stout toolmaking studies, adding in brain imaging studies of art-making and the only study of the making of something like 'glyph-like' markings, a study on Japanese kanji-writing. To reduce the degree of projection bias and reconstruct *Homo habilis* capacities for design, I map the neural network for Oldowan toolmaking onto paleoneurology endocast studies of the *Homo habilis* brain (Tobias 1987; Falk 1983; Holloway and Post 1982; Holloway 1981, 1978, Bruner and Holloway 2010). I then compare this to a checklist of design principles and their neural substrates.



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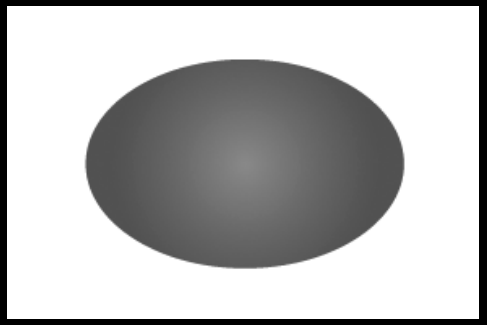
Method #1

Initial identification of design features using a Wynn visuospatial analysis approach

(after Thomas Wynn, John Gowlett, Nicholas Toth)

The Oldowan artist uses hierarchical-dependence-in-sequencing rule to make the art space of the medium (the stone ‘canvas’ and ‘frame’)

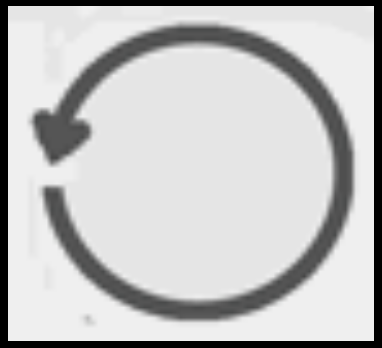


Pecking and battering make its opposite, ‘a clean slate’, the everyday phenomenal stone object is transformed into a ‘canvas’/‘frame’ on/in which a design will be incised, marked. (‘affordance’)

and

After it is marked the design is available to be further pounded, battered, erased. (‘anti-affordance’)

The Oldowan artist uses syntactic sequencing rule to incise two complementary reversal transformations



A line repeated makes a circle

A circular dot repeated makes a line

Nearbyness *contiguity, contact, overlap, proximity* *(cf. trimming)*	***Separation*** *apartness, standing apart* *usually by means of boundary*
the Pair *set of two or four* *similar knapping actions, marks*	***Alternation*** *this side/that (other) side* *(cf. bifacial flaking)*
Syntactic Sequencing and Reversal *concatenation of elements joined in ordered series* *= nearbyness + separation + repetition + constant direction* *Finite State Grammar (FSG) ABABAB and Sequence Reversal, e.g. ABCD → DCBA*	
Hierarchical Rule Use in Sequencing *actions, geometric shapes; hierarchical (embedded) dependency;* *visuospatial goal-subgoals action outcome prediction*	
Surface/Core *nutmeat from shell;* *reverse: flakes from core*	***Matrix/Pit*** *matrix with pit in it; reverse: pit with* *a 'matrix' in it (e.g., cupule)*

Oldowan Visuospatial Features

Top 3 rows: Wynn, T. (1979, 1981, 1985); Gowlett (1984), Toth (1987). Wynn (1979:17) suggests sequence reversal does not appear until Acheulian bilateral symmetry; I suggest it is intentionally applied on the Oldowan pitted and grooved cobble. 4th row: based on Oldowan toolmaking brain imaging (Stout, Toth, Schick & Chaminade 2008). Bottom row: Harrod (1992)

The Oldowan grooved and pecked cobble markings in Conceptual Space

A Hypothesis

Dialectic of Oldowan Body Techniques in Conceptual Space

topologically and conceptually complementary whole or worldview of 'elementary actions on matter', gesture-movement-forms, informing the conceptual space of symbolic behavior

Cut, slice, divide, divide into shares; shear, split, scrape off; separate linearly *(product) carved, distributed meat, fruit sustenance; bast fiber, tendon, grass, leaves, twigs* *(by-product) scraped hide, husk, hair, fur, feathers; bone* ***Tool: sharp edge flake, knife, scraper***	***Pierce, puncture, drill, dig into that which envelops to reveal, discover, 'un-bound'*** *(product) food sustenance* *(by-product) hole, indentation (cf. cupule)* ***Tool: digging stick, pointed chopper core, awl***
Pound, hammer, percuss to strike off, remove hard cortex; separate circularly *(product) core-seed-essence, ground or softened food, sustenance* *(by-product) shattered, crushed, husk, shell, cortex, bone; inner matter pulverized* ***Tool: chopper core***	***Bound, bind, join, link, concatenate, curve into curved shape to encircle, envelop*** *(product) thread, twine, knot, plaiting, curved bark* *(by-product) ?container to carry, protect, e.g., bedding, sleep nest, windbreak, ties, baby sling, net-bag, bark tray bracelet, necklace* ***Tool: fingers, hand, other body-instrument***

Oldowan stone tool use wear or residue studies indicate 'cutting grass, fibrous tubers and other plant material', Kanjera South, 2 Ma (Lemorini et al 2009); 'cutting soft plant tissue and scraping and sawing wood', plus 'cutting soft animal tissue', Koobi Fora, 1.5 Ma (Keeley and Toth 1981)

The Oldowan palaeoartist applied

all four of these body techniques
(gesture-movement-forms),

which constitute a conceptual-space-worldview,

to make the grooved and pecked cobble design.

Cut, slice, divide, separate linearly = *groove*	Pierce, puncture, dig out, 'un-bound' = *cupules*
Pound, hammer, percuss to strike off, separate circularly = remove cortex pulverize top disk	Bound, bind, join, link, curve to encircle, envelop = circumferential circle group dot-points (4 by 2)

The Oldowan grooved and pecked cobble markings in Phonological-Lexico-Semantic Space

A Hypothesis

Oldowan Phonological-Lexical-Semantic Space

***t(p)V**	cut, slice; shear, split off, separate linearly
***m(n)V**	curve, turn, bend, circle; bound, contain, issue between two surfaces, join
***t(p)V-m(n)V**	pound, hammer, hit, strike, smash, crush, break into pieces, take pieces off, chip, chew; suffer or make suffer, thin, faint, troubled; stretch, lengthen
***m(n)V-t(p)V**	make a pit, pierce, puncture, dig, drill, peck, indent (cf. cupule); bore a hole, dig up, walk, pursue, seek

Mary LeCron Foster in a series of papers (1996, 1994, 1992, 1990, 1983, 1978) developed a hypothesis for reconstructing the structure and root stems of "primordial language" (PL) based on 'phememes', which overlap sound and mouth-movement shape, and hypothesized how PL evolved through various paleolithic stages. Foster reconstructed two basic Oldowan phememes (V = vowel): *t(p)V and *m(n)V.

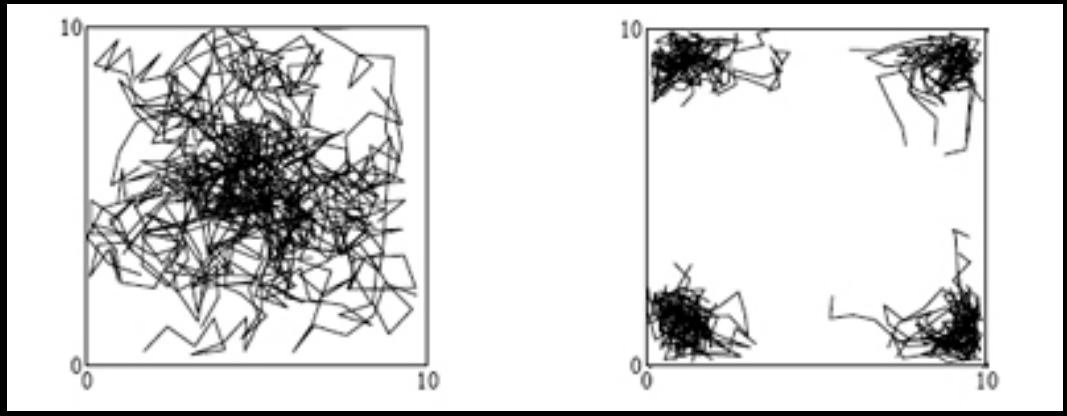
In the light of the my proposed basic fourfold elementary body-techniques (gesture-movement-forms) in conceptual space, I take Foster's hypothesis a step further by adding two permuted combinations of the two Foster phememes to reconstruct four basic lexemes of Spoken Oldowan, which map onto the Oldowan conceptual-space-worldview.

I propose that all four of these

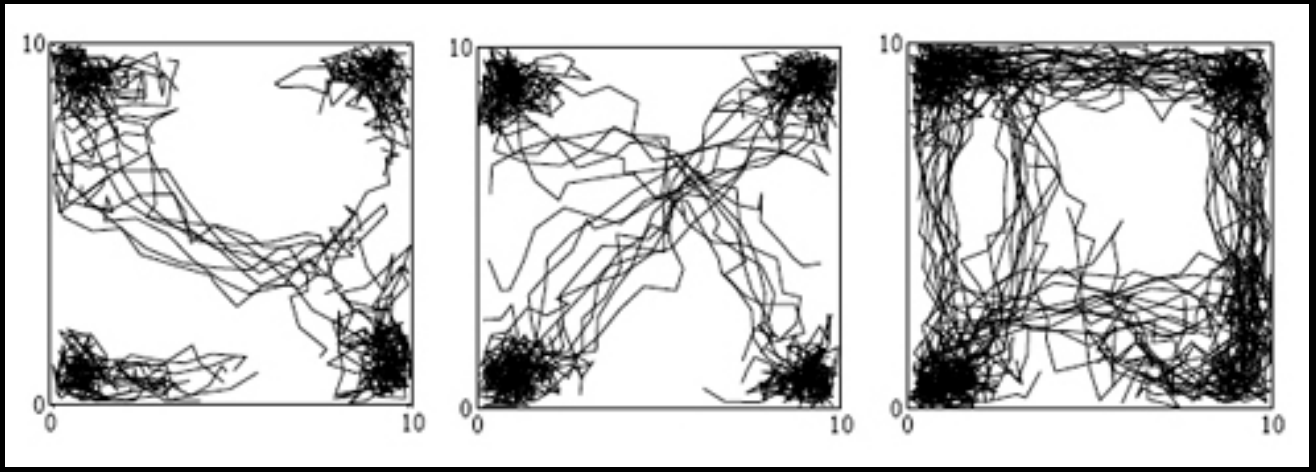
How is it that these quaternion structures, (fourfoldnesses) appear evident in the Oldowan art space, conceptual space and phonological-lexical space?

Self-Organizing Combinatorial Systems in Acoustic Phonological Space

(simulation imitation language game with 10 agents interacting to 60,000 generations)



randomly initialized state 4 trajectories, after 60,000 generations



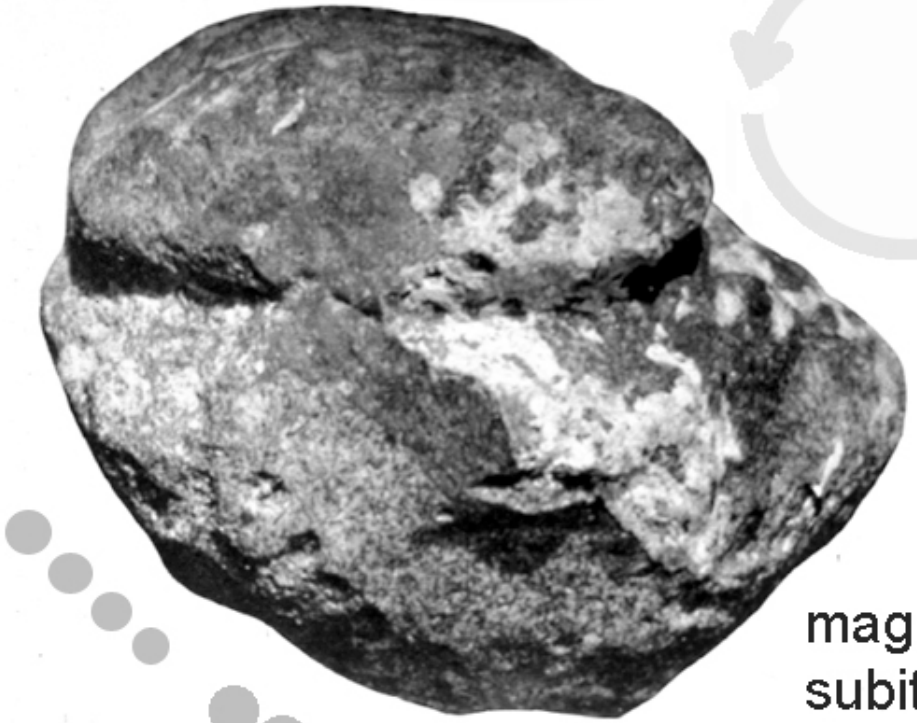
5 trajectories 6 trajectories 10 trajectories

De Boer B and Zuidema W. 2010. Multi-agent simulations of the evolution of combinatorial phonology. *Adaptive Behavior* 18(2): 141-154; figs 3, 5 and 6 (*modified, rearranged as one figure*)

Olduvai Gorge, FLK North, grooved and pecked cobble

topological sequential order reversal -- phonemic-semantics and numerosity

Grooved line turns into circle



***t-*t-*t-*m**

magnitude comparison, subitization (small number quantification recognition)

Pecked cupules turn into line

***m-*m-*m-*t**

In search of an ‘art theoretic’ method

"But, after all, the aim of art is to create space - space that is not compromised by decoration or illustration, space within which the subjects of painting can live."

Frank Stella (1986)

(quoted, dedication) Tyler, Christopher W. and Ione, Amy. 2001. "The Concept of Space in Twentieth Century Art." In B. E. Rogowitz and T. N. Pappas (Eds.), *Human Vision and Electronic Imaging: Proceedings of Photonics West, Technical Conference.* The International Society for Optical Engineering (SPIE) and the Society for Imaging Science and Technology (IS&T). San Jose, California.

Method #2

In search of an ‘art theoretic’ method

Step 1

To approach the Oldowan artifact as an example of palaeoart, I first see a need to clarify what are the constitutive ontological spaces of experience that might beat work in this Oldowan artifact.

How many ‘spaces’ are there?

Five (5) Fundamental Ontological Spaces of Experience

(each with its own constitutive principles)

1. The phenomenal space of the lived, phenomenal world

2. The multiple embedded spaces of the artwork
   a) Place (embed) art object in the lived phenomenal world-space (landscape)
   b) Make space of the medium (conveyance of form, design, information)
   c) Incise, mark (embed) a design on/in the space of the medium
   d) (techniques, methods, processes of producing structured forms
   e) Space the space of the design (pattern, motif, figure) by application of design principles
   f) Make space of visuospatial illusions of design/space
   g) Space the *agôn*, agent/patient dynamics (grammatical 'animacy')
   h) Make the space of curation (holding as special; caring, treasuring, salvaging; intimately showing, displaying as a gift, in gratitude)
   i) Formulate the audience space (space for observing, visual analysis, interpretation, understanding, appreciation, critique)

3. Mathematical space (space of numerosity)

4. Conceptual space (conceptual worldview)

5. Combinatoric phonological-lexico-semantic space

In search of an 'art theoretic' method

Step 2

Do an art-visual-analysis of the Oldowan artifact, focusing on its three art-spaces

- **The spacing of design itself by application of design principles**
- **The embed of marks (motif, figure, pattern) on/in the medium**
- **The medium**

Step 3

Reduce projecting own bias onto a prior species and clarify uniqueness of Oldowan palaeoart by deriving a cross-mapping of patterns of correlations between

- **Paleoneurology endocast studies of the *Homo habilis* brain**
- **Neuroscience brain imaging of *sapiens sapiens* making Oldowan tools**
- **Basic graphic design principles (after Macnab 2012, 2008)**
- **Add hypothetical reconstructions of habiline brain neural networks for the act of making art, numerosity, conceptual worldview, and language.**

The Oldowan grooved and pecked cobble markings in

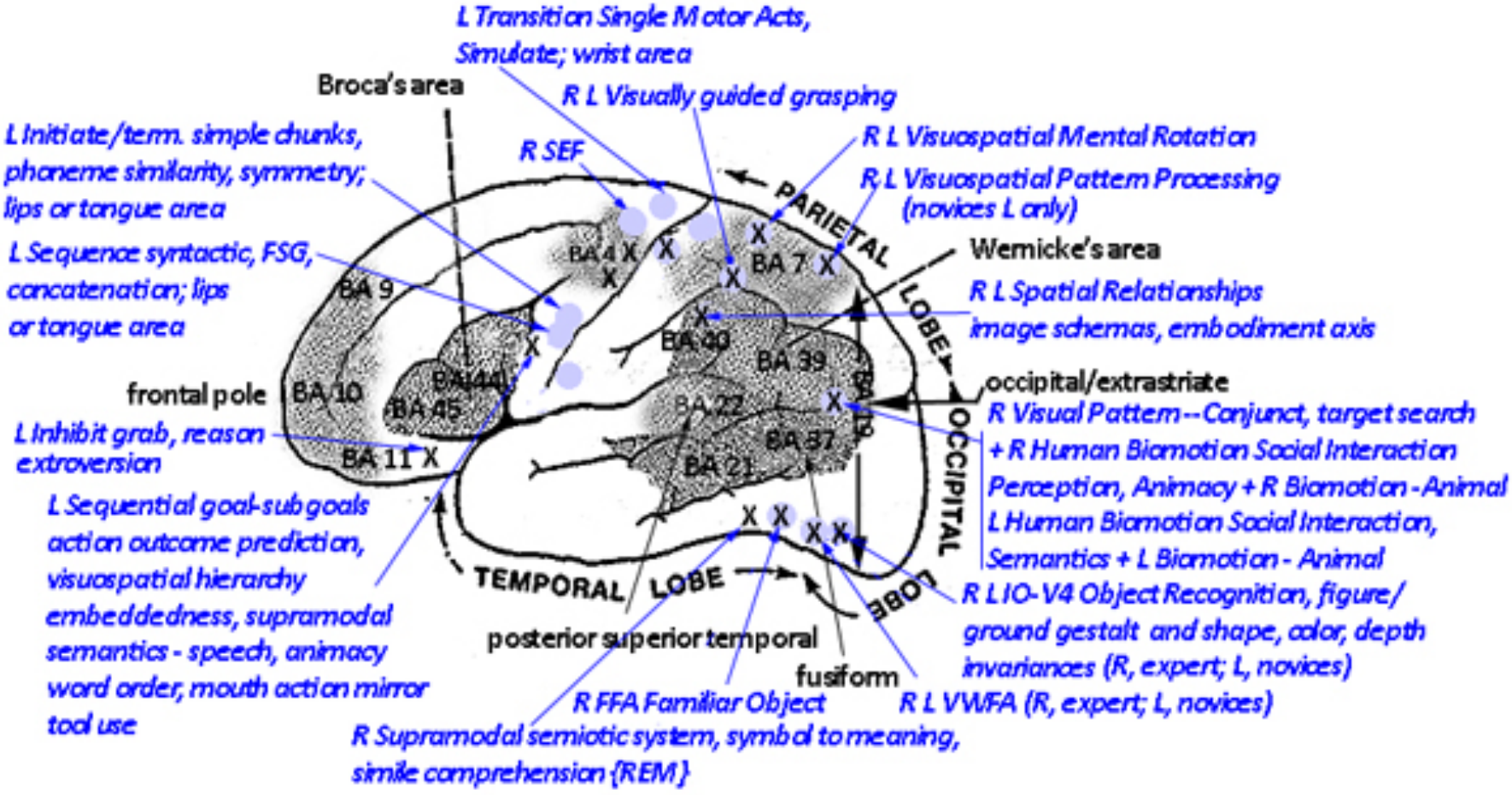
The Design Space of the Artwork

What design competencies did Homo habilis have?

Homo habilis brain expansion and reorganization areas

(*Homo sapiens sapiens* brain outline illustrated)

and areas activated by Oldowan stone tool knapping



X Expert ● Novice

(Source: Tobias 1987; Falk 1983; Holloway and Post 1982; Holloway 1981; Holloway 1978, Bruner and Holloway 2010)

(Source: Stout, Toth, Schick and Chaminade 2008; Stout and Chaminade 2007; Stout, Toth and Schick 2000)

Worksheet for Design Principles (Macnab + Harrod)

Brain Area (Tal. Coordinates) *design principle (italics)*	***Design Principles*** (M = Macnab, H = Harrod) neural substrate: T = Oldowan toolmaking (ACH = Acheulian), K = Kanji-writing, A = Art-drawing N = Oldowan numerosity (not including SS-PM nodes)		
R L IO-V4: Visual Object Area (object identity integration; shape, color, depth, light invariances; gestalt processes); R L = N	**1) Phosphenes** • **Shape, degrees of freedom** (point, line, plane, geometric 3-D) • **Sensory elements** (color, lighting, etc.) • **Gestalt structure principles** (figure/ground, closure or completion, continuance, similarity, proximity)	M	T A N
R L OT: Visual Word Form Area (VWFA); L = N	**2) Message-1 'Visual language'** (meaning linked to form, shape, pattern; 'visual language' arising from form, 'from grouping to shape to visual meaning', Pinna [2010], Pinna and Albertazzi [2011])	H	T A K N
R IT: medial FFA Familiar Object Area; R = N	**3) Familiar objects** (equipment, affordances?)	H	T K N
R MT/ITS: Supramodal semiotic system (links symbol to meaning; iconic gesture meaning, e.g., 'huge,' 'high', 'round', to spoken meaning (image, sound, object, number), simile comprehension {REM}); L = N	**4) Message-2 Link symbol to meaning** (glyphs, glyph-like markings, gesture movement forms?)	M H	T N

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R L IPS/PCS: Visually guided grasping, haptic manipulation; R = N	**5) Touch, grasp, manipulate, hold, show (curate)**	H	? A K N
R L SP7: Visuospatial Orientation Pattern Processing (L/R orientation, navigate egocentric virtual space, follow trail; compare magnitudes; visually explore, spatial IQ, match patterns similar, dissimilar in serial or simultaneous array, matrix, attend to visual motion of/in patterns); R = N	**6) Patterns of movement** (constructal flow patterns, fractal, scalable, which store, connect, transport energy)	M	T A N
R L SP7: Visuospatial Mental Rotation; R = N	**7) Symmetry -- Rotational**	M	T N
R L SMG40: Spatial Relationships (L/R, locatives, view-dependent reference frame) (Lakoff-Johnson image schemas)	**8) Axial, Locative Image Schemas**	H	T A
R TOS: Visual Pattern—Conjunct (Search for target pattern conjunction of shape and sensory elements)	**9) Search for, find target pattern conjuncts of shape and sensory elements (make conjuncts)**	H M	T
R L IPL/MO/SO: Biomotion—Social Interaction (Animacy perception and semantics) + R L Biomotion (Animal)	**10) Aliveness, animacy in social interaction** (qualia of Bergson *élan vital*; Minkowski personal *élan* and contact with reality) **+ Animal shapes-contours, alive in living movement**	H	T

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L PM4: Transition between Single Motor Acts (execute start/stop, nest segments in hierarchically organized action plan, motor enact). [R: ACH]	**11) Agency – Imprint** (organize plan, execute start/stop, sequence segments of single motor acts)	H	T A K
L PC6: Initiation/Termination of Simple Chunks (phoneme similarity; symmetry judge > aesthetic; lip, tongue area); R L = N	**12) Symmetry – Translational**	M	T A N
L PM4/PC6: Sequential Syntactic Processing (concatenation, finite state grammar – FSG: *ABABAB*)	**13) Concatenate, link, join, join character strings** (Finite State Grammar: ABABAB)	H	T
L IFG6/44: L Sequential goals-subgoals action outcome prediction; Visuo-spatial hierarchy (embed) rules use in sequence processing, Supramodal semantics, speech, gesture, animacy word order, mouth mirror action, tool use, ACH (expert only); R = N	**14) Structural Forms of Flow –** Arrange clusters of objects by partition, chain, linear order, ring, hierarchy, tree, grid, cylinder [Kemp and Tenenbaum 2008]	M	T K N

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R Broca BA 44, near BA6: Sequential goals-subgoals action outcome prediction (geometric, non-biol. and bio.); R Visuo-spatial hierarchy (embed) rules use in sequence processing, hierarchical dependency; R 1st, 2nd, and 3rd person auditory verbal imagination; ACH; R = N	**15) Archetypal patterns** ('patterns of regeneration and connectivity', such as branch, meander, spiral, helix, and 'patterns that stack and pack', such as tessellating shapes, especially triangle, square, hexagon) + **Hierarchical lattices of space and/or symbols**	M H	x N
L Broca BA 45: L Initiation / Termination of Supraordinate Chunks (pre-learned sequence of categorization tasks); L Integrate discourse context and world knowledge (T/F proposition in real world), semantic meaning, and violation judgments; inner speech, monitoring one's thoughts in verbal modality	**16) Higher-order structural forms of flow** (such as hierarchy (internal tree), tree (bifurcating branches), grid, cylinder)	M	x
R L medial BA6: R Transition between Simple Chunks, symmetry; L Transition between Simple Chunks, attention to single letters (symbols)	**17) Symmetry – reflection, mirror, bilateral**	M	A
?	**18) Self-similar shape scaling, fractals**	M	x
R Broca BA 45: R Initiation / Termination of Supraordinate Chunks (pre-learned sequence of categorization tasks); Visual object decision (match visual forms to memory); R Integrate discourse context and world knowledge (T/F proposition in real world), pragmatics; introversion; novel metaphor > conventional metaphor > literal word pairs; Golden Ratio perception; ACH	**19) Golden ratio**	M	x

Question

How many of the Oldowan toolmaking design principles appear evident in the Olduvai Pecked Cobble?

Fourteen (14) Oldowan Design Principles (1-4)

'The Spacing of the Space of the Design'

(derived from Oldowan toolmaking brain imaging neural nodes, checked against checklist of 19 basic art-design principles (after Macnab 2012, with several principles added)

Inferior Occipital, Inferior Temporal, Extrastriate	
R L IO-V4: Visual Object Area (object identity integration; shape, color, depth, light invariances; gestalt processes)	**1) Phosphenes** • **Shape, degrees of freedom** (point, line, plane, geometric 3-D) • **Sensory elements** (color, lighting, etc.) • **Gestalt structure principles** (figure/ground, closure or completion, continuance, similarity, proximity)
R L OT: Visual Word Form Area (VWFA)	**2) Message-1 'Visual language'** (meaning linked to form, shape, pattern; 'visual language' arising from form, 'from grouping to shape to visual meaning', Pinna [2010], Pinna and Albertazzi [2011])
R IT: medial FFA Familiar Object Area	**3) Familiar objects** (equipment, affordances?)
R MT/ITS: Supramodal semiotic system (links symbol to meaning; iconic gesture meaning, e.g., 'huge,' 'high', 'round', to spoken meaning (image, sound, object, number), simile comprehension {REM})	**4) Message-2 Link symbol to meaning** (glyphs, glyph-like markings, gesture movement forms?)

Note 1. Apparently, five of nineteen basic art-design principles are not found in Oldowan toolmaking: (15) archetypal patterns, such as branch, meander, spiral, helix, and stackable and tessellating shapes, including hierarchical lattices of space and/or symbol, which does occur in the Acheulian; (16) higher-order structural forms of flow, such as hierarchy (internal tree), tree (bifurcating branches), grid, cylinder; (17) symmetry – reflection, mirror, bilateral, which is activated in Art-making (drawing); (18) self-similar shape scaling, fractals; and (19) golden ratio, which also occurs in the Acheulian.

More Oldowan Design Principles (5-10)

'The Spacing of the Space of the Design'

(derived from Oldowan toolmaking brain imaging neural nodes, checked against checklist of 19 basic art-design principles (after Macnab 2012, with several principles added)

Superior Parietal, IPS, Inferior Parietal and Extrastriate Middle Occipital, TOS	
R L IPS/PCS: Visually guided grasping, haptic manipulation	**5) Touch, grasp, manipulate, hold, show (curate)**
R L SP7: Visuospatial Orientation Pattern Processing (L/R orientation, navigate egocentric virtual space, follow trail; compare magnitudes; visually explore, spatial IQ, match patterns similar, dissimilar in serial or simultaneous array, matrix, attend to visual motion of/in patterns)	**6) Patterns of movement** (constructal flow patterns, fractal, scalable, which store, connect, transport energy)
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R TOS: Visual Pattern—Conjunct (Search for target pattern conjunction of shape and sensory elements)	**9) Search for, find target pattern conjuncts of shape and sensory elements (make conjuncts)**
R L IPL/MO/SO: Biomotion—Social Interaction (Animacy perception and semantics) + R L Biomotion (Animal)	**10) Aliveness, animacy in social interaction** (qualia of Bergson *élan vital*; Minkowski personal *élan* and contact with reality) **+ Animal shapes-contours, alive in living movement**

More Oldowan Design Principles (11-14)

'The Spacing of the Space of the Design'

(derived from Oldowan toolmaking brain imaging neural nodes, checked against checklist of 19 basic art-design principles (after Macnab 2012, with several principles added)

Extended Broca's Area (*sensu lato*): anterior Primary Motor, Premotor, posterior BA44	
L PM4: Transition between Single Motor Acts (execute start/stop, nest segments in hierarchically organized action plan, motor enact). [R: ACH]	**11) Agency – Imprint** (organize plan, execute start/stop, sequence segments of single motor acts)
L PC6: Initiation/Termination of Simple Chunks (phoneme similarity; symmetry judge > aesthetic; lip, tongue area)	**12) Symmetry – Translational**
L PM4/PC6: Sequential Syntactic Processing (concatenation, finite state grammar – FSG: *ABABAB*)	**13) Concatenate, link, join, join character strings** (Finite State Grammar: ABABAB)
L IFG6/44: L Sequential goals-subgoals action outcome prediction; Visuo-spatial hierarchy (embed) rules use in sequence processing, Supramodal semantics, speech, gesture, animacy word order, mouth mirror action, tool use, ACH (expert only)	**14) Structural Forms of Flow –** Arrange clusters of objects by partition, chain, linear order, ring, hierarchy, tree, grid, cylinder [Kemp and Tenenbaum 2008]