Modeling Ancient Perceptual Regimes through Adjustable Symbolic Scaffolds

A Heuristic Workflow for Artifact Analysis Using Perceptual Synthesizers

Methodological Note

Abstract

Modern archaeological and art-historical interpretations of ancient artifacts are often shaped by contemporary perceptual and symbolic frameworks—most notably decimal-linear measurement, alphabetic habits of attention, and a tendency to treat symbolic systems as secondary to technical processes. This methodological note outlines a heuristic workflow that employs adjustable computational models of symbolic perceptual overlays ("perceptual synthesizers") to generate alternative hypotheses about how ancient artisans and observers may have parsed the same geometric forms. By systematically varying numeric base scaffolds (base-10, base-20, base-60, and hybrids), resolution density, chunking style, phase sensitivity, and convergence weighting, researchers can render visible the differential salience of features that default modern perception tends to flatten or ignore. The workflow is designed as a generative, not evidentiary, instrument: outputs are treated as structured hypotheses requiring triangulation with conventional lines of evidence (archaeometry, linguistics, iconography, archaeoastronomy). Crucially, the synthesizer does not recover ancient perception; it externalizes the researcher's own reconstruction of a perceptual regime as an explicit, parameterized, and shareable model, making the interpretive assumptions available for inspection, contestation, and controlled testing. An illustrative application to questions of precision and error tolerance in Sumerian stone sculpture demonstrates how the method can reframe debates about craft standards and perceptual economy without displacing established technical histories.

1. Introduction

The interpretation of ancient material culture is constrained not only by the survival of evidence but by the perceptual and cognitive filters through which contemporary observers reconstruct past experience. These filters—rooted in the symbolic systems, measurement practices, and attentional habits of the interpreter—often remain unexamined. The result is a systematic risk of anachronism: features that were highly salient within an ancient perceptual regime may appear marginal or invisible to modern eyes, while modern categories (e.g., "art vs. craft," "symbolic vs. technical") may be projected onto contexts where they had little purchase.

This note proposes a practical workflow for using interactive perceptual modeling tools—here termed perceptual synthesizers—to make such filters adjustable and observable. The approach builds on longstanding insights from spatial theory (Lefebvre 1991; Soja 1996), cognitive archaeology (Renfrew and Zubrow 1994), and the anthropology of number and measurement (Crump 1990), but operationalizes them through a lightweight, replicable digital instrument. The goal is not to recover an "authentic" ancient perception (an epistemologically fraught ambition) but to generate structured, falsifiable-in-principle alternative readings of artifacts that can be tested against independent evidence.

It is important to state at the outset what such an instrument can and cannot do. Because the symbolic overlays are supplied by the researcher, the synthesizer cannot independently discover how ancient observers parsed form; whatever salience it renders is a function of the parameters entered. Its contribution is therefore not evidentiary but methodological: it converts an otherwise tacit perceptual reconstruction into an explicit, manipulable, and reproducible model. In doing so it makes the analyst's assumptions visible and contestable rather than smuggled in as background—an analytic overlay that can be applied without being mistaken for the ancient perception it models.

2. Theoretical Background

2.1 Symbolic Scaffolds and Perceptual Overlays

Human perception of spatial form is never raw. Retinal and early visual processing supply geometric information that is subsequently organized by learned symbolic systems—numeric bases, metrological conventions, angular and modular grammars, and culturally transmitted attentional templates. In predictive-processing accounts of cognition, perception is precisely such an interaction between bottom-up sensory signals and top-down generative models, with attention operating as a mechanism for weighting expected precision (Clark 2016; Friston 2010; Hohwy 2013). Symbolic scaffolds can be understood as one culturally transmitted source of these top-down models: they bias which features of a given geometry become salient, how deviations are weighted, and how relationships (proportional, phase, hierarchical) are parsed. Material-engagement and ecological approaches similarly hold that cognition is distributed across body, artifact, and environment, such that the forms themselves participate in shaping the perception of their makers and users (Ingold 2000; Malafouris 2013).

That numeric systems are cognitive technologies rather than transparent notations is supported by cross-cultural and developmental research on number: number concepts are culturally constructed and elaborated rather than simply innate (Dehaene 2011; Núñez 2017), and communities without an elaborated counting system show correspondingly different performance on exact-quantity tasks (Frank et al. 2008). The present approach should nonetheless be distinguished from strong linguistic-relativity claims. It does not assert that a numeric base determines perception in a deterministic, Whorfian sense; it proposes the weaker and more tractable claim that learned symbolic systems modulate the salience and weighting of features within a shared geometry—an effect to be demonstrated case by case rather than assumed (cf. Boroditsky 2001; Lucy 1992).

2.2 Relevance to Ancient Artifact Analysis

Many ancient societies operated within symbolic regimes whose numeric, metrological, and cosmological grammars differed markedly from the decimal-linear habits that dominate contemporary technical and scholarly perception. Base-60 and related sexagesimal systems (Mesopotamia), vigesimal and body-based systems (Mesoamerica and parts of Africa; Closs 1986), and various duodecimal or highly composite modular frameworks produced distinct patterns of salience, phase tracking, and convergence. The sexagesimal organization of Mesopotamian metrology, timekeeping, and astronomy is especially well documented (Neugebauer 1975; Powell 1995; Robson 2008). When modern observers examine artifacts produced inside these regimes, default perceptual settings can flatten or misattribute the very features—fine angular control, nested cyclical commensurability, hierarchical resolution gradients—that were most motivationally and technically significant to their makers.

3. The Perceptual Synthesizer as Methodological Instrument

The workflow centers on an interactive web-based perceptual synthesizer, implemented as a set of self-contained HTML/JS instruments in the Perceptual Scaffold Modeling Lab. Three are currently available: Instrument I (3D Box Perception Visualizer) models the scaffold as a static structural overlay on cube geometry; Instrument II (Perceptual Event Visualizer) models it as a temporal process, emphasizing rotation, attentional grouping, memory trace, and phase residue; and Instrument III (Pyramid Perception Synthesizer) combines the structural and event models on a square pyramid, adding convergence and apex weighting relevant to hierarchical and processional forms. Each renders a simplified three-dimensional proxy geometry (cube, pyramid, or custom artifact-derived form) and exposes the symbolic overlay as adjustable parameters while holding the projected geometry fixed. Key adjustable dimensions include:

1. **Numeric base scaffold** (base-10 rectilinear, base-20 quinary-chunked, base-60 angular-modular, or user-defined hybrids).
2. **Resolution density** (subdivision steps per axis or angle).
3. **Chunk and phase emphasis** (highlighting of culturally attested factors; radial/angular overlays for base-60 conditions).
4. **Top-down prediction and salience weighting** (strength of symbolic guidance over bottom-up edge and depth signals).
5. **Convergence and hierarchical gradient** (apex or center weighting, relevant to pyramidal and processional forms).
6. **Error salience / precision tolerance** (controlled micro-deviations on edges or surfaces to observe differential detection thresholds).

The instrument separates the fixed projected geometry from the variable interpretive overlay, making explicit the contribution of symbolic scaffolding to what appears "obvious," "smooth," or "resolved."

Two consequences follow from this architecture and should be stated plainly. First, because the overlay parameters are set by the analyst, the instrument cannot by itself adjudicate which scaffold an ancient population actually used; it renders the consequences of an assumed scaffold, not evidence for it. Second, and for the same reason, its methodological value lies in externalization: it transforms a perceptual hypothesis that would otherwise remain implicit into an explicit, logged, and shareable object that other researchers can reproduce, vary, and challenge.

4. Proposed Workflow

The workflow is intended to be lightweight, replicable, and transparent. It consists of seven iterative stages.

Stage 1: Artifact Selection and Proxy Geometry Construction

7. Select an artifact or class of artifacts whose modern interpretation appears over-determined by contemporary perceptual defaults (e.g., unusually high surface finish, precise angular alignments, nested cyclical iconography).
8. Construct a simplified geometric proxy (wireframe, low-polygon mesh, or 2D elevation with depth cues) that preserves the principal spatial relationships while remaining computationally tractable. Photogrammetry or published measured drawings can supply the source data.
9. Document the proxy construction decisions so that later researchers can replicate or vary the geometric assumptions.

Stage 2: Scaffold Parameterization

Define the set of symbolic scaffolds to be compared. A minimal starting set includes:

(a) Base-10 rectilinear (default modern technical perception).
(b) Base-20 or body-based chunked (ethnographically attested in multiple regions).
(c) Base-60 or sexagesimal angular-modular (attested in Mesopotamian metrology, astronomy, and timekeeping).
(d) Hybrid or reconstructed scaffolds derived from linguistic, metrological, or iconographic evidence specific to the culture under study.

For each scaffold, set initial values for resolution density, chunk/phase emphasis, top-down strength, convergence weighting, and error salience threshold. Record all parameter values in a structured log.

Stage 3: Controlled Variation and Systematic Observation

10. Run the proxy geometry through each scaffold condition while holding rotation, lighting, and viewing angle constant or systematically varied.
11. Log observations along pre-specified dimensions: (a) which edges, surfaces, or alignments become most salient; (b) at what magnitude micro-deviations register as errors; (c) how phase or cyclical relationships appear coherent or disrupted; (d) how hierarchical or convergent gradients are experienced.
12. Use side-by-side or rapid-toggle comparison modes ("combo view") to highlight differential effects that single-condition viewing obscures.
13. Include a null control condition: a scrambled or randomized overlay of equivalent visual density but without culturally motivated structure. Differences that appear under this control as strongly as under the reconstructed scaffolds indicate artifacts of overlay-presence rather than effects specific to the symbolic system being modeled.
14. Wherever feasible, separate the roles of parameter-setter and observer. Naïve coders who record salience and error-detection judgments without knowing which scaffold condition is displayed provide a check against demand characteristics; report inter-rater agreement

so that "what becomes salient" is an inter-subjectively coded result rather than the parameter-setter's expectation confirmed.

15. Where the question concerns error tolerance, treat the tool's controlled micro-deviation parameter as the basis for a psychophysical staircase: vary deviation magnitude to estimate an observer's detection threshold under each overlay, yielding a quantitative measure rather than an impressionistic one.

Stage 4: Identification of Perceptually Salient Differences

Synthesize observations into structured contrasts: features that are foregrounded under one scaffold but backgrounded under another. Particular attention should be paid to (i) error tolerance thresholds, (ii) phase coherence across nested cycles or alignments, and (iii) convergence or apex resolution gradients. These contrasts constitute the primary output of the modeling exercise.

Stage 5: Translation to Archaeological Hypotheses

Convert perceptual contrasts into candidate archaeological hypotheses. Examples: "Under a base-60 angular scaffold, the observed surface finish on Type X sculptures falls at or below the modeled error detection threshold, suggesting that what appears 'exceptionally smooth' to modern observers may have constituted the minimum culturally expected resolution." Or: "A base-20 bodily chunking scaffold redistributes salience away from continuous curvature and toward ordinal segment boundaries, potentially explaining the stepped rather than continuously modeled forms in corpus Y." Hypotheses should be stated in falsifiable or at least disconfirmable language. To make this requirement operational, each hypothesis should be paired with at least one explicit disconfirming observation specified in advance—an independent finding that, if obtained, would count against the scaffold reading. A scaffold hypothesis that no realistic evidence could disconfirm should be reformulated or set aside.

Stage 6: Triangulation with Independent Evidence Lines

Subject generated hypotheses to cross-validation against conventional datasets: metrological studies, linguistic reconstructions of number and measurement terminology, archaeoastronomical alignments, iconographic programs, tool-mark and use-wear analysis, and ethnographic or ethnohistoric analogues. The modeling output does not replace these lines of evidence; it supplies structured alternative readings against which they can be tested.

Stage 7: Documentation, Replication, and Iteration

Publish parameter logs, proxy geometry files, observation protocols, and generated hypotheses in a form that permits independent replication or variation. Iterate the workflow on the same artifact class with revised proxies or additional scaffold conditions as new evidence or scholarly feedback emerges. The Perceptual Scaffold Modeling Lab supports this directly: the instruments are self-contained and shareable, and the lab's local annotation log (a file-based comment store requiring no database) records scholarly questions, parameter suggestions, and proposed additions against specific sections, providing a lightweight, version-able channel for the cumulative refinement described here.

5. Illustrative Applications

The method is illustrated below in two domains chosen to contrast its evidential footing: one where the relevant scaffold is securely attested, and one where it is contested.

5.1 Angular and Phase Parsing in Babylonian Astronomical Practice

Sexagesimal organization is most securely attested not in figural art but in Mesopotamian computational, calendrical, and astronomical practice, where the division of the circle, the day, and the ecliptic into sixty-based units is textually documented (Neugebauer 1975; Robson 2008). This makes astronomical and timekeeping artifacts—tablets recording angular positions, period relations, and phase phenomena—a domain in which a base-60 angular-modular scaffold is grounded in direct evidence rather than inferred. Applying the synthesizer here, a base-60 scaffold with high phase sensitivity foregrounds modular angular subdivisions and the commensurability of nested cycles that a default base-10 rectilinear overlay tends to flatten into continuous linear quantities. The resulting hypothesis—that practitioners working within this regime attended preferentially to phase coherence and modular angular alignment—can be tested against the actual structure of the computational texts.

Disconfirmation criterion. The hypothesis is weakened if the relevant tablets specify angular and temporal quantities in non-sexagesimal or purely linear units, or if attested period relations show no preferential expression in modular sixty-based terms.

5.2 Precision and Error Salience in Sumerian Sculpture: A Contested Case

Sumerian stone statuary and reliefs are frequently described in modern scholarship as exhibiting remarkable surface finish and formal precision; technical histories document the copper tools, abrasives, and long apprenticeship traditions through which these results were achieved (Moorey 1994). The synthesizer offers a complementary, and deliberately contestable, reading: under a base-60 angular-modular scaffold with high phase sensitivity and tight rotational-axis weighting, the modeled detection threshold for angular deviation and surface discontinuity is lower than under default base-10 rectilinear conditions. On this reading, what registers to contemporary viewers as "smooth as silk" may correspond to the lower bound of acceptable resolution within a perceptual economy in which micro-phase deviations were salient and socially costly.

This reading must, however, be tested against a strong rival hypothesis that its own evidential context supplies. The apprenticeship and skilled-practice literature holds that high finish in craft traditions is governed primarily by tacit, embodied, non-numerate competence acquired through prolonged practice, rather than by an explicit numeric grammar (Keller and Keller 1996; Marchand 2010). On this account, surface finish reflects the trained hand and eye of the carver and the social organization of the workshop, with no necessary recourse to sexagesimal parsing. The two hypotheses make different predictions: the scaffold account predicts that finish standards and error tolerances should track sexagesimally structured units and vary across domains by the presence of such structure, whereas the embodied-skill account predicts that finish tracks apprenticeship length, tool and material constraints, and workshop transmission independent of numeric base.

Disconfirmation criterion. The scaffold reading is disconfirmed if comparable surface finish is achieved in high-precision traditions lacking sexagesimal numeracy (for example, Old Kingdom Egyptian hardstone working), or if metrological and administrative records associate craft tolerances with non-sexagesimal units. Stated this way, the synthesizer's output is not a claim that Sumerian artisans "saw in base-60" but a precise, parameterized hypothesis positioned explicitly against the embodied-skill account, to be adjudicated by metrological texts, records of craft specialization, and comparative craft studies.

6. Epistemological Considerations, Limitations, and Cross-Validation

The workflow is explicitly heuristic and generative. Its outputs are structured perceptual hypotheses, not direct evidence of ancient subjective experience. Several limitations must be acknowledged:

16. **Parameter circularity**: Because salience and error-tolerance outputs follow from analyst-set parameters, single-observer use risks confirming the very assumptions entered. This is the central methodological hazard of the approach; it is mitigated—though not eliminated—by null-overlay controls, blinded naïve coding with reported inter-rater agreement, and psychophysical rather than impressionistic threshold estimates (Stage 3).
17. **Proxy simplification**: Geometric proxies necessarily abstract from material, color, lighting, and embodied viewing contexts that would have shaped ancient perception.
18. **Scaffold reconstruction**: Base assignments and parameter weightings are necessarily under-determined by surviving evidence; multiple plausible reconstructions may exist for a given culture.
19. **Modern observer bias**: Even when using the tool, contemporary researchers remain anchored in their own trained perception; the instrument mitigates but does not eliminate this.
20. **Over-interpretation risk**: Visual salience in the model does not automatically translate into cultural or ritual significance.

Mitigation lies in rigorous documentation of parameters, pre-specification of disconfirming observations for each hypothesis, transparent statement of hypotheses as provisional, and systematic triangulation with independent evidence. The method is most powerful when used to surface readings that conventional approaches have overlooked or deemed implausible, then testing those readings against the full range of available data.

7. Future Development

The workflow can be extended by (a) expanding the library of culturally attested scaffold reconstructions; (b) standardizing the quantitative logging and psychophysical protocols introduced above into a shared, comparable instrument across studies; (c) integrating multi-sensory or embodied parameters (viewing-angle sequences, processional movement); and (d) coupling the synthesizer to formal shape-analysis or photogrammetric pipelines for higher-fidelity proxies. Open sharing of parameter logs and proxy files will support cumulative, community-driven refinement.

8. Conclusion

Modern consensus interpretations of ancient artifacts are powerful but carry the risk of unexamined perceptual anachronism. By treating symbolic scaffolds as adjustable parameters rather than fixed background assumptions, the workflow outlined here provides a replicable method for generating alternative, structured hypotheses about how ancient makers and observers may have parsed form, precision, and cyclical or hierarchical relationships. When used responsibly—always in dialogue with conventional evidence lines—the approach can expand the range of questions that artifact analysis is permitted to ask and the range of answers it is permitted to consider. Used in this way, the instrument's value lies less in any single output than in making perceptual assumptions explicit, shareable, and answerable to evidence.

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This methodological note is offered as an open, evolving framework. Researchers are encouraged to adapt the workflow, share parameter sets, and publish both positive and negative results so that the instrument and its applications can be collectively refined.