Signs to Scripts: Cultural Evolution and Visual Transformation of the Proto-Elamite Writing System

Abstract:

This study develops a heuristic cultural-evolutionary framework to trace the visual transformation of the Elamite writing system (ca. 3500–1850 BCE), emphasizing how evolving signs and artistic styles co-shaped the emergence, stabilization, and regional diversification of early writing systems. Grounded in cultural evolution theory, the research examines the Proto-Iranian writing sequence, encompassing Proto-Elamite and Linear Elamite as reconceptualized by Desset. Co-evolving stylistic trajectories are traced from representational motifs to increasingly abstract linear forms. A corpus of approximately 400 artefacts was systematically coded using analytically defined graded variables capturing pictoriality-abstraction, motif-script integration, stylistic complexity, and overall compositional geometry, enabling a detailed assessment of cultural dynamics and temporal patterns.

Manually generated heuristic cultural-evolutionary reconstructions visualize directional patterns of change, highlighting continuity, divergence, experimentation, and innovation without asserting discrete clades or formal homologies. Findings demonstrate that iterative engagement with visual signs structured variation, transmission, and selective retention, while artistic styles actively mediated abstraction, spatial standardization, and compositional integration in writing.

Integrating Material Engagement Theory (MET), this study emphasizes the distributed and entangled nature of cognition, showing how repeated interactions with clay tablets, seals, and other artefacts distributed memory and structured knowledge across mind, body, environment, and social practice. MET provides a conceptual lens for understanding how material engagement both scaffolds cognitive processes and actively shapes cultural evolution, facilitating individual learning, apprenticeship, and population-level transmission of stylistic and scriptural conventions over extended temporal and spatial scales.

While material engagement and artistic conventions played a central role, administrative and socio-economic constraints simultaneously shaped the evolution of writing, functioning as integral components within the mind/brain-body-environment nexus. By operationalizing graded variables through a heuristic framework, this research offers a theoretically rigorous yet flexible methodology for studying early writing systems under comparable archaeological and stylistic conditions, highlighting the reciprocal influence of cognition, culture, and material engagement in the co-evolution of writing and visual style across diverse contexts.

Keywords: Cultural Evolution, Proto-Elamite Writing System, Artistic Styles, Visual Transformation, Proto-Iranian Script

Introduction:

Writing systems do more than record information: they actively reshape cultural repertoires through repeated interactions with material supports such as clay tablets, seals, and pottery. This study adopts François Desset's (2017; 2021) chronology, which frames Proto-Elamite and Linear Elamite as successive phases of a broader Proto-Iranian writing tradition spanning roughly 3500-1850 BCE. This framework represents a productive working model rather than a definitive scholarly consensus. Building on this temporal foundation, I develop a cultural-evolutionary

account that foregrounds the visual dimension of script change: specifically, how artistic idioms, from representational motifs to streamlined linear conventions, co-evolved alongside graphic signs.

The central claim of this paper is that stylistic conventions functioned as channels of transgenerational memory and as active agents reshaping sign repertoires, influencing variation, transmission fidelity, and selective retention. Rather than treating the shift from pictorial marking to abstract script as a unilinear, purely functional progression, this study emphasizes the mutual, co-evolutionary dynamics between visual style and written signs, including branching tendencies across securely dated archaeological contexts. To explore this, a corpus of approximately 400 artefacts spanning the Susa I through Neo-Elamite horizons was systematically analyzed. This corpus enables tracing recurrent compositional strategies, motif distributions, and the evolving spatial relations between image and inscription.

While prior accounts have emphasized administrative drivers of early writing (e.g., accounting or bureaucratic needs), this paper proposes a complementary explanation: material engagement and stylistic dynamics jointly contributed to the stabilization and transformation of graphic systems, with administrative and socio-economic constraints functioning as integral components of the mind/brain-body-environment nexus. The study integrates Material Engagement Theory (MET; Malafouris 2013) with cultural-evolutionary concepts of variation, inheritance, and selection, exploring how repeated mark-making, apprenticeship conventions, and surface constraints shaped trajectories of script standardization.

The following sections develop this argument by outlining the theoretical framework, describing the corpus and coding methodology, and presenting heuristic cultural-evolutionary reconstructions that visualize directional trajectories, branching tendencies, and co-evolutionary patterns of style and script, without asserting formal homologies or statistically inferred lineages. Four guiding research questions frame this study:

1. How and why did artistic forms shift from pictorial to abstract configurations, and what co-evolutionary and branching patterns do these shifts reveal?
2. How did interactions with Proto-Elamite signs structure variation, transmission, and innovation?
3. How did stylistic change mediate administrative, social, and material practices?
4. Can cultural-evolutionary modeling provide a transferable framework for analyzing related early writing traditions?

Theoretical Framework: Material Engagement Theory (MET)

This study integrates Material Engagement Theory (MET; Malafouris 2013), a central framework within Evolutionary Cognitive Archaeology (ECA; Wynn & Coolidge 2017; Fenici & Garofoli 2017; Malafouris 2019), as a complementary lens to cultural evolution. MET conceptualizes material artefacts not as passive records but as active extensions of intergenerational memory and practice (Malafouris & Renfrew 2010; Renfrew 2004). Cognition and culture emerge through recursive human–material entanglement: clay tablets, seals, motifs, and other artefacts distribute memory and structured knowledge across body, objects, and environment (Malafouris 2013).

Artistic creation is understood not merely as aesthetic expression but as a fundamental cognitive process, intertwined with technological innovation, apprenticeship, and cultural transmission (Malafouris 2013: 89-90; Garofoli 2016). Artistic styles act as dynamic mnemonic scaffolds, evoking past practices and shaping future adaptations without requiring deliberate symbolic encoding. Visual conventions mediate abstraction, compositional organization, and spatial standardization in graphic systems. By explicitly linking artefact features to graded stylistic variables, the integrated MET–ECA framework provides the foundation for understanding how recurrent mark-making, apprenticeship, and material constraints drove variation, selective retention, and co-evolution in the Proto-Iranian script (Farsi & Hoseinzadeh 2025). This approach positions material engagement and artistic style as constitutive elements in the cultural evolution of writing, complementing socio-economic and administrative influences within the broader mind/brain-body-environment nexus. Moreover, by integrating MET with a heuristic cultural-evolutionary approach, this study links micro-level material interactions with macro-level cultural trajectories, allowing us to operationalize co-evolutionary patterns between style and script in a manner not achievable by either framework alone.

The Emergence of Early Writing Systems in Iranian Plateau

Literacy in Proto-Elamite society was likely restricted to a small administrative and religious elite. Evidence from seal ownership, scribal training tablets, and restricted find-contexts indicates that writing served institutional rather than popular communication. Consequently, the durability of clay as a medium for recording information has preserved critical insights into ancient civilizations, particularly through the Proto-Elamite writing system (ca. 3500–1850 BCE), one of the earliest scripts on the Iranian Plateau. This section outlines the historical development of this script, focusing on its evolution and artistic styles, to contextualize the cognitive archaeological model proposed in this study. Drawing on Material Engagement Theory (MET), it explores how material interactions with clay tablets, seals, and pottery shaped cognitive and cultural processes (Malafouris 2013) in Elamite society, beyond their administrative roles. Following François Desset's (2022) reinterpretation, this study adopts his six-stage framework that redefines the script as Proto-Iranian writing, encompassing Early, Middle, and Late phases, and identifies its language as the Hatamtite to avoid historical misconceptions associated with the later Elamite polity (Desset 2016; 2017).

The Proto-Iranian writing system emerged in Susa around 3300–2900 BCE, primarily for administrative purposes, and was abandoned by 1850 BCE, likely due to the adoption of Mesopotamian cuneiform (Potts, 2004). Algaze (2008) links the rise of early writing and accounting to growing "interpersonal interactions" that enabled intergenerational memory storage through material artifacts like tablets (pp. 135–139). This aligns with MET's view of writing as a cognitive scaffold that externalized memory and thought (Malafouris 2013). Yet, the complexity of early scripts up to 1,500 signs restricted literacy to an elite few, reinforcing social stratification or "technologies of power" (Mann 1986). Cooper (2004) emphasizes that writing's emergence was not inevitable; as some complex societies lacked writing, and its presence did not always enhance complexity (p. 94). In Susa, the 1,560 texts from the Susa III period primarily document

administrative practices, such as recording goods (Potts 2004; Dahl 2009), but their artistic styles, visible in tablet layouts and seal motifs, suggest broader cognitive and cultural roles (Figure 1).
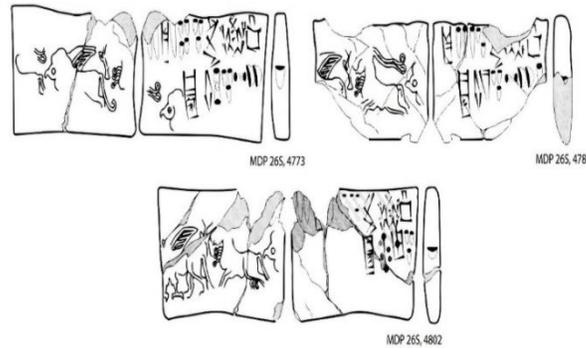

Figure 1. The placement of motifs with numerical signs
Source: Matthews and Fazeli Nashli, 2022, fig 7.2

Historical Model: The Evolution of Proto-Iranian Writing

Following Desset's six-stage schema (2025, direct conversation with Desset), this paper treats the Proto-Elamite and Linear Elamite corpora as chronologically and structurally linked components within a unified Proto-Iranian script tradition. He proposes that Early Proto-Iranian (Proto-Elamite), Middle Proto-Iranian, and Late Proto-Iranian (Linear Elamite) represent stages of a single evolving writing system, rather than distinct scripts, culminating in the adoption of cuneiform for the Hatamtite language. This six-stage model, based on material evidence from tablets, seals, and pottery across the Iranian Plateau, traces the script's development and its cognitive implications:

Stage 1 (3500–3300 BCE): Numerical tablets and proto-writing emerged, using tokens and counting objects, widespread from Syria to central Iran. Signs represented numerical values or objects, with pictorial motifs (e.g., zoomorphic designs) dominating.

Stage 2 (3300/3000–2900 BCE): Early Proto-Iranian writing developed in Susa, paralleling Proto-Cuneiform in Mesopotamia and early scripts in Egypt. This stage introduced a complex system of approximately 1500-1700 more abstract logograms and phonetic signs, retaining pictorial elements but requiring learned conventions, indicating a shift toward cognition.

Stage 3 (3000/2900–2300 BCE): Middle Proto-Iranian writing, a transitional phase, is poorly documented, with only four known texts. Logogrammatic signs were gradually abandoned, and phonetic signs decreased from 250–300 to under 100 by 2300 BCE, suggesting scribal standardization and cognitive adaptation to simpler, more abstract systems. Regional variations are evident across sites like Susa, Tell Malyan, Tepe Yahya, Shahr-i Sokhta, Tepe Ozbaki, and

Tepe Sialk, reflecting local cultural and linguistic diversity in numerical systems and anthroponymic sequences.

Stage 4 (2300–2000 BCE): Late Proto-Iranian writing, or Linear Elamite, saw further reduction in signs, fully documented in western (Susa, Fars) and eastern (Shahdad, Konar Sandal) traditions. Inscriptions, such as those of Puzur-Shushinak in Susa, reflect a fully abstract script, requiring formal learning and indicating advanced cognitive demands.

Stage 5 (2000–1850 BCE): Cuneiform was adopted alongside Late Proto-Iranian writing to record the Hatamtite language, extending from Susa to Fars. This phase marks a transitional period of coexistence between local and Mesopotamian scripts (Potts 2004).

Stage 6 (After 1850 BCE): The Proto-Iranian script disappeared, supplanted by Mesopotamian cuneiform, likely due to its growing influence among Hatamtite scribes. By the 19th century BCE, cuneiform dominated official and administrative records in Susa and Fars (Desset 2021; 2017; 2016; Potts 2004).

The historical model highlights the Proto-Iranian script's evolution from pictorial to abstract forms, paralleled by changes in artistic styles (e.g., from zoomorphic to geometric motifs) observed in seals, tablets, and pottery. While this framework effectively traces the temporal development of the script, it primarily focuses on the progression of writing systems, with less attention to the evolution of artistic styles and their significance in shaping cognitive and cultural dynamics. This study addresses this aspect by proposing that the transformation and importance of these artistic styles are integral to understanding the broader context of Elamite society (See Tables 1-2). MET's concept of metaplasticity suggests that these material engagements through repetitive inscribing and learning drove neural plasticity, fostering cognitive capacities like memory offloading and abstraction, which underpinned Elamite social complexity (Malafouris, 2013). The script's regional variations reflect localized cognitive and cultural practices, enriching the cognitive archaeological model proposed in this research .The detailed six-stage evolutionary schema of the Proto-Iranian writing system, including the progressive reduction of sign inventories and the emergence of phonetic components, is presented in Desset's work. For clarity, the present study adopts this widely accepted chronological framework without modification (see also Álvarez-Mon 2020 for complementary visual documentation).
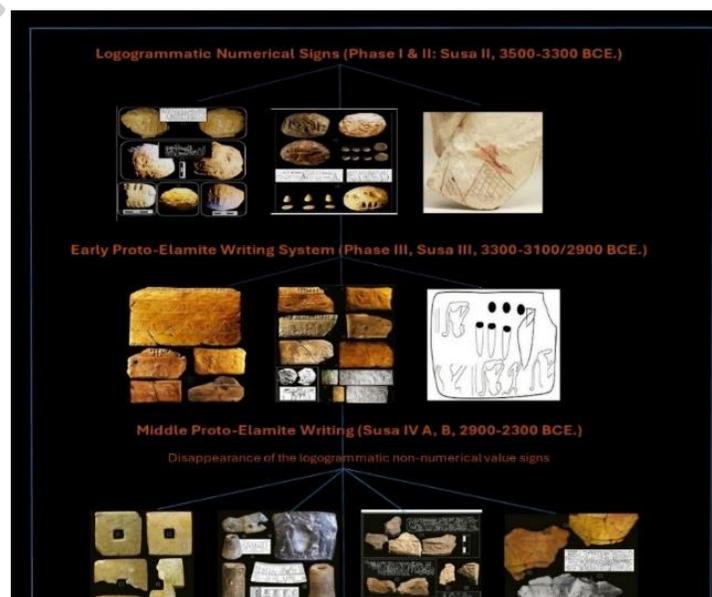
Table 1. Motif-sign integration on a Proto-Elamite tablet, illustrating historically informed relationships between visual forms and framing conventions. Source: Farsi (2025), adapted from Matthews & Fazeli (2022) and Álvarez-Mon (2020).

A Heuristic Cultural-Evolutionary Approach to Elamite Writing and Artistic Styles

Cultural evolution provides the central analytical lens for this study, conceptualizing stylistic and scriptural change as processes of variation, transmission, and selective retention across generations (Boyd & Richerson 1985; Mesoudi 2011, 2016; Henrich 2016). Unlike genetic inheritance, cultural transmission is context-sensitive and reconstructive: inferential reasoning, material constraints, and local practices frequently introduce modifications, producing mutation-like diversity (Henrich & Boyd 2002). Consequently, cultural lineages rarely follow strict, tree-like patterns familiar from biology, instead exhibiting branching tendencies interwoven with innovation, borrowing, and recombination (Temkin 2016; Straffon 2019). Following Straffon (2019), this study adopts a heuristic approach to tracing cultural evolution. Because our reconstructions are manually generated and exploratory rather than statistically inferred, the term heuristic cultural-evolutionary emphasizes structured, theory-driven visualizations of directional and co-evolutionary patterns in style and script, without implying formal biological homology or discrete lineages. This approach allows us to trace continuities, divergences, and innovations across securely dated artefacts, connecting material evidence, stylistic analysis, and cultural-evolutionary principles in a coherent framework.

A critical distinction in material culture research is between typological and phylogenetic approaches. Typological classification groups artefacts according to shared formal or technical attributes without necessarily implying historical descent (Bahn 1992). Phylogenetic approaches, by contrast, aim to reconstruct patterns of descent with modification, tracing structured continuities

and transformations over time (O'Brien & Lyman 2009; Straffon 2019). In cultural contexts, strict biological homology rarely applies, as traits often blend, borrow, or recur in new forms (Straffon 2019). In this study, phylogenetic inference is explicitly heuristic: it does not posit discrete clades or formal homologies but serves as a theory-driven, exploratory tool to visualize directional tendencies, branching possibilities, and co-evolutionary patterns in stylistic and scriptural change. The term heuristic cultural-evolutionary highlights structured, analytical visualizations derived from repeated material practices, apprenticeship conventions, and securely dated archaeological contexts, rather than statistically inferred trees or biologically grounded lineages. In this sense, the approach aligns with cultural evolutionary principles while remaining flexible to new data and interpretive refinements, and is closer to an explicitly theory-driven, exploratory seriation than to a formal phylogenetic reconstruction.

Approximately 400 visual artefacts from Susa, Tepe Yahya, and Konar Sandal (ca. 3500-1850 BCE) were analyzed to explore co-evolutionary dynamics between artistic styles and the Proto-Iranian writing system. Four analytically defined variables capture how visual conventions responded to the progressive abstraction and formalization of script: (1) the pictoriality-abstraction continuum; (2) motif-script integration, including spatial and compositional interactions, framing, and alignment; (3) stylistic complexity, encompassing emergence, combination, diversification, and omission of traits; and (4) overall compositional geometry, focusing on visual balance and the distribution of occupied versus empty space.

Rather than statistically inferred phylogenies, heuristic cultural-evolutionary reconstructions were manually produced in strict chronological order for each artefact class. Hand-made pottery and seals/seal impressions generated the most continuous and diagnostically robust evolutionary signals, reflecting their abundance, fine-grained chronological resolution, and pronounced stylistic variation. These reconstructions foreground patterned continuity, divergence, and innovation, illustrating how repeated engagement with visual signs structured transmission and shaped the evolving form of Proto-Iranian writing (Table 3).

By emphasizing directional trends, branching tendencies, and co-evolutionary interactions, this heuristic cultural-evolutionary approach provides a coherent framework for connecting material evidence, stylistic analysis, and cultural evolutionary theory. It demonstrates how artistic styles mediated the emergence, abstraction, and spatial standardization of writing, offering a model that is both theoretically rigorous and archaeologically grounded.

Data and Methods

This design explicitly links theoretical constructs to measurable artefact variables, allowing us to operationalize the co-evolution of script and style in a reproducible and transparent manner .To operationalize the heuristic cultural-evolutionary framework described above, a corpus of approximately 400 visual artefacts was assembled, including hand-made pottery, seals and seal impressions, tablets, jewellery, figurines, and statuettes. Artefacts were deliberately selected to

ensure broad chronological coverage (ca. 3500-1850 BCE) and to capture diagnostically informative stylistic variation across securely dated archaeological contexts. Each artefact was systematically coded by the author using four analytically defined graded variables designed to measure stylistic change along continua rather than as discrete categories. Coding followed explicit rubrics (see Appendix A), allowing each variable to be assessed consistently across artefact classes, promoting reproducibility and minimizing subjective bias.

The four variables operationalize theoretical constructs central to the study:

1. **Pictoriality–abstraction continuum**, evaluates the degree to which visual elements retain figurative qualities versus exhibiting schematic or abstract forms.
2. **Motif–script integration**, examines the spatial and compositional relationships between visual motifs and written signs, including overlap, framing, alignment, and mutual constraint, capturing how script influenced or was influenced by artistic composition.
3. **Stylistic complexity**, tracks the emergence, combination, diversification, and omission of visual traits within and across artefact classes, providing an index of cumulative innovation and selective retention.
4. **Overall compositional geometry**, addresses the organisation of visual space, including balance, symmetry, and the distribution of occupied versus empty areas, operationalizing the interaction between motif placement and spatial abstraction.

Cultural-evolutionary reconstructions were manually generated from the character matrix in strict chronological order for each artefact class. These reconstructions are explicitly heuristic, intended to visualise directional trajectories of stylistic and scriptural change over time, rather than to assert discrete clades or formal homologies. Separate reconstructions for each artefact category were employed to prevent cross-media distortion. For example, a Susa III seal depicting a zoomorphic motif was scored 3/5 on the pictoriality-abstraction continuum, reflecting partial abstraction while retaining figurative clarity. Hand-made pottery and seals/seal impressions produced the most continuous and diagnostically robust evolutionary signals, owing to their abundance, fine-grained chronological resolution, and pronounced stylistic shifts (Table 1). Table 2 presents a deliberately selective subset of artefacts with the clearest and most extreme expressions of the four variables in each chronological phase, serving as paradigmatic illustrations of broader co-evolutionary trends.

Selective presentation in tables and figures reflects constraints of space and analytical clarity rather than data exclusion. The complete corpus of approximately 400 artefacts, including all coded variables, reconstruction diagrams, and supplementary visual materials, is openly archived at Zenodo (https://doi.org/10.5281/zenodo.17345251), enabling further examination, reanalysis, and comparative research. By explicitly linking coded variables to theoretical constructs and heuristic reconstructions, this section clarifies how the methodology operationalizes cultural-evolutionary principles, addresses interpretive challenges, and provides a structured approach to examining stylistic-script co-evolution across securely dated archaeological contexts.

Caveats and Limitations

Several limitations of the present study should be acknowledged, particularly given the heuristic and exploratory nature of the phylogenetic reconstructions. First, the reconstructions presented here are manually generated and explicitly heuristic rather than statistically inferred phylogenies. The term heuristic cultural-evolutionary refers to visually inferred evolutionary trajectories that emphasize directional trends, branching tendencies, and co-evolutionary dynamics, without implying formal homology, discrete clades, or biological lineage structures. Apparent branching patterns illustrate potential divergences and innovations in stylistic trajectories, rather than asserting discrete historical lineages. These reconstructions function as interpretive heuristics, offering structured insights into the co-evolutionary dynamics of script and artistic style while remaining flexible to revision as new data emerge.

Second, the coding of artefacts using graded variables inherently involves interpretive judgment, particularly along continua such as pictoriality-abstraction or motif-script integration. Explicit rubrics were applied to promote internal consistency, ensure reproducibility, and minimize subjective bias; however, alternative coding schemes or thresholds could highlight distinct trajectories or emphasize alternative stylistic dimensions. These considerations ensure that interpretations remain exploratory, emphasizing general tendencies rather than asserting deterministic causal relationships between stylistic change and script evolution. Researchers should treat these variables as analytical tools to operationalize theoretical constructs, rather than as absolute measurements.

Third, although all 400 artefacts from Susa, Tepe Yahya, and Konar Sandal were systematically analyzed, the selective presentation of diagnostically strong specimens in Tables 1, 2 and 3, and in figures reflects constraints of space and analytical clarity rather than data exclusion. Less extreme or ambiguous examples may reflect parallel practices, local experimentation, or short-lived stylistic deviations, which are not foregrounded in the reconstructions. The complete dataset, including coded variables, reconstruction diagrams, and supplementary visual materials, is openly archived at Zenodo (https://doi.org/10.5281/zenodo.17345251), enabling further exploration, comparative research, and reanalysis.

This study adopts Desset's Proto-Iranian framework as a provisional working model rather than a settled consensus. The evolutionary trajectories identified here, including increasing abstraction, motif-script integration, compositional standardization, and apparent branching tendencies, are contingent upon current chronological, epigraphic, and archaeological interpretations, and should therefore be understood as heuristic and open to revision in light of new data, alternative models, or complementary analytical approaches. By explicitly recognizing these caveats, the study balances methodological rigor with interpretive caution, clarifies the scope and limits of inference, and maintains coherence with its heuristic cultural-evolutionary framework and co-evolutionary emphasis.
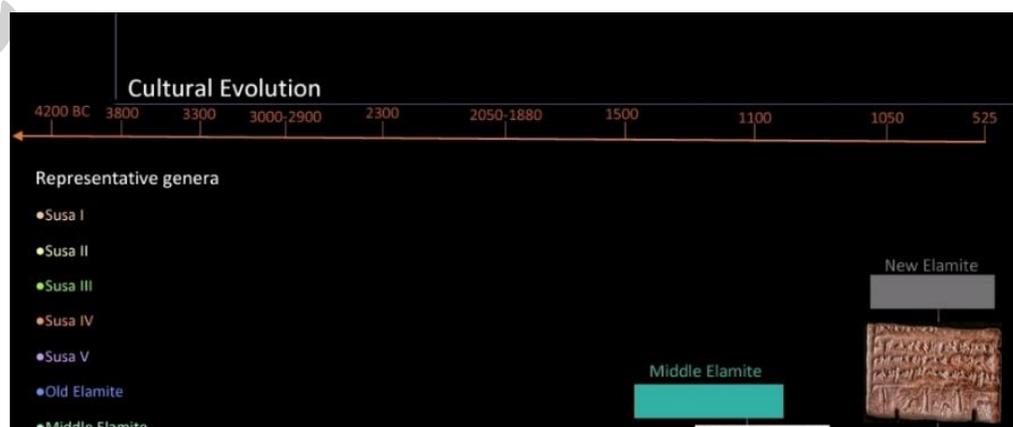
Table 2. Heuristic overview of the co-evolutionary dynamics between artistic styles and writing systems across Elamite periods. Source: Author, based on Matthews & Fazeli (2022) and Álvarez-Mon (2020).
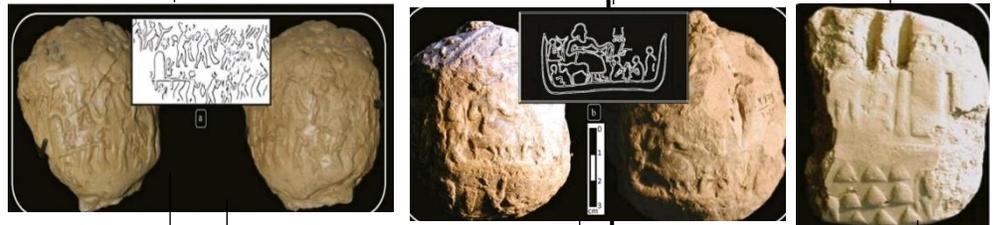
SUSA I, Sealing

4200-3800 BCE.

3800-3100 BC.

●Emergence of the numerical signs, on which there is witnessed motifs as well.

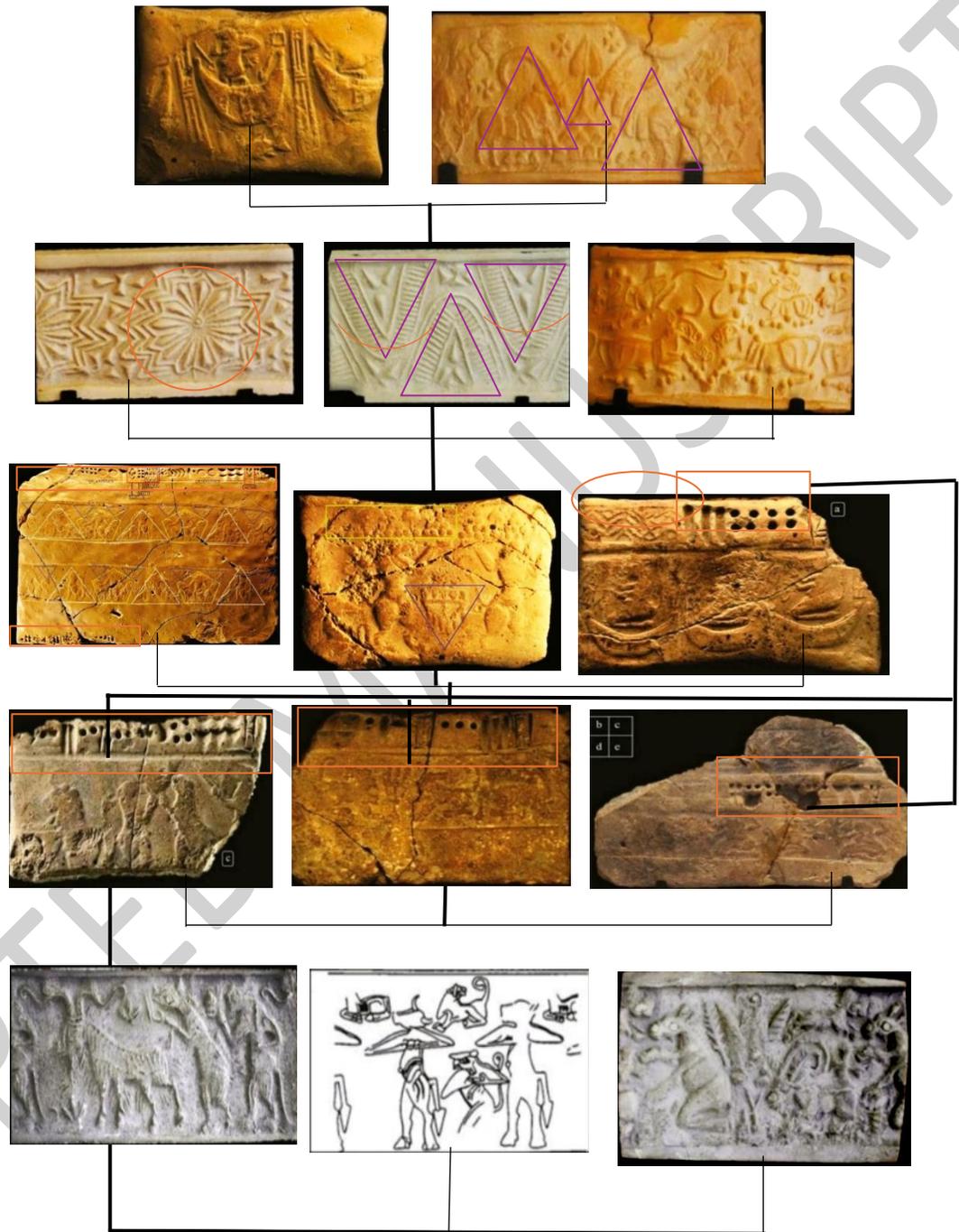●Decreasing the dispersal of motifs throughout sealing.
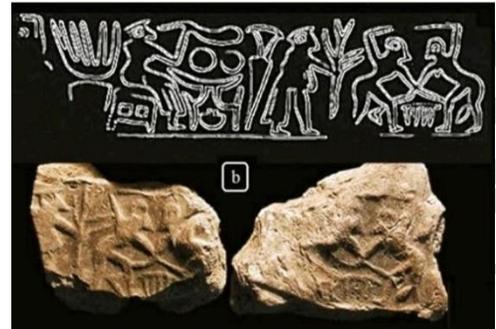
SUSA II, Sealing

3800-3100 BCE.

SUSA IV A, Sealing

2900-2200 BCE.

●Elimination of numerical sings.

●Emergence of narration after the Susa III.

●Advent of "symmetry"

●Dispersal of motifs throughout sealing equally

● Repetition as a key element in covering spaces
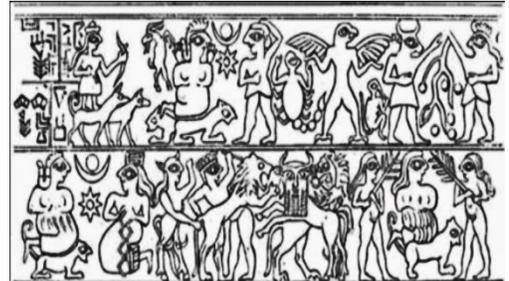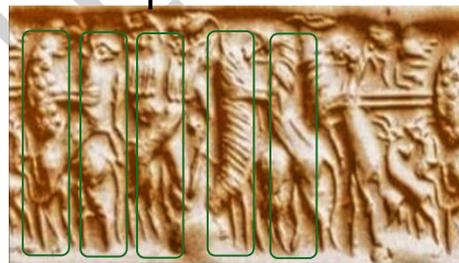
SUSA IV B, Sealing

2350-2100 BCE.

●Emergence of Writing signs after passing Susa IVA, which usually have been bounded by frames.

●After a while that ground and placing motifs on specific lines was not defined, we witness frames around the writing elements purposely. Accordingly, the order of motifs is in the same line which gives a most geometry and discipline, and consequently, decrease the dispersal of motifs.
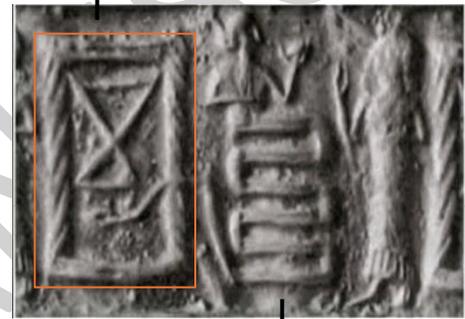
SUSA V B, Sealing
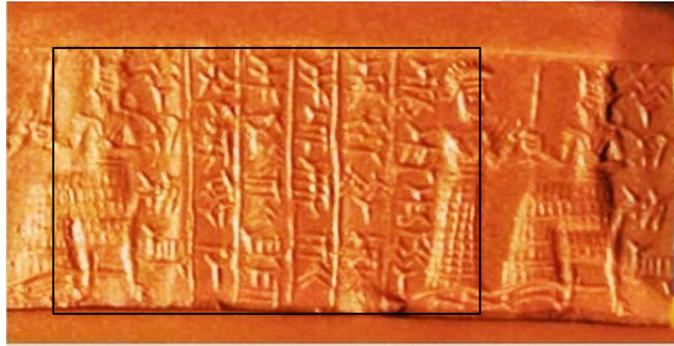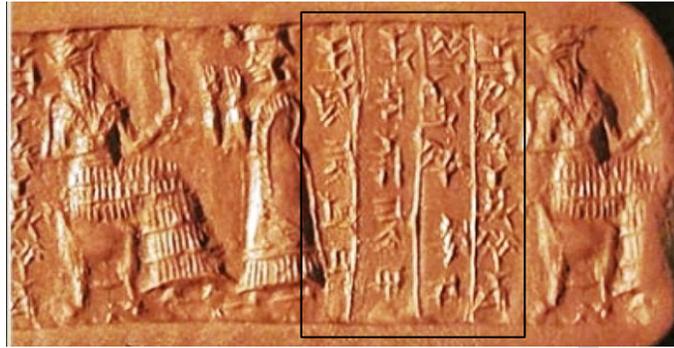
2050-1880 BCE.

Shimashki Period

= Ur III
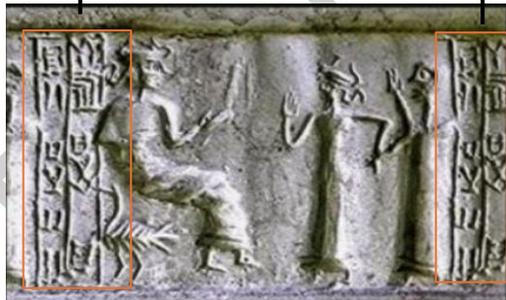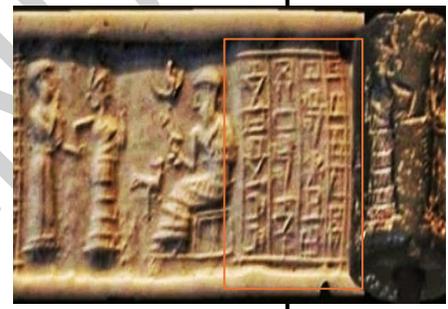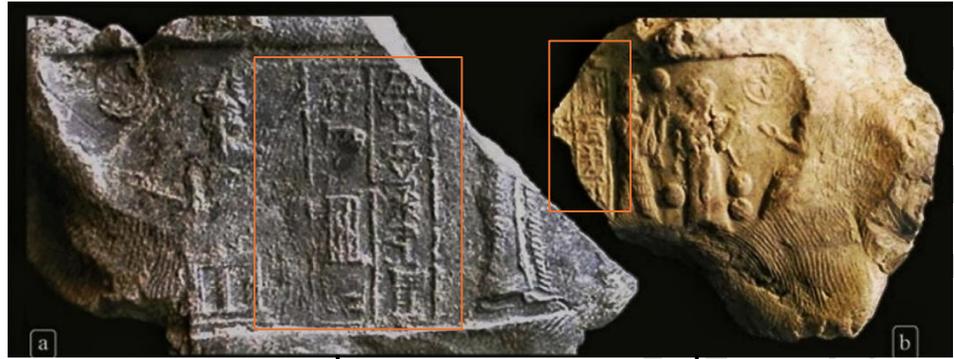
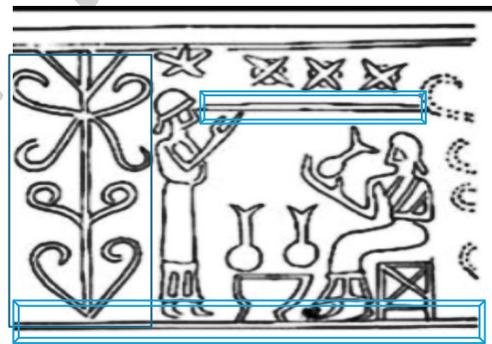Old Elam, Sealing

1880-1500 BCE.

Sukkalmakh
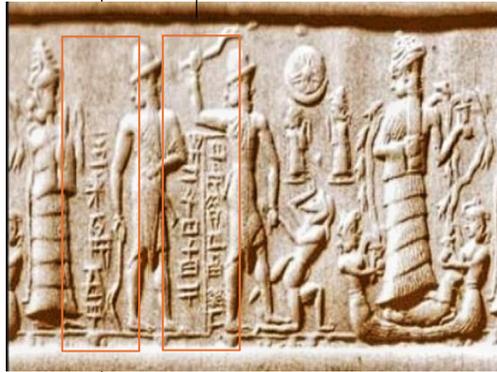
Old Elam, Glyptic

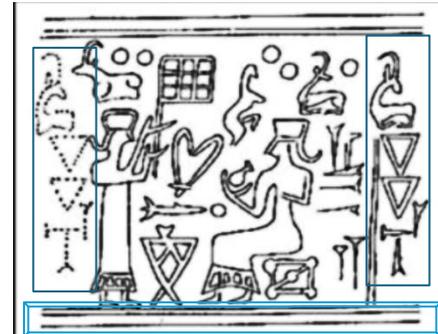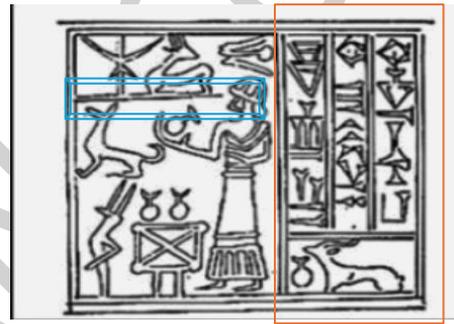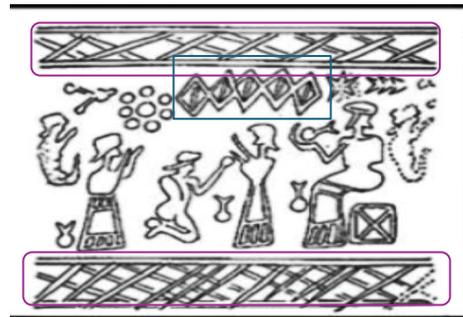1880-1500 BCE.

Sukkalmakh
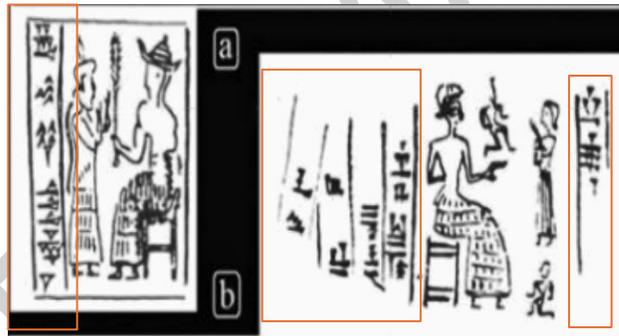
Middle Elam, Sealing

1880-1100 BCE.

Or, 1500-1100 BC.

Susa & Anshan
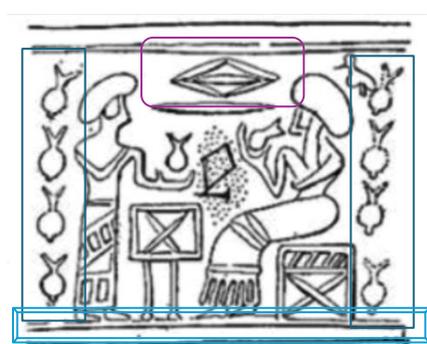
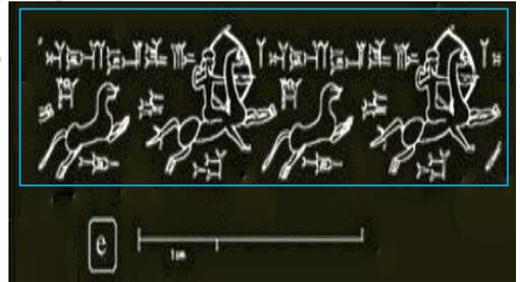New Elam, Sealing

1050-525 BCE.

Table 3. Heuristic cultural-evolutionary reconstruction of sealing styles illustrating directional trends and branching tendencies in the cultural evolution of visual forms. Source: Author, based on Matthews & Fazeli (2022) and Álvarez-Mon (2020).

Conclusion

Proto-Elamite artistic styles functioned as active extensions of cognition, distributing memory and practice across body, artefact, and environment. Visual and scriptural forms co-evolved, producing directional trends in abstraction, compositional geometry, motif–script integration, and stylistic complexity. Early phases (Susa I-III) emphasized figurative motifs, allowing narrative prominence alongside textual marks, while later Linear and Neo-Elamite phases show stronger structural interdependence between text and image, reflecting the growing spatial dominance of script. These developments demonstrate that stylistic and scriptural change were mutually constitutive rather than solely administratively driven. This argument does not seek to replace administrative or socio-economic explanations, but to situate them within a broader co-evolutionary framework in which material engagement and visual conventions operated alongside. Visual styles and material engagement did not act as isolated causal forces, but operated in continuous interaction with documented administrative pressures, jointly shaping the trajectories of abstraction, standardization, and transmission.

Manually generated heuristic reconstructions trace these co-evolutionary trajectories, highlighting continuity, divergence, experimentation, and selective retention without asserting discrete clades or formal homologies. Coding graded variables, including pictoriality-abstraction, motif-script integration, stylistic complexity, and compositional geometry, enabled systematic tracking of nuanced shifts, while selective presentation of diagnostically strong artefacts emphasizes broader trends without excluding local variation.

The Proto-Iranian script emerged through matter-mind-culture entanglement, where repeated mark-making and apprenticeship fostered new cognitive capacities and behavioral routines. Its eventual disappearance reflects shifting social and institutional pressures rather than cognitive regression. This heuristic framework not only clarifies the intertwined evolution of visual culture and cognition in Elamite society but also offers a transferable methodology for analyzing other early writing systems, emphasizing the enduring role of material engagement in shaping cultural persistence and transformation. Finally, it bears emphasis that the Proto-Iranian framework adopted from Desset is employed here as a productive and explicitly provisional working model rather than as a settled scholarly consensus. The evolutionary trajectories identified in this study, such as increasing abstraction, changing motif-script relations, and regional branching tendencies, remain contingent upon current chronological, epigraphic, and archaeological interpretations, and are open to revision as new evidence or alternative models emerge.

References

Álvarez-Mon, J. (2020). *The art of Elam ca. 4200–525 BC*. Routledge.

Algaze, G. (2008). *Ancient Mesopotamia at the dawn of civilization: The evolution of an urban landscape*. University of Chicago Press.

Boyd, R., & Richerson, P. J. (1985). *Culture and the evolutionary process*. University of Chicago Press.

Cooper, J. S. (2004). Babylonian beginnings. In S. D. Houston (Ed.), *The first writing: Script invention as history and process* (pp. 71–99). Cambridge University Press.

Dahl, J. L. (2009). Early writing in Iran. In C. Woods (Ed.), *Visible language: Inventions of writing in the ancient Middle East and beyond* (pp. 145–155). Oriental Institute Museum Publications.

Desset, F. (2025). Personal Communication.

Desset, F. (2016). Proto-Elamite writing in Iran. *Archäologische Mitteilungen aus Iran und Turan*, 48, 1–20. https://doi.org/10.3406/arnil.2016.1104

Desset, F. (2017). *Here ends the history of Elam: Toponomy, linguistics and cultural identity in Susa and south-western Iran, ca. 2400–1800 B.C.* Ugarit-Verlag.

Desset, F. (2021). Considerations on the history of writing on the Iranian Plateau (ca. 3500–1850 B.C.). *Journal of Archaeology and Archaeometry*, 1(1), 1–11. https://doi.org/10.30495/JAA.2022.694354

Farsi, M., & Hoseinzadeh Sadati, J. (2025). The fluidity of mind: The role of material culture as a mnemonic tool. *Journal of Archaeology of Iran*. https://sanad.iau.ir/en/Journal/aoi/Article/1205597

Fenici, M., & Garofoli, D. (2017). *The biocultural emergence of mindreading: Cognitive archaeology and human development*. Springer.

Garofoli, D. (2016). Cognitive archaeology and the evolution of mind. *Cambridge Archaeological Journal*, 26(3), 487–502. https://doi.org/10.1017/S0959774316000168

Henrich, J. (2016). *The secret of our success: How culture is driving human evolution, domesticating our species, and making us smarter*. Princeton University Press.

Henrich, J., & Boyd, R. (2002). On modeling cognition and culture: Why cultural evolution does not require replication of representations. *Journal of Cognition and Culture*, 2(2), 87–112. https://doi.org/10.1163/156853702320281836

Houkes, W. (2011). Cultural phylogenetics and the emergence of design. In P. E. Vermaas et al. (Eds.), *Artefact kinds: Ontology and the human-made world* (pp. 135–152). Springer.

Lewens, T. (2024). *Cultural selection*. Cambridge University Press.

Malafouris, L. (2004). The cognitive basis of material engagement: Where brain, body and culture conflate. In E. DeMarrais, C. Gosden, & C. Renfrew (Eds.), *Rethinking materiality: The engagement of mind with the material world* (pp. 53–62). McDonald Institute for Archaeological Research.

Malafouris, L. (2013). *How things shape the mind: A theory of material engagement*. MIT Press.

Malafouris, L. (2019). Mind and material engagement. *Phenomenology and the Cognitive Sciences*, 18, 1–17. https://doi.org/10.1007/s11097-018-9606-7

Malafouris, L., & Renfrew, C. (2010). Archaeology, material engagement and the extended mind. In *The cognitive life of things: Recasting the boundaries of the mind*. McDonald Institute for Archaeological Research.

Mann, M. (1986). *The sources of social power, Vol. 1: A history of power from the beginning to AD 1760*. Cambridge University Press.

Matthews, R., & Fazeli Nashli, H. (2022). *The archaeology of Iran: From the Palaeolithic to the Achaemenid Empire*. University of Reading Press.

Mesoudi, A. (2011). *Cultural evolution: How Darwinian theory can explain human culture and synthesize the social sciences*. University of Chicago Press.

Mesoudi, A. (2016). Cultural evolution: A review of theory, findings, and applications. *Evolutionary Biology*, 43(4), 481–497. https://doi.org/10.1007/s11692-016-9383-5

O'Brien, M. J., & Lyman, R. L. (2009). *Seriation, stratigraphy, and index fossils: The backbone of archaeological dating*. Springer.

Overmann, K. A. (2016). Beyond writing: The development of literacy in the ancient Near East. *Cambridge Archaeological Journal*, 26(2), 285–303.

Potts, D. T. (2004). Foundation texts and new research opportunities. In H. Crawford (Ed.), *The Sumerian world* (pp. 241–254). Routledge.

Renfrew, C. (2004). Towards a theory of material engagement. In E. DeMarrais, C. Gosden, & C. Renfrew (Eds.), *Rethinking materiality: The engagement of mind with the material world* (pp. 23–32). McDonald Institute for Archaeological Research.

Richerson, P. J., & Boyd, R. (2004). *Not by genes alone: How culture transformed human evolution*. University of Chicago Press.

Schmandt-Besserat, D. (2007). *When writing met art: From symbol to story*. University of Texas Press.

Straffon, L. M. (2019). Evolution and origins of visual art: An archaeological perspective. In A. M. Prentiss (Ed.), *Handbook of evolutionary research in archaeology* (pp. 319–338). Springer Nature. https://doi.org/10.1007/978-3-030-11117-5_16

Temkin, I. (2016). Homology and phylogenetic inference in biological and material cultural evolution. *Biological Theory*, 11(4), 213–225. https://doi.org/10.1007/s13752-016-0246-7

Whiten, A., Hinde, R. A., Laland, K. N., & Stringer, C. B. (2011). Culture evolves. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 366(1567), 938–948. https://doi.org/10.1098/rstb.2010.0372

Wynn, T., & Coolidge, F. L. (2017). *Cognitive models in Palaeolithic archaeology*. Oxford University Press.