

Paleoart as Epistemic Mediation and a Psychogenetic Device: Reconstruction of Fossil Species and Symbolic Formation in Educational Contexts

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Abstract

Paleoart is an interdisciplinary field at the intersection of the visual arts and the Earth sciences, devoted to the visual reconstruction of extinct organisms and ecosystems from fossil evidence. Although it is often perceived as a form of popular-science “illustration,” specialized scholarship has repeatedly emphasized that paleoart is integral to the epistemic culture of Paleontology, insofar as it translates anatomical, functional, and paleoenvironmental hypotheses into evaluable representations. Such representations can guide scientific communication and, in some cases, contribute to the formulation and refinement of interpretations—for example, by making gaps, inconsistencies, and anatomical choices explicit. At the same time, studies indicate that aesthetic and scientific decisions in paleoart are not always documented transparently, which can perpetuate inaccuracies across successive media cycles and reinterpretations. This article proposes an integrated Art–Paleontology–Education framework that conceptualizes paleoart production as (i) a reconstruction protocol grounded in evidential traceability (decision chains, levels of inference, and plausible alternatives) and (ii) a formative and diagnostic device inspired by the Educational Psychogenetics of Fr. Joaquim Ferreira Xavier Júnior, sjr.

Keywords: paleoart, epistemic mediation, inferential traceability, educational psychogenetics

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Introduction

Paleoart is a boundary practice between the visual arts and paleontology, responsible for making communicable hypotheses about the morphology, posture, integument, and ecosystems of extinct organisms on the basis of incomplete evidence. Images do not function as mere informational ornament; rather, they operate as a means of constructing and stabilizing reference: they organize what should be “seen” in the fossil record, which anatomical relations deserve emphasis, and which inferences may be accepted as plausible within a community of specialists (Daston & Galison, 2007; Latour, 1986). From an aesthetic standpoint, this entails recognizing that representation is not reducible to resemblance: it depends on symbolic systems, conventions, and shared rules of correctness through which a visual artefact can denote and exemplify properties without literally “copying” reality (Goodman, 1976). In cognitive and educational terms, reconstruction is also an exercise in coordinating perspectives and making criteria explicit, consistent with constructivist accounts of knowledge and with Piaget’s emphasis on the role of intellectual operations in building structures of understanding (Piaget, 1952).

Despite this relevance, paleoartistic production frequently faces a recurring methodological problem: the inferential layers that connect osteological evidence to non-preserved attributes (e.g., musculature, organs, skin, and feathers) are not always documented with sufficient clarity. This opacity facilitates the spread of anachronisms and the crystallization of visual solutions through repetition across media and subsequent reinterpretations. The specialized paleoart literature has therefore emphasized the need to make the reconstructive process explicit and to treat visual production as work with gaps, uncertainties, and distinct levels of inference, rather than presenting the final image as a mirror of the past (Witton, 2018). In the case of Phorusrhacidae, whose reconstructions require careful articulation between comparative anatomy and functional reconstruction, systematic revisions have shown how strongly the group’s taxonomic and morphological organization depends on rigorous analyses of fragmentary material and refined interpretations (Alvarenga & Höfling, 2003). This is the context in which the present article’s case study is situated, focusing on the artistic elaboration of the anatomy of *Paraphysornis brasiliensis*.

This article proposes an integrated Art–Paleontology–Education framework in which paleoart is understood both as traceable epistemic mediation and as a formative and analytical device inspired by the Educational Psychogenetics of Fr. Joaquim Ferreira Xavier Júnior, sjr. The psychogenetic emphasis shifts attention from the “visual product” to the decision-making and symbolization processes that constitute it, valuing the documentation of choices, the explicit statement of premises, and reflection on plausibility criteria as structuring dimensions of practice (Xavier Júnior, 2004).

The general objective of the study is to propose and demonstrate a paleoart reconstruction protocol grounded in evidential traceability, capable of making explicit levels of inference and alternative pathways in the transition from fossil to image. As specific objectives, the study applies the protocol to a case study devoted to *Paraphysornis brasiliensis*, articulating classical and digital art techniques in the modelling of anatomical and integumentary layers, with an explicit justification for each reconstructive choice.

Paleoart as an Epistemic Culture

Paleoart can be understood as a regime of visualization situated between scientific illustration and disciplined imagination, in which the image functions as an instrument for synthesizing and communicating paleontological hypotheses, producing what may be described, in epistemological terms, as socially negotiated “visual evidence.” Such evidence does not arise from the object’s immediate transparency, but rather from a set of conventions, techniques, and collective criteria that organize perception, hierarchize anatomical traits, and assign relevance to particular morphological relations—bringing paleoart close to the traditions of atlases, diagrams, and scientific figures that helped shape modern objectivity (Daston & Galison, 2007). From this perspective, a paleoart image does not merely represent an extinct organism; it stabilizes a way of reading the fossil record, enabling specialists and non-specialists alike to compare, discuss, and revise interpretations through a shared visual artefact.

However, because it depends on a structurally incomplete fossil record, paleoart operates under conditions of lacunarity: fossils preserve limited portions of an organism and often remain silent precisely about aspects that are decisive for reconstruction (integument, coloration, feather patterns, fine muscular volumes, soft tissues, and many behavioral markers). Consequently, image production requires a continuum of inferences ranging from direct evidence (e.g., measurable osteological proportions) to comparative inference (analogies with extant taxa that are phylogenetically close or functionally analogous) and to controlled hypothesis (plausible but unconfirmable elements). This passage entails commitments to plausibility and to rules of correctness that are not purely “empirical”: they involve representational and symbolic choices, insofar as scientific representation denotes and organizes properties through conventional systems rather than reducing itself to photographic resemblance (Goodman, 1976). By making these levels explicit, paleoart renders visible the inferential structure of paleontology itself, exposing—in visual language—what is demonstrable, what is probable, and what remains conjectural.

It is precisely here that recurring problems emerge in the circulation of reconstructions. A first risk is visual anachronism: the inadvertent projection of contemporary stereotypes (skin patterns, popular “textures,” arbitrary chromatic choices, or poses derived from cultural imaginaries) onto organisms for which the evidence does not authorize such details. A second risk is the copy effect, whereby visual solutions become tacit models and are replicated in cascade (across museums, books, documentaries, and the internet), producing the stabilization of errors: what is repeated comes to appear “true,” even when it originated in a fragile choice or an insufficiently examined convention. The practical literature on paleoart has warned against this phenomenon by insisting that reconstructions should be treated as visual hypotheses rather than portraits, and that public and academic trust depends on clarity regarding what counts as evidence and what counts as inference (Witton, 2018).

In response to these challenges, best practices have emerged that reposition paleoart as an auditable and cumulative production. Among them are: systematic documentation of decisions (e.g., anatomical sheets, decision logs, and the bibliography used), image versioning (with records of changes prompted by new evidence or specialized critique), and explicit justification of inferential layers—preferably through captions or uncertainty maps distinguishing what is supported by fossil material from what is reconstructed by analogy or hypothesis. Taken together, these practices bring paleoart closer to an ethics of methodological transparency: the goal is not to eliminate imagination—an inevitable element in lacunar records—but to

discipline it and make it criticizable, allowing the image to fulfill its epistemic function without concealing the conditions of its production (Daston & Galison, 2007; Witton, 2018).

Symbolic Mediation, Educational Psychogenetics, and the Coordination of Perspectives

In the humanities and the arts, the notion of symbolic mediation refers to the set of operations through which experience is organized into shareable forms of meaning. It is not an accessory added after knowledge, but rather a condition of possibility for something to become intelligible, communicable, and criticizable. This point becomes particularly important when research relies on objects that are not immediately available to direct observation, or whose intelligibility depends on reconstruction, as is the case with paleoart. Here, the image functions as a symbolic form that condenses decisions, perceptual hierarchies, and publicly shared criteria of correctness, enabling a community to compare, revise, and debate hypotheses (Cassirer, 1944; Goodman, 1976).

The “scientific gaze” is not a natural given but a historically and culturally constituted competence. In artistic traditions, training the gaze involves learning to perceive relevant differences (proportion, rhythm, volume, contrast, texture), distinguishing what is essential from what is incidental, and recognizing styles, techniques, and conventions. In scientific traditions, it involves learning to stabilize an object through selections, instruments, and representations, as well as internalizing procedures of validation and contestation. The convergence of these two axes is crucial for understanding paleoart: the paleoartist does not “see” the extinct animal in the fossil as if the image were already contained within it; what is seen is a constructed visual hypothesis, which must be disciplined by evidence and made feasible through compositional resources and the grammar of visual language (Daston & Galison, 2007; Mitchell, 1994).

Two implications follow from this conception. First, every paleoart image carries a grammar: choices of framing, pose, scale, environment, “finish,” and texture are not neutral; they guide the observer’s inferences and generate cognitive effects of naturalization. Second, symbolic mediation can be objectified and documented: the image-making process can be described as a decision chain with premises, alternatives, and constraints, shifting paleoart from the domain of the “final result” to that of an auditable epistemic practice. This shift is necessary because it allows visual language to be integrated into an explicit inferential regime, in which plausibility is not merely a “sense of verisimilitude” but a methodologically sustained property (Daston & Galison, 2007; Goodman, 1976).

The Educational Psychogenetics of Fr. Joaquim Ferreira Xavier Júnior: Foundations and Relevance

The Educational Psychogenetics of Fr. Joaquim Ferreira Xavier Júnior, sjr, can be understood as an interpretive framework for human development and learning that systematically emphasizes the interaction between subject and object, the centrality of the body as an operative condition for knowing, and the need to observe processes (rather than only products) in order to understand the genesis of meaning. In this formulation, “learning” is not merely the accumulation of content, but the reorganization of modes of interaction, the expansion of repertoires of action, and the elevation of the level of reversals applied to external and internal objects—that is, the capacity to go back and forth over the same object from distinct angles, refining one’s relation to it (Xavier Júnior, 2004).

A particularly fruitful core for the present research lies in the way Xavier describes curiosity and understanding as functions of a repertoire of reversals. Knowing is not equivalent to “capturing” an object; it is the capacity to sustain cycles of return to it, gradually producing a finer differentiation of its properties and relations. The metaphor of spiral movement underscores that repetition is not mere repetition: it is a return that reconfigures the subject, because the subject is transformed as they assimilate the object and reorganize their strategies of interaction (Xavier Júnior, n.d.). This point is highly relevant to paleoart: a well-grounded reconstruction does not emerge from a single decision, but from an iterative circuit of approximations, revisions, and re-evaluations, in which the same set of evidence can be “re-encountered” under new criteria—for example, when new functional comparisons are introduced, when posture is tested against biomechanical constraints, or when integumentary layers are reassessed in light of new hypotheses.

Another relevant foundation is the psychogenetic emphasis on the body as a structuring dimension of knowing. Xavier’s discussion of proprioception proposes a distinction between proprioception that is merely physiological (as a form of registration) and a psychogenetic proprioception understood as a founding action: the subject acts, apprehends their own modification, and integrates that modification as part of their operative structure (Xavier Júnior, 2004). Methodologically, this implies recognizing that symbolic production (including image production) is inseparable from a regime of bodily and perceptual actions: drawing, modelling, cutting, overlaying layers, comparing proportions, and testing poses are actions that generate information, because they reorganize the perceptual field and make explicit incompatibilities or gaps that would not appear in purely verbal interpretation.

The relevance of this framework to the article’s proposal is therefore direct: Educational Psychogenetics provides a language for describing reconstruction as process, making it possible to treat paleoart as a practice of progressive interaction and self-regulation of judgment. Rather than restricting the discussion to the “degree of realism” of the final product, it becomes possible to examine the regime of reversals, the coordination of evidence, and the documentation of choices, within a perspective that understands learning (for both the paleoartist and the audience) as the reorganization of structures of meaning (Xavier Júnior, 2004).

Articulation With Piaget: Assimilation/Accommodation and the Coordination of Perspectives

The Piagetian lineage that runs through Xavier’s Psychogenetics can be made explicit through three operators: assimilation, accommodation, and the coordination of perspectives. In Piaget, assimilation refers to the incorporation of the object into already available schemes of action and thought; accommodation refers to the modification of those schemes when the object resists—that is, when interaction generates disequilibrium and requires reorganization. Knowledge, in this framework, is a constructive process oriented by successive equilibrations rather than a passive mirroring of reality (Piaget, 1952; Piaget, 1970).

Table 1

Operational Synthesis of Piagetian Concepts of Assimilation, Accommodation, Disequilibrium, and Equilibration: Definitions, Effects on the Subject, Observable Indicators, and an Example Applied to the Paleoart Reconstruction Process

Concept (Piaget)	Concise definition	What happens in the subject	Typical indicator (sign it is occurring)	Example applied to paleoart reconstruction
Assimilation	Incorporation of the object into already available schemes of action and thought (Piaget, 1952).	The subject interprets the new object through prior structures, using consolidated repertoires and models.	Rapid recognition; direct application of a “known model”; sense of continuity (“I already know what this is like”).	The author initially adopts a standard musculature model from extant cursorial birds to guide volumes and insertion points, because this scheme already “fits” their reading of the fossil.
Accommodation	Modification of schemes when the object resists, generating disequilibrium and requiring reorganization (Piaget, 1952).	The subject changes the scheme to address constraints and incompatibilities posed by the object, producing a better-adjusted structure.	Emergence of conflict (“it doesn’t fit”); need to revise proportions/hypotheses; reformulation of the drawing/model.	The initially proposed posture proves unfeasible when certain bone articulations impose movement limits; the author reconfigures the trunk axis and redistributes body mass to respect anatomical constraints.
Equilibration (successive equilibria)	Regulatory process coordinating assimilation and accommodation, producing provisional stability at increasingly complex levels (Piaget, 1970).	The subject seeks a new equilibrium, integrating modified schemes and increasing the internal coherence of interpretations.	More robust provisional stability; greater consistency among parts; fewer contradictions; ability to justify choices.	After successive revisions, the final reconstruction remains coherent across skeleton, musculature, volumes, integument, and environment, with justifications for each layer and an indicated level of inference.
Disequilibrium (perturbation)	Cognitive tension caused by a discrepancy between the subject’s expectations and the object’s properties, triggering reorganizations (Piaget, 1970).	The subject identifies flaws, gaps, and contradictions; understanding enters a revision state.	Productive doubt; need to test alternatives; search for new comparisons and sources.	Comparative evidence suggests the proposed feather/skin solution is incompatible with the presumed ecology; the author revises the integument and records plausible alternatives in distinct versions.

When transposed to the problem of paleoart, this framework makes it possible to characterize with precision what takes place in responsible reconstructions. The paleoartist assimilates when using already consolidated patterns (for example, comparative anatomical models, musculature repertoires based on cursorial birds, and conventions for the representation of feathers). Accommodation occurs when fossil evidence or functional constraints require a reconfiguration of the model: a joint does not allow a certain range of motion; a cranial proportion imposes a different mass distribution; an integumentary hypothesis conflicts with aerodynamic or ecological demands. The reconstruction process, in this sense, is a sequence of equilibria and disequilibria between representational schemes and empirical constraints (Piaget, 1952; Witton, 2018).

Table 2

Operational Definitions, Effects on the Subject, Observable Indicators, and Examples Applied to Paleoartistic Reconstruction for the Concepts of Assimilation, Accommodation, Disequilibrium, and Equilibration, According to Fr. Xavier's Psychogenetics

Concept (in operational terms)	Synthetic definition in the Psychogenetics of Fr. Joaquim Ferreira Xavier Júnior	What occurs in the subject	Typical indicator (sign that it is happening)	Example applied to the process of paleoartistic reconstruction
Assimilation	Assimilation is understood as an act of the subject: it is not the object that "acts" upon the subject, but rather the subject who assimilates the object and is modified by it, including at the sensorimotor and interpretive levels (Xavier Júnior, 2004).	The subject incorporates the object into his or her field of interaction, mobilizes an "organ"/structure, and registers, through action itself, the modification that the object produces as an effect of its assimilation.	The subject "grasps" the object through successive approximations and recognizes that he or she has been transformed through the interaction (greater capacity to discriminate, compare, and sustain focus).	At the beginning of the reconstruction, the author assimilates the fossil material through measurements, comparison of proportions, and pose testing; with each round of work, changes become apparent in the author's own criterion for anatomical reading (greater precision and less visual guesswork).
Accommodation (reorganization through reversal)	The reorganization of the subject occurs through reversals: going toward the object and returning, repeatedly, from different angles, thereby refining the interaction; reversal, in Xavier, is a central mechanism for expanding the capacity for interaction and constitutes the basis of psychogenetic pedagogy (Xavier Júnior, 2004).	The subject alters internal strategies: redoes perceptual pathways, adjusts hypotheses, and reconfigures actions in order to deal with newly perceived characteristics of the object.	Deliberate revisions emerge: "returning to the object from another angle," comparing alternatives, reworking layers, and incorporating constraints that had previously been ignored.	The author changes the initial musculature/volume scheme upon identifying incompatibilities with the skeleton and returns to the fossil and to comparative analogies, reconfiguring the solution in successive versions.
Disequilibrium (limit of the repertoire)	The "limit" appears when the repertoire of back-and-forth movements over the object is exhausted; upon reaching this limit, curiosity weakens, because there are no longer enough available reversals to sustain the interaction (Xavier Júnior, 2004).	The subject encounters an operational barrier: he or she cannot move forward while maintaining the same repertoire of actions, and must expand internal discipline, method, or repertoire in order to continue.	A feeling of stagnation; unproductive repetition; difficulty sustaining focus and generating new operational questions about the object.	When attempting to define integument and feathers without sufficient constraints, the author perceives stagnation and the risk of anachronism: this signals the limit of the repertoire and requires the search for new comparisons, functional constraints, and explicit documentation of the degree of inference.
Equilibration (provisional stabilization through the discipline of inner space)	Stabilization results from disciplining reversals (including those directed toward "internal objects"), thereby creating conditions for repose and consistency in the work: improving the speed and quality of reversals improves interaction; and inner	The subject reaches a provisional level of consistency: integrates choices, controls interferences, sustains focus, and is able to justify decisions with greater internal unity.	Increasing coherence; reduction of contradictions between layers; ability to record decisions and maintain the method without "drifting" into fantasy.	The author stabilizes a version in which pose, volumes, musculature, and integument remain consistent; produces dissected plates with anatomical layers and inference legend, preserving a record of decisions and justifications.

life (inner space) is
described as the
discipline of applying
the repertoire of
reversals in an ordered
manner (Xavier Júnior,
2004).

The coordination of perspectives emerges as the key operation that transforms reconstruction into an epistemic practice. We do not conceive of “perspective” merely in spatial terms, but rather as an inferential point of view: direct evidence; comparative inference; controlled hypothesis; and aesthetic choices of presentation. The maturity of the process lies in not collapsing these layers into a uniform appearance of certainty. The Piagetian articulation is useful because it emphasizes reversibility and decentration as criteria of advancement: being able to “return” to the object, reassess a solution, and coordinate different invariants within a more comprehensive system. Educational Psychogenetics, as developed by Xavier, reinforces and expands this point by insisting that the repertoire of reversals is a condition for deepening interaction and expanding the inner space of analysis, thereby distinguishing free fantasy from effective work on an object, even when that object is partly internal and symbolic (Piaget, 1970).

The convergence from Piaget to Xavier is not merely a genealogical reference, but a device for formalizing method: paleoart can be described as a process of constructing visual invariants under constraints, through successive accommodations and with explicit coordination of inferential perspectives. This formalization makes it possible to establish criteria of quality that go beyond aesthetic taste and move closer to epistemic criteria: traceability, reversibility (the capacity for revision), and suggested coherence (the capacity to maintain internal consistency among anatomy, function, and environment).

Educational Implications: From the Visual Product to the Documented Cognitive Process

The most relevant educational consequence of the framework proposed here is a shift in emphasis: from the final image as an “answer” to the process as an “object of learning.” In terms of visual culture, this means redirecting attention from the immediate impact of the figure to the architecture of decisions that sustains it; in psychogenetic terms, it means redirecting attention from apparent performance to the operations that are mobilized: how the subject selects evidence, how constraints are hierarchized, how gaps are handled, how premises are made explicit, and how self-regulation takes place in the face of inconsistencies (Xavier Júnior, 2004; Piaget, 1952).

This transition from product to process has at least four practical implications for the paleoart model:

Table 3

Methodological-Psychogenetic Implications of the Paleoart Protocol: From the Final Image to the Documented Process

Implication	Synthetic formulation	Methodological function in the protocol	Psychogenetic gain	Recommended evidence/artifacts
1. Documentation as an extension of the method	Documentation is not external bureaucracy, but a constitutive part of the rationality of reconstruction, since it makes explicit the chain of decisions and the degree of inference involved in each layer.	It makes the process open to critique and transmissible; reduces inferential “leaps”; enables the auditing of premises and alternatives.	It externalizes the “inner space”: making explicit what would otherwise remain unexamined intuition expands the capacity for reversal upon one’s own procedure (Xavier Júnior, 2004; Daston & Galison, 2007).	Decision log; anatomical record sheet; list of discarded alternatives and reasons; layered legend (skeleton, musculature, organs, integument, feathers).
2. Versioning as a form of reversibility	Versioning institutionalizes the possibility of returning, correcting, and reworking without erasing the history of reasoning.	It prevents uncritical stabilization; allows the incorporation of new evidence; preserves the traceability of changes over time.	A version functions as a marker of a spiral: a return to the same object at a reorganized level of interaction, with an improved repertoire of reversals (Piaget, 1970; Witton, 2018; Xavier Júnior, 2004).	Version control (V1, V2, V3...); revision notes; side-by-side comparison; repository organized by dates and criteria.
3. Explicit marking of uncertainty as visual literacy	Uncertainty is treated as information: distinguishing direct evidence, comparative inference, and controlled hypothesis improves the reading of the image.	It increases transparency; prevents the aesthetic “certainty effect”; improves scientific and museological communicability.	It trains the coordination of perspectives: it prevents the improper assimilation of heterogeneous layers as though they had the same status (Daston & Galison, 2007; Goodman, 1976).	Uncertainty maps; legend indicating degree of inference; layer-based coding; methodological notes attached to the final plate.
4. Integration between gesture, perception, and judgment	The process includes a material regime of actions (sketching, measuring, comparing, overlaying, rotating, testing volume) that produces understanding, even in digital art.	It provides an operational anchoring for choices; enables validation through visual and functional tests; reduces arbitrariness in reconstructive details.	Proprioception as a founding action: making explicit the regime of actions renders visible how the subject is modified while interacting with the object and how judgment is disciplined (Piaget, 1952; Xavier Júnior, 2004).	Step-by-step records (screenshots, photos, timelapse); measurement and comparison protocols; process journal; methodological narratives by phase.

The psychogenetic foundation, especially in Xavier, supports the argument by demonstrating how paleoart can be treated as a form of symbolic mediation with epistemic status when reconstruction is conceived as an iterative process of interaction and when this process is documented in such a way as to make visible the operations that constitute it. This perspective does not reduce art to science, nor science to art; rather, it makes explicit the productive point of contact between the two: the capacity to cultivate a way of seeing that can recognize gaps, sustain reversals, coordinate perspectives, and justify choices in the face of incomplete evidence (Piaget, 1970; Witton, 2018; Xavier Júnior, 2004).

Artistic Elaboration of the Anatomy of *Paraphysornis Brasiliensis*

The shift from the “visual product” to the “documented cognitive process” constitutes the operational core of this framework, since it displaces paleoart from a logic of result (the final image as a silent synthesis) to a logic of procedure (reconstruction as an explicable chain of decisions). This shift is consistent with Piaget’s understanding that knowledge is not reducible to a passive mirroring of reality, but is instead organized through successive equilibria, in which schemes of action and thought are reconfigured as the object resists and demands reorganization (Piaget, 1952, 1970). At the same time, it is aligned with the Educational Psychogenetics of Fr. Joaquim Ferreira Xavier Júnior, S.J.R., insofar as it emphasizes reversibility and the “back-and-forth” movement over the object as a condition for deepening interaction and expanding judgment, thereby transforming repetition into a spiral of refinement (Xavier Júnior, 2004).

In the field of paleoart, this repositioning demonstrates that reconstruction should not be interpreted as a “portrait” of the past, but as a visual hypothesis composed of different layers, each supported by distinct degrees of evidence and inference. This perspective is in dialogue with the history of practices of objectivity and with the idea that scientific images are part of normative regimes of seeing and proving, in which credibility depends both on method and on the devices of visualization and validation (Daston & Galison, 2007). From an aesthetic-semiological point of view, representation is not reducible to resemblance; it depends on conventions and on criteria of public correctness through which a visual artifact denotes and organizes properties of the object, even when the object is partially inaccessible (Goodman, 1976). For this reason, the educational and epistemic gain lies not only in producing a convincing image, but also in making intelligible the path that led to it.

Below, four implications of the protocol are systematized, formulated so as to operate as principles of methodological design, quality criteria, and devices for the formation of the scientific gaze.

Figure 1

*Set of Evidence/Reference Elements Used for the Reconstruction of *Paraphysornis Brasiliensis*, With Indication of the Directly Observable Anatomical Constraints*



First Implication: Documentation as an Extension of the Method

If paleoartistic reconstruction is a circuit of reversals, documentation cannot be treated as external bureaucracy or as an editorial appendix. It is a constitutive part of the rationality of the process, because it transforms a sequence of tacit choices into a chain that can be criticized and transmitted. In psychogenetic terms, this record operates as an exteriorization of the “inner space”: what would otherwise remain as unexamined intuition is converted into an object of return and revision, thereby increasing the capacity for reversal upon the procedure itself (Xavier Júnior, 2004). From the standpoint of scientific visual culture, this movement is equivalent to reintroducing into the final artifact the conditions of its production, bringing the image closer to a standard of methodologically sustained objectivity (Daston & Galison, 2007).

Documentation should record, at a minimum, four classes of information: (i) direct evidence and material constraints; (ii) comparative analogies employed; (iii) plausible alternatives considered and reasons for their rejection; and (iv) the degree of inference involved in each layer (skeleton, musculature, organs, integument, and feathers). This decomposition is decisive for the case study of *Paraphysornis brasiliensis*, because it allows the plates and images to appear not as a “homogeneous certainty,” but as a stratified and auditable synthesis.

Second Implication: Versioning as a Form of Reversibility

The culture of versions, consolidated in scientific and technological practices, can be understood as the institutionalization of reversibility: the possibility of returning, correcting, and reworking without erasing the history of the reasoning process (Piaget, 1970). In the context of paleoart, this is crucial for two reasons. First, because it reduces the risk of uncritical stabilization of visual solutions that become “standards” merely through repetition. Second, because it allows the incorporation of new evidence and specialized criticism without turning the image into dogma.

In psychogenetic terms, versioning materializes the idea of a spiral: one returns to the same object, but at a reorganized level of interaction, with a refined repertoire of reversals and greater consistency of judgment (Xavier Júnior, 2004). What is at stake is the conversion of the revision process into a constitutive element of the method, rather than a punctual correction. The practical literature on paleoart reinforces that reconstructions frequently depend on controlled iterations and revisions, especially when dealing with animals whose soft tissues and integument require cautious inference (Witton, 2018).

In the case study, it is recommended that versions be organized so that they are minimally distinguishable by purpose: an “anatomical” version (focused on osteomuscular coherence), an “integumentary” version (hypotheses concerning skin and feathers), and a “scenic” version (environment and lighting), each with its own history of alterations and justifications. This arrangement makes it possible to separate revisions of different natures and prevents cosmetic changes from obscuring conceptual changes.

Third Implication: Explicit Marking of Uncertainty as Visual Literacy

One of the most recurrent weaknesses in widely disseminated paleoartistic images is the “certainty effect” produced by homogeneous visual finishing. When all layers appear with the same degree of definition, the observer tends to infer that they all possess the same evidentiary status. The protocol proposed here reverses this logic: uncertainty is treated as information, not

as a flaw. Legends indicating degree of inference, uncertainty maps, and the explicit distinction between direct evidence, comparative inference, and controlled hypothesis qualify the reading of the image and improve both scientific and museological debate (Witton, 2018).

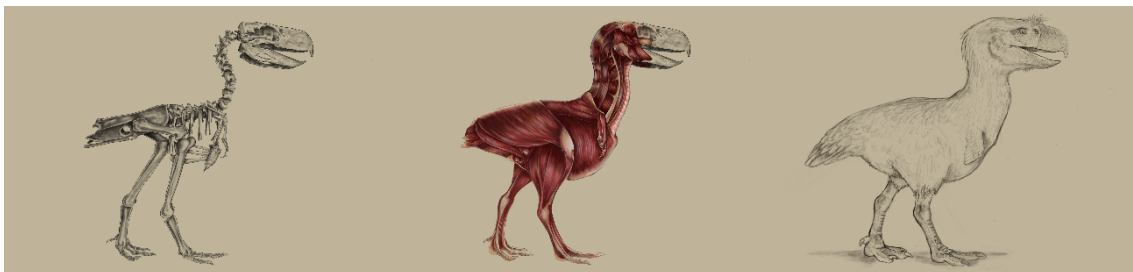
Figure 2

Paraphysornis Brasiliensis: Osteological Layer (Base)



Figure 3

Comparison Between V1, V2, and V3 Versions of the Reconstruction of Paraphysornis Brasiliensis



From an aesthetic-semiological point of view, this procedure is defensible because representational power does not depend on concealing conditions of reference; rather, it may gain density by making visible the structure of denotation and the symbolic commitments that sustain representation (Goodman, 1976). In psychogenetic terms, explicit marking functions as a discipline of the inner space: it limits the slide into “visual fantasy” and preserves critical reversibility over each layer (Xavier Júnior, 2004).

Figure 4

Paraphysornis Brasiliensis: Muscular and Volumetric Layer



Figure 5

Paraphysornis Brasiliensis: Integumentary Layer (Skin and Feathers)



Fourth Implication: Integration Between Gesture, Perception, and Judgment

The fourth implication places the body and materiality back at the center of the method. Even when the final product is digital, reconstruction depends on a regime of actions: sketching, measuring, comparing, overlaying, rotating models, testing shadows and volumes, and verifying functional coherence. In Xavier, this foundation gains its own formulation by emphasizing proprioception and founding action as structuring elements in the constitution of the subject and in the subject's capacity for interaction, reinforcing that knowing implies modifying oneself through active assimilation and disciplining the return to the object (Xavier Júnior, 2004).

Making the regime of actions explicit is a component of validity. When the process records which tests were carried out (for example, checking proportions, compatibility of articulations

with the pose, and coherence between muscular volume and osteological support), the reconstruction approaches a standard of visual argumentation that allows critique and replication.

Conclusion and Final Considerations

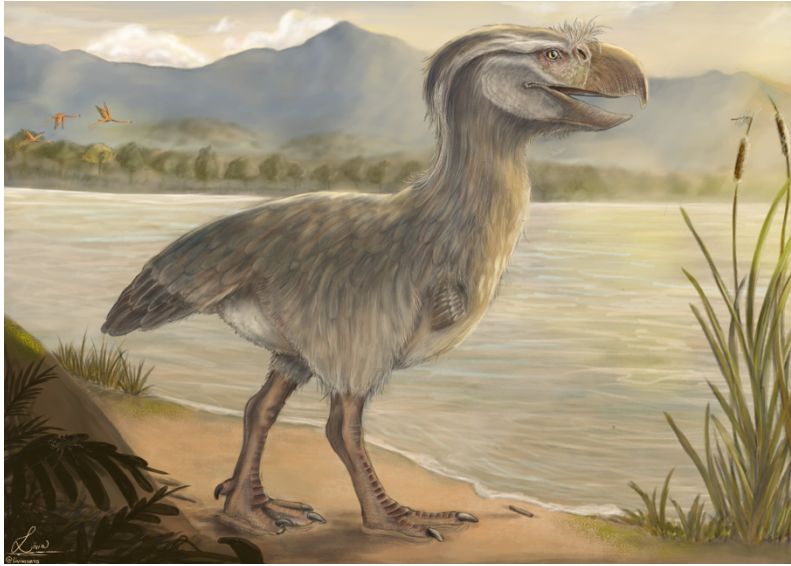
Paleoart can be treated as an epistemic mediation insofar as it transforms incomplete evidence from the fossil record into visually assessable representations capable of organizing anatomical, functional, and paleoenvironmental hypotheses in a way that is comparable, debatable, and revisable. In terms of scientific visual culture, the main contribution of this protocol is to relocate the credibility of the image onto the axis of method, bringing it closer to a regime of objectivity grounded in procedures and in transparency regarding the conditions of production (Daston & Galison, 2007). In aesthetic-semiological terms, this article reinforces that representation does not depend on imitating the real, but on operating through systems of reference and public correction, so that the image gains density when it makes explicit the structure of its choices and inferences (Goodman, 1976).

The psychogenetic reading of the process offers the distinctive axis of this article. By grounding reconstruction as a circuit of reversals and as the discipline of returning to the object, the Educational Psychogenetics of Fr. Joaquim Ferreira Xavier Júnior, S.J.R., makes it possible to understand paleoartistic elaboration as a practice of symbolization constructed through progressive interaction, rather than through isolated intuition. The central point is that the quality of reconstruction depends less on “talent” understood as a gift and more on the organization of inner space: the capacity to return to the same object from different angles, expand repertoires of comparison, sustain focus, and make explicit the decisions that, if left undocumented, would remain mere impressions. This conception converges with Piaget’s constructivist perspective, but gains particular emphasis in Xavier by transforming reversibility into an operational and formative criterion (Xavier Júnior, 2004). This protocol describes a way of forming judgment.

As future research, we understand that the following are necessary in order to strengthen this protocol: (i) inter-rater validation studies, comparing the judgments of paleontologists and paleoartists regarding the same set of evidence; (ii) reception studies, examining how different audiences interpret uncertainty markings and inference maps; (iii) replicability tests, in which different teams reconstruct the same taxon using the same protocol; and (iv) expansion to new taxa and new media, such as 3D models, augmented reality, and interactive plates, with methodological triangulation among comparative anatomy, biomechanics, and scientific visualization.

Figure 6

Paraphysornis Brasiliensis: Final Dissected Plate With Layers



Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

The author declares that Grammarly, an AI-assisted writing software, was used in proofreading and refining the language used in the manuscript. Its use was limited to correcting grammatical and spelling errors and rephrasing statements for accuracy and clarity. The author further declares that, apart from Grammarly, no other AI or AI-assisted technologies were used to generate content in the writing of this manuscript. The ideas, design, procedures, findings, analyses, and discussion were originally written and derived from the careful and systematic conduct of the research.

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