
Holons and Sopans: A Dual Ontology of Structure and Manifestation

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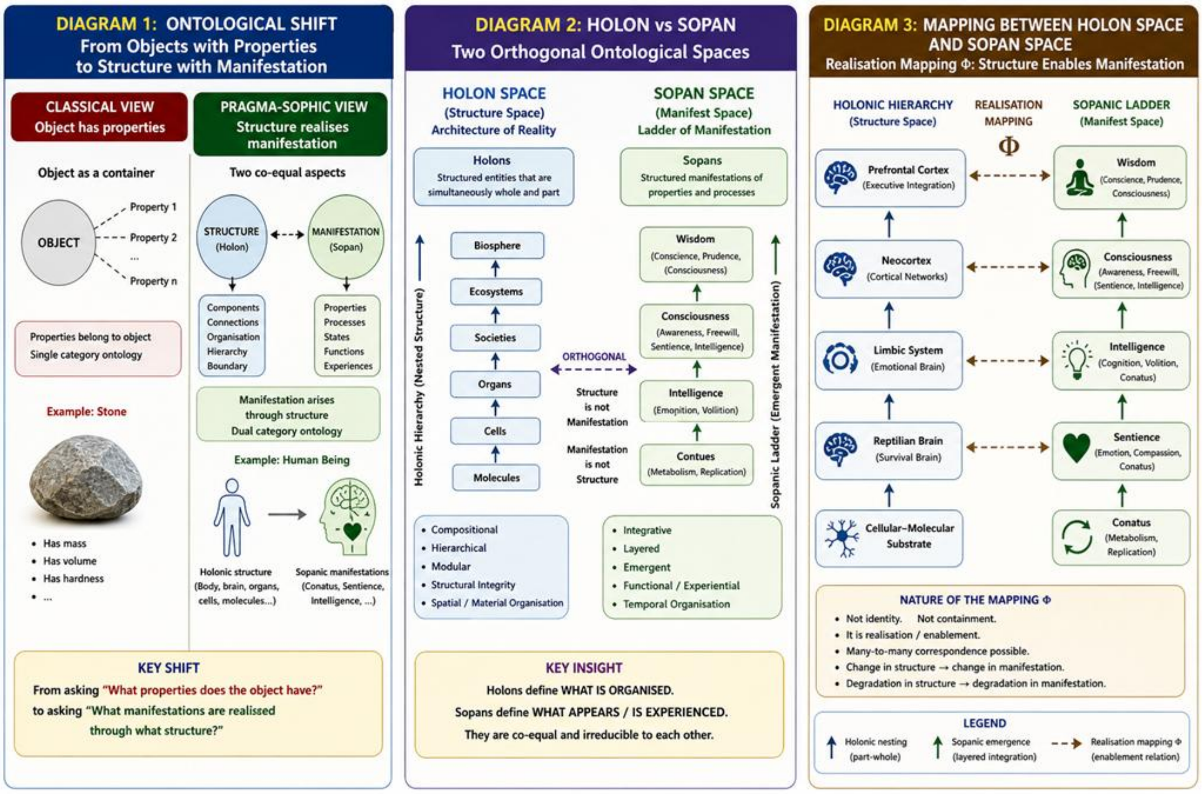
A formal transition from object–property ontology to structure–manifest ontology

Abstract

Classical ontology represents reality through objects bearing properties, formalised as a mapping $O \to \{p_i\}$. While adequate for low-complexity systems, this formulation fails when applied to higher-order phenomena such as life, cognition, and consciousness, where properties are non-local, integrative, and emergent. This essay develops a dual ontological framework in which **structure** and **manifestation** are treated as irreducible and orthogonal categories. Structure is formalised through **holons**, recursively defined part–whole entities forming a hierarchical space $\mathcal{H}$. Manifestation is formalised through **sopans**, structured configurations of properties and processes forming a layered space $\mathcal{S}$. A realisation mapping $\Phi: \mathcal{H} \to \mathcal{S}$is introduced to capture the relation between structure and manifestation without reduction or containment. The resulting framework provides a mathematically coherent basis for modelling emergence, clarifying consciousness, and guiding the design of complex and artificial systems.



Introduction

In classical ontology, an object O is associated with a set of properties $\{p_1, p_2, \dots, p_n\}$, yielding the relation $O \mapsto \{p_i\}$. This representation assumes that properties are intrinsic, local, and assignable. Such an assumption is valid when properties are scalar or weakly coupled. However, when dealing with systems of high organisational complexity, this formulation becomes inadequate. Properties such as intelligence or consciousness do not admit decomposition into independent components, nor can they be localised to specific structural elements without loss of meaning. The mapping $p_i \in O$ thus becomes ontologically unstable.

The earlier framework developed in "From Objects to Wisdom" already introduced structure and behaviour as descriptors of systems. However, these were implicitly embedded within the *object-centric ontology*. The present development requires a categorical refinement. Instead of treating properties as attributes of objects, we introduce manifestation as a distinct ontological category. This leads to a reformulation:

$$O \to \{p_i\}\ Reformed\ to\ \mathcal{H} \overset{\Phi}{\Rightarrow} \mathcal{S}$$

where $\mathcal{H}$ is the space of structures and $\mathcal{S}$ is the space of manifestations. The diagram used in the episode serves as a pivot representation of this transition.

From Attribute Assignment to Realisation

The classical view assumes a containment relation $p_i \in O$. This implies that properties are elements of the object. However, for emergent phenomena, this assumption fails. We therefore replace containment with **realisation**, expressed through a mapping:

$$\Phi: \mathcal{H} \to \mathcal{S}$$

such that a structure $H \in \mathcal{H}$ realises a manifestation $S \in \mathcal{S}$, i.e., $S = \Phi(H)$. This mapping is not an inclusion $S \subseteq H$, nor an identity $S = H$, but an enablement relation.

This shift transforms ontology from a **set-membership model** to a **mapping-based model**, thereby accommodating non-local and integrative phenomena.

Holons: Formal Structure Space $\mathcal{H}$

A holon H is defined as a structured entity:

$$H = (C, R, \partial H)$$

where $C = \{c_i\}$ is a set of components, $R \subseteq C \times C$ defines relations (connections), and ∂H denotes the boundary separating internal and external domains. Each component c_i is itself a holon, leading to recursive embedding:

$$c_i \in \mathcal{H}, \forall c_i \in C$$

The space of holons is thus:

$$\mathcal{H} = \{H_1, H_2, \dots\}$$

with a partial order $\prec$ such that:

$$H_i \prec H_j \iff H_i \subseteq H_j$$

This induces a hierarchical structure, often representable as a directed acyclic graph or lattice. The depth of a holon, denoted $d(H)$, measures the number of nested levels.

Holon space is characterised by compositional closure, modularity, and hierarchical organisation. It supports formal analysis using graph theory and systems theory. Importantly, all elements of $\mathcal{H}$ are structural; they do not encode manifestation.

Sopans: Formal Manifestation Space $\mathcal{S}$

A sopan S is defined as a structured manifestation:

$$S = (P, \Psi)$$

where $P = \{p_i\}$ is a set of properties and processes, and Ψ defines integrative relations among them. Unlike holons, sopans are not spatially bounded entities but configurations in a state or functional space. The sopan space is defined as:

$$\mathcal{S} = \{S_0, S_1, S_2, \dots\}$$

with an ordering relation($\triangleleft$)based on integrative depth:

$$S_i \triangleleft S_j \iff S_j = \mathcal{I}(S_i, \Delta_i)$$

where $\mathcal{I}$ is an integration operator and Δ_i represents additional coupling or structure.

A canonical chain is given by:

$$S_0 = \text{Conatus}, S_1 = \text{Sentience}, S_2 = \text{Intelligence}, S_3 = \text{Consciousness}, S_4 = \text{Wisdom}$$

Each level satisfies:

$$S_{k+1} = \mathcal{I}(S_k, \Delta_k)$$

indicating progressive integration rather than simple accumulation.

Orthogonality: $\mathcal{H} \perp \mathcal{S}$

The fundamental assertion is:

$$\mathcal{H} \perp \mathcal{S}$$

meaning that holon space and sopan space are orthogonal. This implies that:

- $\nexists\, f: \mathcal{H} \to \mathcal{H}$ such that $f(H) = S$
- $\nexists\, g: \mathcal{S} \to \mathcal{S}$ such that $g(S) = H$

In other words, neither space is reducible to the other. However, they are coupled through Φ. This orthogonality eliminates category errors such as treating consciousness as a structural component or treating structure as an experiential entity.

Realisation Mapping Φ

The mapping:

$$\Phi: \mathcal{H} \to \mathcal{S}$$

assigns to each holon a sopan. Its properties include:

- **Non-injectivity**:

$$\exists H_1 \neq H_2 \text{ such that } \Phi(H_1) = \Phi(H_2)$$

Non-surjectivity:

$$\exists S \in \mathcal{S} \text{ such that } \nexists H \in \mathcal{H}, \Phi(H) = S$$

Context dependence:

$$\Phi(H, E) = S$$

where E represents environment or coupling context.

A useful functional representation of sopanic magnitude is:

$$\| S \| = f(d(H), \kappa(H))$$

where $d(H)$ is structural depth and $\kappa(H)$ is cross-level coupling. This formalises depth-dependent emergence.

Interpretation of the Pivot Diagram

The diagram may be interpreted mathematically as follows. The left panel represents the invalid model $O \to \{p_i\}$. The central panel separates the domains into $\mathcal{H}$ and $\mathcal{S}$, illustrating orthogonality. The right panel introduces the mapping Φ, connecting hierarchical brain structures to layered manifestations.

Thus, for a cognitive system:

$$\Phi(H_{\text{brain}}) = S_{\text{consciousness}}$$

without implying that consciousness is contained within or identical to the brain.

Implications for Consciousness

Within this framework, consciousness satisfies:

$$\text{Consciousness} \in \mathcal{S}, \text{Brain} \in \mathcal{H}$$

and:

$$\text{Consciousness} = \Phi(\text{Brain})$$

This resolves the classical dilemma. Consciousness is not reducible to neural components, as no mapping $H \to p_i$ suffices. Nor is it independent, as it requires structural realisation. It is a sopanic configuration arising from depth-integrated holonic structure.

Implications for Artificial Systems

In artificial systems, one must design not only $H \in \mathcal{H}$ but also ensure that:

$$\Phi(H) \to S_{\text{desired}}$$

This implies that manifestation cannot be directly engineered but must be enabled through structural and integrative design. Conscious systems, therefore, require:

$$\max \ \| S \| \text{ subject to} H \in \mathcal{H}$$

where optimisation occurs over structural depth and coupling.

Integration with Pragma-sophy

The Pragma-sophic framework can now be expressed as:

$$KS \subseteq \mathcal{H}, AS \subseteq \mathcal{A}, WS = \Phi(\mathcal{H}) \oplus AS$$

where $\mathcal{A}$denotes action space. Thus, Wisdemic Snippets arise from the coupling of manifestation and action.

Recapitulation

The transition may be summarised as:

$$O \to \{p_i\} \Rightarrow \mathcal{H} \overset{\Phi}{\Rightarrow} \mathcal{S}$$

where structure and manifestation are orthogonal yet coupled. Holons define structured existence, sopans define manifested reality, and the mapping Φconnects the two.

Informed Opinion

This dual ontology represents a necessary refinement rather than a mere extension. The classical framework conflates structure and manifestation, leading to conceptual ambiguity in emergence and consciousness. By introducing orthogonal spaces and a mapping relation, the present framework restores clarity and enables formal reasoning. It aligns naturally with systems theory while extending it into domains of cognition and wisdom. Its strength lies in its scalability and its ability to integrate physical, biological, and experiential phenomena within a single coherent architecture.

References

Ludwig von Bertalanffy — *General System Theory*

Bertalanffy's work provides the ontological precursor to the holon concept by establishing that entities must be understood as open systems characterised by organisation, boundary, and interaction rather than isolated substances. His rejection of reductionism and emphasis on hierarchical organisation directly anticipates the structure space $\mathcal{H}$. However, his framework remains structurally focused and does not explicitly distinguish manifestation as an independent category. The Holon–Sopan formulation extends Bertalanffy by separating structural organisation from manifested properties and introducing a formal mapping Φ, thereby transforming systems theory into a dual ontological framework.

Norbert Wiener — *Cybernetics: Control and Communication in the Animal and the Machine*

Wiener's introduction of feedback, control, and information flow provides the dynamic backbone for understanding how holonic structures sustain organised behaviour over time. His formulation implicitly bridges structure and manifestation through control loops, but treats behaviour as emerging within the same ontological domain as structure. In the Holon–Sopan framework, cybernetic processes can be interpreted as components of the mapping Φ, where structural configurations generate regulated manifestations. The extension lies in elevating manifestation to an independent space $\mathcal{S}$, thereby generalising cybernetics from regulation to ontological realisation.

W. Ross Ashby — *An Introduction to Cybernetics*

Ashby's concepts of state space, variety, and the Law of Requisite Variety contribute directly to the formal characterisation of both holon and sopan spaces. Holons can be seen as generators of state spaces, while sopans correspond to structured regions within those spaces defined by integrative coherence. Ashby's emphasis on internal complexity as a prerequisite for regulation aligns with the function $\parallel S \parallel = f(d(H), \kappa(H))$, where manifestation richness depends on structural depth and coupling. The Holon–Sopan framework extends Ashby by explicitly separating the structural generator from the manifested configuration.

Claude Shannon — *A Mathematical Theory of Communication*

Shannon's formalisation of information as a measurable quantity independent of meaning provides a foundational component for the flows within holon space. Information, along with material and energy, constitutes the interaction channels in $\mathcal{H}$. However, Shannon deliberately excludes semantics and experience, leaving manifestation unaddressed. In the present framework, Shannon's theory operates entirely within structure, while sopans capture the domain of meaning and experience. Thus, the Holon–Sopan distinction can be seen as completing Shannon's framework by reintroducing semantics through a separate ontological category.

Herbert A. Simon — *The Sciences of the Artificial*

Simon's theory of hierarchical systems and nearly decomposable structures provides a rigorous foundation for holonic architecture. His concept of bounded rationality and decision-making aligns with intermediate sopanic levels such as intelligence. However, Simon's framework remains primarily within the design and functional domain, without a formal distinction between structure and manifestation. The Holon–Sopan ontology extends Simon by introducing a mapping Φthat separates the implementational structure from the realised cognitive and experiential states, thereby integrating design theory with ontological clarity.

Donella Meadows — *Thinking in Systems*

Meadows' emphasis on stocks, flows, feedback loops, and leverage points reinforces the importance of structure in determining system behaviour. Her insight that "structure drives behaviour" aligns directly with the mapping $\Phi: \mathcal{H} \rightarrow \mathcal{S}$, where manifestation is a function of structure. However, Meadows does not formalise behaviour as an independent ontological category. The Holon–Sopan framework generalises her insight by distinguishing structural drivers from manifested outcomes, thereby enabling a clearer analysis of intervention and systemic change.

Herbert Koestler — *The Ghost in the Machine*

Koestler introduced the term "holon" to describe entities that are simultaneously wholes and parts, forming nested hierarchies. This concept directly informs the definition of holon space $\mathcal{H}$. However, Koestler did not develop a corresponding theory of manifestation. The introduction of sopans completes the conceptual pair, transforming holons from a descriptive idea into one half of a dual ontology. The Holon–Sopan framework can thus be seen as a formal completion and generalisation of Koestler's insight.

Giulio Tononi — Integrated Information Theory (IIT)

Tononi's IIT proposes that consciousness corresponds to the degree of integrated information Φ_{IIT}within a system. This aligns closely with the idea that higher sopanic levels require strong cross-level integration. However, IIT operates within a single ontological domain, attempting to quantify manifestation directly from structural relations. In the Holon–Sopan framework, IIT can be interpreted as an attempt to approximate the mapping Φ, with integrated information serving as a proxy for sopanic magnitude $\| S \|$. The present framework extends IIT by explicitly separating structure and manifestation and defining their coupling.

Gerald M. Edelman — Neural Darwinism and Re-entrant Signalling
Edelman's theory emphasises dynamic, recursive interactions across neural structures as the basis for higher cognitive functions. His concept of re-entrant signalling provides a biological mechanism for cross-level coupling $\kappa(H)$, which is essential for generating higher sopans. While Edelman focuses on biological implementation, the Holon–Sopan framework abstracts this mechanism into a general principle: manifestation arises through recursive integration across holonic levels. This generalisation allows the concept to be applied beyond biology to artificial systems.

David Marr — Levels of Analysis (Computational, Algorithmic, Implementational)
Marr's tri-level framework distinguishes between what a system does, how it does it, and how it is physically realised. This separation parallels the distinction between sopans (computational and algorithmic manifestations) and holons (implementational structure). However, Marr treats these levels as methodological perspectives rather than ontological categories. The Holon–Sopan framework elevates this distinction to an ontological level, asserting that manifestation and structure belong to fundamentally different domains connected through realisation.

Roger W. Sperry — Downward Causation

Sperry's concept of downward causation demonstrates that higher-level organisational states can influence lower-level processes. This introduces bidirectionality into the relation between structure and manifestation. In the Holon–Sopan framework, this can be interpreted as feedback from $\mathcal{S}$ to $\mathcal{H}$, suggesting that the mapping Φ is part of a broader coupled system rather than a one-way function. This insight supports the possibility of adaptive restructuring driven by manifested states.

Stuart Kauffman — *The Origins of Order*

Kauffman's work on self-organisation and autocatalytic networks explains how complex order can arise spontaneously in systems operating near criticality. This provides a physical basis for the emergence of higher-order holonic structures and, consequently, richer sopanic manifestations. His ideas support the transition from entropy to organised complexity and align with the dependence of $\| S \|$ on structural depth and coupling. The Holon–Sopan framework incorporates this by treating emergence as a mapping rather than an unexplained phenomenon.

Thomas Nagel — "What Is It Like to Be a Bat?"

Nagel's argument highlights the irreducibility of subjective experience and the limitations of purely objective descriptions. This directly motivates the need for a separate ontological category for manifestation. In the Holon–Sopan framework, Nagel's "what it is like" corresponds to elements of $\mathcal{S}$, which cannot be captured within $\mathcal{H}$. The framework provides a formal response to Nagel by distinguishing structure from experience while maintaining their coupling through Φ.

John von Neumann — Theory of Self-Reproducing Automata

Von Neumann's work establishes the importance of layered architectures and self-referential systems in artificial design. His distinction between logical and physical levels parallels the separation between sopans and holons. However, his framework does not explicitly address manifestation as a separate ontological domain. The Holon–Sopan framework extends this by suggesting that higher-order manifestations such as consciousness require not only layered architecture, but also cross-level integration captured through the mapping Φ.

Closing Integration

Taken together, these works form a coherent intellectual scaffold for the Holon–Sopan ontology. Bertalanffy and Koestler establish the structural foundation; Wiener and Ashby provide dynamic and regulatory principles; Shannon formalises informational flows; Simon and Marr contribute hierarchical and multi-level perspectives; Tononi, Edelman, and Kauffman address emergence and integration; Sperry introduces bidirectional causation; Nagel highlights experiential irreducibility; and von Neumann anchors artificial realisation.

Informed Opinion: The originality of this contribution lies in synthesising these strands into a formally clean architecture $\mathcal{H} \overset{\Phi}{\Rightarrow} \mathcal{S}$, where structure and manifestation are explicitly separated yet rigorously coupled. This resolves long-standing ambiguities and provides a scalable foundation for modelling reality, consciousness, and wisdom within a single unified framework.