

Never Bored: Voluntary Constraint, Didactic Framing, and the Structural Conditions of Sustained Attention

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Abstract

This essay examines a personal founding mythology: the claim of never experiencing boredom. Rather than treating this claim as a psychological trait or anecdotal curiosity, the essay reframes it as an emergent consequence of a constraint-driven approach to learning and attention. It argues that boredom arises not from insufficient stimulation but from underconstrained option spaces in which distinctions fail to matter. By contrast, sustained engagement emerges when environments are structured through voluntary limitation, didactic reframing, and a persistent orientation toward generality and integration rather than completion. Drawing on examples from learning practices, developmental experience, and formal domains such as mathematics and computation, the essay develops a constraint-first account of attention that treats difficulty as information and limitation as generative. The mythology of never being bored is thus reinterpreted as a methodological origin story: evidence that internalized constraint-generation can stabilize attention over long horizons and can, by extension, inform the design of cognitive, computational, and institutional systems.

Introduction

Boredom is commonly treated as a deficit condition, whether of stimulation, attention, or motivation. In educational psychology and popular discourse alike, it is often assumed that boredom signals either an impoverished environment or a failure on the part of the individual to engage appropriately. From this standpoint, the absence of boredom appears either implausible or indicative of unusual temperament. This essay advances a different interpretation. The persistent claim of never being bored is not approached as a literal psychological invariant but as a founding mythology: a narrative compression of a set of learning practices, attentional strategies, and structural commitments that render boredom increasingly unlikely.

Understood this way, the mythology does not describe an absence of affect but the presence of organization. What appears subjectively as inexhaustible interest emerges from a sustained orientation toward constraint, generality, and didactic reframing. Situations are persistently treated not as consumable experiences but as sites for structure extraction. Difficulty is not avoided but metabolized. Options are narrowed rather than expanded, not to restrict activity but to make distinctions matter. The result is an attentional ecology in which engagement is stabilized by unfinished structure rather than fueled by novelty.

This approach aligns with a broader constraint-first worldview that treats irreversibility, limitation, and path dependence as primary. Within such a framework, boredom is not a primitive psychological state but an emergent symptom of poorly structured option spaces. The analysis that follows situates the mythology of never being bored within this structural account, tracing how voluntary constraint and didactic framing operate at the level of learning practices and how these mechanisms generalize beyond the individual case.

Boredom and Option Space

Boredom does not arise simply because there is nothing to do. It arises when available actions are insufficiently differentiated to sustain meaningful choice. In an option space where possibilities are numerous but equivalently weighted, attention decays because no action carries informational advantage over another. Effort expended in such a space produces little structure, and without structure there is no accumulation of relevance. Boredom, on this view, is not a response to scarcity but to excess without constraint.

The mythology of never being bored corresponds to the opposite condition. From an early stage, attention is oriented toward environments populated by projects, problems, and subjects that are not interchangeable but hierarchically related. Algebra is not merely

another topic among many but a generative substrate that reappears across computation, physics, and formal reasoning. Programming languages are not consumed as toolkits but treated as concrete realizations of abstract constraint systems. Natural languages are not learned solely for communicative competence but for the structural comparisons they enable across grammar, symbolism, and meaning.

In such an environment, no activity exhausts its relevance upon completion. Each task opens onto others, not through novelty but through dependency and reuse. The attentional field is therefore populated less by finished objects than by partially resolved structures that continue to exert pull. Boredom has little opportunity to stabilize because attention is continuously recruited by unresolved generalities rather than depleted by repetitive consumption.

Didactic Framing as a Cognitive Strategy

A central mechanism supporting this condition is the systematic reframing of situations as didactic learning experiences. Rather than evaluating activities in terms of entertainment, efficiency, or external validation, the relevant question becomes what general structure can be extracted from them. This posture treats the environment itself as a text to be decoded, with each encounter serving as a probe into underlying constraints.

Didactic framing converts immediate performance goals into long-term representational gains. Errors become informative rather than discouraging, revealing the boundaries of admissible transformations. Difficulty functions as a signal that an invariant is present but not yet articulated. Under this regime, learning is not episodic but continuous, because even repetition deepens the internal model rather than exhausting interest.

This strategy also alters the temporal experience of attention. Waiting, delay, and friction are no longer empty intervals but opportunities for consolidation and abstraction. Time is experienced cumulatively rather than punctually. Engagement persists not because conditions are optimized for ease, but because the learner remains oriented toward structure formation rather than task completion.

Didactic framing thus supplies an internal source of constraint that stabilizes attention independently of external novelty. It enables environments to remain generative even when resources are limited or conditions are repetitive. In doing so, it lays the groundwork for understanding how voluntary limitation and difficulty can function as engines of sustained engagement rather than as obstacles to be eliminated.

Voluntary Handicapping and Productive Difficulty

An important but often misunderstood component of the mythology of never being bored is the role of voluntary handicapping. Constraints such as dyslexia are not treated merely as obstacles to be compensated for, nor are they romanticized as latent advantages. Instead, they are incorporated into learning practices as endogenous constraint generators that shape representational experimentation. Difficulty in fluent reading, for example, becomes an occasion to explore symbolic substitution, cipher-like encodings, and alternative pathways for manipulating meaning.

This posture generalizes beyond neurocognitive differences. Deliberate limitation of tools, representations, or methods functions as a way of surfacing hidden structure. Learning algebra without calculators, programming without high-level abstractions, or language without reliance on translation shortcuts forces engagement with foundational mechanisms. Convenience, while efficient, often masks invariants by collapsing distinctions. Voluntary handicapping reintroduces friction in a controlled manner, ensuring that learning proceeds through compression rather than accumulation.

Crucially, this is not an ethic of austerity. Difficulty is not valued for its own sake, but for the information it produces. A constraint is productive insofar as it reveals which transformations preserve meaning and which do not. When limitations are chosen rather than imposed, they can be tuned to expose structure without overwhelming capacity. In this way, voluntary handicapping operates as a methodological tool: a means of calibrating the learning environment so that distinctions become salient and progress remains generative.

Within this framework, the absence of boredom is not the absence of challenge but its sustained presence. Difficulty continuously reopens questions rather than closing them. Attention is held not by ease but by the promise of further structure extraction.

The Overstimulation Paradox

Contemporary responses to boredom in educational and developmental settings frequently proceed from the assumption that boredom is a stimulation deficit. From this perspective, the appropriate remedy is the provision of continuous novelty. Summer camps, enrichment programs, therapeutic interventions, and highly curated learning environments are therefore organized around rapid activity transitions, diversified sensory input, and constant external engagement. These environments often succeed in eliminating the subjective experience of boredom for the duration of their operation.

This success, however, is structurally non-portable. The anti-boredom effect depends on

sustained external orchestration rather than on the internal generation of constraint. When the programmed sequence ends, learners are returned to an option space that is once again undifferentiated, but now without having developed the mechanisms required to structure it. Attention, having been calibrated to expect externally supplied novelty, lacks the capacity to stabilize itself through endogenous projects. What appears as enrichment thus functions as a dependency relationship: the learner becomes increasingly adept at consuming structured activity while remaining unable to produce structure independently.

This limitation becomes clearer when viewed through the lens of didactic framing. Environments that rely on constant topic switching and scheduled engagement inhibit the extraction of general patterns. Each activity is bounded, self-contained, and optimized for immediate participation rather than cumulative integration. The learner encounters a sequence of experiences rather than a system of relations. Knowledge accumulates as a catalogue rather than as an architecture.

From a constraint-first perspective, overstimulation addresses symptoms while leaving underlying dynamics untouched. By preventing sustained engagement, it forecloses the very processes through which internal constraint-generation might emerge. Boredom is deferred rather than resolved. Once the substitutions cease, the original problem reappears, often in amplified form, because the learner has been trained to expect structure rather than to create it.

Specialization, Generality, and Temporal Order

A natural objection to the generality-seeking orientation developed thus far is that, in many intellectual and professional trajectories, deep specialization appears to precede the capacity for generalization. Mathematicians typically begin not with unifying abstractions but with specific domains such as algebra, analysis, or topology, acquiring local techniques before recognizing their shared structure. Programmers master particular languages and paradigms before abstracting across them. From this standpoint, an emphasis on generality risks appearing premature or detached from the realities of skill acquisition.

This apparent contradiction can be resolved by distinguishing between two forms of generality. The first is comparative generality, which arises from explicit comparison across multiple domains and indeed presupposes prior specialization. The second is structural generality, which consists in treating any single domain as a site for pattern extraction rather than as a repository of facts. The latter does not require breadth of coverage. It requires a particular orientation toward depth.

Within a constraint-driven learning ecology, specialization and generality are not opposed

but nested. Engagement with a narrow domain may appear specialized when measured by topic diversity, yet internally the posture is already generality-seeking. Learning algebra, on this account, is not exhausted by acquiring techniques for symbolic manipulation. It involves asking what properties make algebraic reasoning portable, which transformations preserve meaning, and how symbolic systems encode invariants. These questions are general even when posed within a single subject area.

Focused inquiry can therefore be a more favorable environment for cultivating generality than diffuse exposure. Constraint is inherent to narrow domains. Degrees of freedom are already limited, which sharpens distinctions and renders invariants visible. Breadth without constraint tends toward superficial familiarity, whereas depth under constraint produces insight that transfers when new domains become relevant.

This perspective also clarifies the strategic value of deliberate ignorance. The capacity to ignore entire fields or topics is not a failure of generality but a precondition for it. Attention is finite, and attempts to survey everything yield dilution rather than synthesis. By contrast, learning to extract maximal structure from minimal coverage develops habits that enable rapid assimilation when engagement becomes necessary. This constitutes a second-order generality: not knowledge that spans domains, but a method for metabolizing domains efficiently once constraint demands it.

Unstructured Time and the Internalization of Constraint

The constraint-driven account of attention must confront a further developmental complication. The capacity to generate internal constraints may itself depend on prolonged exposure to unstructured time. If every moment is scheduled, optimized, or externally scaffolded, the learner never encounters the problem that constraint-generation solves. Boredom must be experienced, not merely theorized, for resilience against it to develop.

Here a paradox emerges. The mythology of never being bored presupposes the possibility of boredom. Long stretches of undirected time—afternoons without programming, weekends without structured learning, periods of enforced waiting—create conditions under which internal projects become necessary rather than optional. In the absence of external structure, attention must either decay or reorganize itself. The learner discovers, often implicitly, that coherence can be produced through self-imposed limitation rather than through external provision.

Play provides a critical developmental mechanism in this process. Play is frequently misconstrued as the absence of constraint, yet it is in fact an arena for experimenting with voluntary limitation. Games impose rules; imaginative play constructs coherent fictional

boundaries; physical play develops through the progressive restriction and refinement of movement. Unstructured time allows play to emerge spontaneously, and play habituates the cognitive system to treating constraint as generative rather than oppressive.

This observation suggests a developmental requirement that cannot be compressed. Techniques for eliminating boredom cannot be taught directly, because they depend on internalized practices that arise only under conditions where external structure is absent. Highly scheduled environments, despite their apparent richness, may therefore fail to cultivate anti-boredom resilience. They train the learner to consume programming rather than to generate structure.

Reconsidered in this light, the founding mythology acquires a more precise interpretation. The claim of never being bored is credible not because stimulation was constant, but because unstructured time was abundant enough to force the development of internal constraint-generation mechanisms. The absence of boredom is not a primitive trait but a residue: the outcome of having learned, over time, to create problems when none are provided.

Generality as an Antidote to Exhaustion

A further stabilizing factor in the mythology of never being bored is the persistent orientation toward generality rather than completion. Tasks framed narrowly are exhaustible. Once completed, they leave little residue beyond the satisfaction of closure. By contrast, tasks framed as instances of broader structural classes remain open even after apparent resolution. Each solution generates new questions, not because the work was insufficient, but because the structure it reveals exceeds any single instantiation.

This orientation alters the temporal dynamics of attention. Projects do not terminate so much as they branch. Completion becomes less significant than integration, and success is measured by the degree to which a problem is embedded within a wider network of relations. Attention is thus recruited by unresolved generalities rather than consumed by finished tasks. Exhaustion is avoided not through rest or distraction, but through the continual reactivation of structure at higher levels of abstraction.

Such a posture explains how multiplicity of interests can coexist with coherence. When domains are approached as structurally related rather than as competing objects of attention, movement between them does not fragment focus. Algebra, computation, language, and logic are experienced not as separate pursuits but as different projections of shared constraints. Generality functions here not as breadth of coverage but as depth of integration, allowing attention to persist across long horizons without collapse.

From Personal Practice to System Design

The techniques that prevent boredom at the individual scale—option-space narrowing, endogenous constraint generation, and the prioritization of integration over completion—are not merely psychological strategies. They are design principles that apply wherever sustained attention, learning, or coordination must be maintained. A programming language that forces early commitment to types performs the same function as voluntary handicapping: it converts difficulty into structural information rather than allowing it to accumulate as unexamined complexity. A scientific theory organized around conserved quantities generates an inexhaustible landscape of inquiry, because each application opens new questions instead of closing old ones. An institution that measures few things precisely rather than many things approximately avoids the boredom-inducing condition of undifferentiated choice.

What appears at the individual level as a disposition toward constraint reveals itself, on inspection, to be a transportable pattern. The core mechanism is consistent across domains: reduce degrees of freedom until distinctions matter, then use those distinctions to generate structure rather than to consume possibilities. This is not asceticism but information theory. Systems maintain coherence under constraint not despite limitation but because of it.

The mythology of never being bored thus doubles as a proof of concept. It demonstrates that a constraint-first orientation is not merely theoretically defensible but practically sustainable over developmental time. If voluntary limitation can stabilize attention across decades of learning, the same principle should stabilize computation across scales of abstraction, theory-building across levels of formalism, and coordination across institutional boundaries. The personal is not universal, but it is portable. What works to organize one mind's trajectory may work, with appropriate translation, to organize knowledge systems, software architectures, and collaborative structures.

Constraint-First Research as a Methodological Inversion

The learning practices described throughout this essay exemplify a broader methodological inversion that characterizes constraint-first research. Rather than beginning with idealized systems and introducing constraints as corrective terms, constraint-first approaches take limitation, irreversibility, and bounded transformation as primary. Structure is not something imposed on an otherwise neutral substrate; it is what emerges when degrees of freedom are reduced to the point where distinctions acquire consequence.

In this sense, the absence of boredom functions as a phenomenological indicator of suc-

cessful constraint placement. Attention persists when constraints are neither so loose that everything becomes equivalent nor so rigid that exploration collapses. This mirrors the methodological stance of constraint-first research more generally, in which explanatory power arises not from maximal freedom but from carefully articulated restriction. Laws, invariants, and conserved quantities do not limit inquiry; they make inquiry possible by stabilizing meaningful variation.

Seen through this lens, the mythology of never being bored reflects an internalized research posture. The learner does not wait for problems to be supplied but actively constructs them by identifying where constraints can be tightened to expose latent structure. This is the same posture that underlies productive work in mathematics, physics, and computation, where progress is achieved by identifying which freedoms must be surrendered in order for new regularities to appear.

Irreversibility, Path Dependence, and Attention

Constraint-first research is distinguished not only by its treatment of limitation but by its insistence on irreversibility as a foundational condition. Processes unfold along paths that cannot be undone without loss, and histories accumulate in ways that shape future possibility. This temporal asymmetry has a direct analogue in the organization of attention.

Learning that proceeds through episodic consumption treats time as reversible. Experiences can be replaced, repeated, or discarded without consequence. By contrast, constraint-driven learning is path dependent. Each choice forecloses others, each abstraction reshapes what can be seen next, and attention becomes increasingly structured by its own history. Boredom is unlikely in such systems because the present moment is always conditioned by accumulated commitments.

The internalization of constraint-generation thus parallels the internalization of irreversible dynamics. Attention ceases to float freely among options and instead follows trajectories shaped by prior structure. This explains why sustained engagement often feels directional rather than cyclical. Interest does not reset after completion; it propagates forward, carrying unresolved constraints with it.

Constraint-first research formalizes this intuition by treating history not as an external record but as an active component of system dynamics. In doing so, it provides a language for understanding why learning ecologies that respect irreversibility tend to be more stable, more generative, and less prone to attentional collapse.

Constraint as an Alternative to Optimization

A further point of contact concerns the relationship between constraint-first approaches and optimization-centered models of cognition and learning. Optimization frameworks typically assume a fixed objective function and treat constraints as obstacles to be managed. Once an optimum is reached, exploration ceases. Boredom, in such systems, is a predictable outcome of success.

Constraint-first research reverses this orientation. Objectives are provisional, while constraints define the space within which objectives can meaningfully evolve. Progress does not terminate at an optimum but continues through the reconfiguration of constraint landscapes. This produces systems that remain perpetually unfinished without becoming directionless.

The learning practices described in this essay instantiate this logic at a personal scale. Tasks are not optimized toward completion but embedded within evolving constraint structures that continuously generate new questions. Difficulty is not minimized; it is modulated to remain informative. Attention is therefore stabilized not by reward maximization but by structural incompleteness.

This perspective helps explain why constraint-first systems resist boredom more effectively than optimization-driven ones. When success does not exhaust relevance, engagement persists. The system remains live because its constraints continue to generate difference.

The Portability of Constraint-First Practices

Finally, the connection between personal learning ecology and constraint-first research underscores the portability of these practices across scales. What functions as a cognitive strategy at the level of individual attention reappears as a methodological principle in formal research and as a design heuristic in institutional systems. In each case, the same invariants recur: limitation precedes structure, history matters, and coherence emerges through selective restriction rather than unrestricted choice.

This portability does not imply uniformity. Constraints must be translated, not copied. The specific limitations that stabilize attention in a learner will differ from those that stabilize a scientific theory or a computational architecture. What transfers is not content but posture: a willingness to treat constraint as generative and to regard boredom, failure, or stagnation as signals of underconstrained structure rather than as deficits to be masked.

By making this connection explicit, the essay situates its founding mythology within a recognizable research tradition. The claim of never being bored is not an idiosyncratic curiosity but a lived demonstration of how constraint-first principles operate when fully

internalized. It shows, at the scale of attention, what constraint-first research seeks to accomplish at the scale of knowledge itself.

Constraint-First Methodology and the Structure of Inquiry

Constraint-first research proceeds from a methodological inversion in which limitation, irreversibility, and bounded transformation are treated as ontologically primary. Rather than beginning with maximally permissive systems and introducing constraints as corrective refinements, this approach treats constraints as the generative substrate from which structure emerges. Explanatory power arises not through freedom but through selective restriction, as distinctions acquire consequence only when degrees of freedom are sufficiently reduced.

Within this framework, sustained attention is not a psychological anomaly but a structural outcome. Engagement persists when constraints are tuned so that variation remains meaningful without becoming chaotic. This balance mirrors the role of constraints in formal inquiry, where conserved quantities, symmetries, and admissibility conditions do not limit understanding but render it possible. Systems without constraint are informationally flat; systems overconstrained collapse into rigidity. Productive inquiry occupies the narrow regime in which restriction generates differentiation.

The internalization of constraint-generation at the level of learning reflects this same methodological stance. Problems are not awaited but constructed by identifying where freedoms can be surrendered to expose latent regularities. This posture aligns individual cognition with the logic of constraint-first research, in which progress is achieved by discovering which limitations must be imposed for structure to stabilize.

Irreversibility, Entropy, and Attentional Dynamics

A defining feature of constraint-first approaches is their treatment of irreversibility as fundamental. Processes unfold along trajectories that cannot be retraced without loss, and histories accumulate in ways that shape future possibility. In thermodynamic terms, entropy production is not a byproduct of imperfect systems but a constitutive feature of real dynamics. Informationally, this corresponds to the progressive narrowing of admissible future states as structure forms.

Attention exhibits an analogous behavior. Learning that proceeds through episodic consumption treats time as effectively reversible; experiences can be replaced, repeated, or

discarded with minimal consequence. By contrast, constraint-driven learning is path dependent. Each abstraction reshapes the space of subsequent inquiry, and prior commitments actively condition what can be perceived or pursued next. Attention becomes structured by its own history rather than reset by novelty.

Under these conditions, boredom functions as a signal of insufficient entropy gradient. When transformations fail to produce informative difference, attentional dynamics stagnate. Sustained engagement, by contrast, corresponds to regimes in which constraint-mediated differentiation continues to occur. The persistence of interest thus reflects ongoing entropy descent within a structured field of possibilities rather than the accumulation of stimuli.

Constraint, Information, and the Failure of Optimization

Optimization-centered models of cognition and learning typically presuppose fixed objective functions and treat constraints as obstacles to be managed. Once an optimum is reached, further exploration is unnecessary. From an informational standpoint, such systems tend toward equilibrium states in which gradients vanish and activity decays. Boredom is a predictable outcome of success under this model.

Constraint-first systems operate differently. Objectives remain provisional, while constraints define the evolving geometry of admissible transformations. Progress consists not in reaching an optimum but in reshaping the constraint landscape itself, thereby generating new informational gradients. Difficulty is not minimized but regulated so that each transformation continues to produce structure.

At the level of attention, this manifests as engagement that does not terminate upon task completion. Problems branch rather than close because their constraints remain active across contexts. Informational relevance persists because the system never settles into a static optimum. The absence of boredom in such regimes is not accidental but structurally enforced by the continual production of difference under constraint.

Field-Theoretic Perspectives on Constraint and Engagement

From a field-theoretic perspective, constraint-first reasoning treats cognition, learning, and inquiry as flows within structured potential landscapes. Constraints shape the curvature of

these landscapes, guiding trajectories toward regions of high informational yield. Engagement corresponds to motion along gradients that continue to exist because the field itself is dynamically reconfigured by prior movement.

In unconstrained fields, gradients flatten and trajectories diffuse without accumulation. In overconstrained fields, motion arrests entirely. Productive engagement occurs in intermediate regimes where constraints create directional flow without eliminating variability. This perspective unifies phenomenological accounts of attention with formal descriptions of dynamical systems, where sustained motion requires neither maximal freedom nor complete fixation.

Internalized constraint-generation functions as a mechanism for maintaining such regimes. By voluntarily reshaping the field—through limitation of tools, representations, or scope—the learner ensures that gradients remain present. Attention is stabilized not through external stimulation but through continuous modulation of the underlying constraint structure.

Constraint Portability Across Scales

The same invariants that stabilize attention under constraint recur across scales of inquiry. In mathematical research, axioms and admissibility conditions delimit spaces in which non-trivial theorems can exist. In physical theory, conservation laws restrict dynamics in ways that render prediction possible. In computation, type systems and formal semantics prevent undifferentiated state explosion. In each case, constraint precedes coherence.

At the individual level, the internalization of these principles manifests as a learning ecology resilient to boredom. At larger scales, they manifest as research programs, computational architectures, and institutional designs capable of sustaining long-horizon coordination. What transfers across scales is not specific content but structural posture: an orientation toward treating limitation as generative and stagnation as evidence of underconstrained dynamics.

Under this view, the mythology of never being bored is neither exceptional nor accidental. It is the subjective trace of a system operating in a regime where constraints are sufficiently articulated to maintain informational gradients over time. Attention persists because structure continues to form, and structure continues to form because freedom has been deliberately constrained.

Constraint-Driven Programming as an Implicit Method

A constraint-first orientation toward learning and inquiry finds a direct analogue in programming methodology. Many programs can be understood not as explicit prescriptions for action, but as the progressive imposition of constraints that delimit what counts as an admissible computation. Rather than specifying how a task must be carried out step by step, the programmer defines the boundaries within which any valid execution must fall. Execution then becomes a process of satisfying constraints rather than following instructions.

This perspective reveals that much of what is commonly described as imperative or procedural programming already operates under an implicit constraint regime. Variables are restricted in type, scope, and lifetime. Functions are constrained by input domains, output codomains, invariants, and side-effect limitations. Control structures enforce admissible orderings of operations. Even when the programmer appears to be issuing commands, those commands are meaningful only insofar as they preserve a background lattice of constraints that is rarely made explicit.

Constraint-driven programming does not replace imperative methods so much as expose their underlying structure. It makes visible what is otherwise distributed across syntax, convention, and informal reasoning. The program's correctness is not guaranteed by the sequence of steps alone, but by the fact that any permissible sequence must satisfy the same structural conditions.

Functions as Boundary Conditions Rather Than Procedures

A similar inversion occurs in mathematical practice. A function is often introduced not by enumerating the steps required to compute it, but by specifying the conditions it must satisfy. Boundary values, continuity requirements, symmetries, conservation laws, or variational principles define a space of admissible functions, within which particular solutions emerge. The function is characterized by what it cannot violate rather than by how it is explicitly constructed.

From this standpoint, function definition is already a constraint-first act. The mathematician narrows the space of possible mappings until only a small class remains, sometimes a unique one. The explicit formula, when it exists, is secondary to the structural conditions that determine it. In many cases, no closed-form expression is necessary; existence and uniqueness follow directly from the constraints.

This approach minimizes the need to state functions individually. By defining the bound-

aries of admissibility, one implicitly defines an entire family of behaviors without enumerating them. The economy achieved is not computational but conceptual: fewer primitives are required because structure is doing the work.

Equivalence of Procedural and Constraint Formulations

Imperative, procedural, and constraint-based formulations are often treated as distinct paradigms, but they are better understood as different surface representations of the same underlying structure. Any procedure that reliably produces correct output does so by respecting a set of constraints, whether or not those constraints are formally stated. Conversely, any sufficiently well-specified constraint system admits procedural realizations that satisfy it.

The difference lies in where complexity is carried. Procedural formulations embed constraints implicitly within control flow and state mutation, distributing them across many local decisions. Constraint-first formulations externalize these conditions, making them global, inspectable, and composable. The computational content remains equivalent, but the cognitive load shifts from tracing execution to reasoning about admissibility.

This shift has consequences for scalability and maintenance. When constraints are implicit, changes propagate unpredictably, and correctness depends on fragile assumptions about execution order. When constraints are explicit, modification becomes an exercise in boundary adjustment rather than wholesale redesign. The system remains coherent because its invariants are preserved by construction.

Constraint Specification as a Compression Strategy

Viewed through an informational lens, constraint-first programming functions as a compression strategy. Instead of specifying every permissible behavior, the programmer specifies the limits within which behavior must occur. This drastically reduces the number of functions that must be explicitly written, because many behaviors are ruled out a priori, while the remaining ones are equivalent with respect to the constraints.

Such compression mirrors the learning strategies discussed earlier. Just as a learner avoids boredom by narrowing option spaces until distinctions matter, a programmer avoids combinatorial explosion by constraining the space of admissible programs. In both cases, the goal is not to eliminate freedom but to concentrate it where it produces structure rather than noise.

This also explains why constraint-based systems often feel more expressive despite appearing more restrictive. Expressivity is not a function of the number of actions available,

but of the richness of the distinctions those actions support. By defining what must hold rather than what must be done, constraint-first methods allow multiple implementations to coexist without requiring them to be individually specified.

Programming Without Prescribing Execution

A final implication of this methodology is that it decouples specification from execution. When constraints are primary, the question of how a task is accomplished becomes secondary to the question of what conditions the outcome must satisfy. Execution strategies can vary, be optimized, or even be deferred to other agents or systems, so long as the constraints are met.

This decoupling aligns programming with other constraint-first domains, such as variational physics or declarative mathematics, where solutions are selected by satisfying global conditions rather than by following explicit recipes. The resulting systems are robust to change because their correctness is not tied to a single path of execution.

Under this view, constraint-first programming is not a niche paradigm but a clarification of what programming has always been doing implicitly. It makes explicit the boundaries that govern behavior, reduces the need for exhaustive specification, and shifts attention from procedural detail to structural coherence. The methodology succeeds not by eliminating imperative reasoning, but by situating it within a larger space defined by constraints that remain invariant across implementations.

Type-Theoretic Constraint as Semantic Delimitation

In type theory, constraint-first reasoning appears in its most explicit and operational form. A type does not merely label a value; it delimits a space of admissible behaviors. By specifying a type, one restricts the transformations that may be applied, the compositions that may be formed, and the contexts in which an expression may appear. Computation proceeds only insofar as these constraints are respected.

From this perspective, type checking is not an auxiliary verification step but a primary semantic operation. The act of assigning a type imposes a boundary condition on computation analogous to the specification of a domain and codomain in mathematics. A function's implementation becomes secondary to the structural guarantee that any implementation inhabiting the type must satisfy certain invariants. The fewer admissible inhabitants a type admits, the more structure is enforced without explicit procedural description.

Advanced type systems make this constraint-first logic increasingly visible. Dependent types, refinement types, and linear types encode logical propositions, resource constraints, and usage disciplines directly into the semantic fabric of the program. Correctness is no longer something proven after execution but something rendered unavoidable by construction. The programmer does not state how correctness is achieved; correctness emerges from the impossibility of violating the imposed constraints.

This aligns programming with a broader constraint-first epistemology. By shifting expressive power into the type layer, one reduces the need to specify behavior explicitly. Programs become shorter not because they do less, but because structure has been moved into the boundaries that define admissibility.

Logic Programming and Satisfaction-Based Computation

Logic programming provides a complementary realization of constraint-first computation, one in which execution is governed by satisfaction rather than instruction. In this paradigm, programs consist of relations and constraints, while control flow is delegated to a resolution mechanism that searches for admissible assignments. The programmer specifies what must be true, not how truth is to be established.

This inversion reveals that computation can be driven entirely by constraint propagation. Variables are not updated procedurally but narrowed through unification and inference. Execution corresponds to the progressive elimination of impossibilities rather than the accumulation of actions. The solution, when it appears, is a configuration that satisfies all stated constraints simultaneously.

Such systems make explicit what is implicit in imperative code. Every conditional branch, loop invariant, or assertion in procedural programming functions as a constraint on admissible states. Logic programming externalizes these constraints and treats them as first-class objects. The result is a computational model in which control is emergent rather than prescribed.

This satisfaction-based approach minimizes the need for explicit function definition. Many behaviors are determined implicitly by the interaction of constraints, without requiring a dedicated procedure for each case. The system remains expressive not because it enumerates possibilities, but because it prunes them aggressively until only structurally coherent outcomes remain.

Category-Theoretic Semantics and Constraint Preservation

Category theory provides a semantic framework in which constraint-first reasoning appears as preservation of structure under morphism. Objects are not defined by their internal composition but by their relationships, and morphisms are admissible only insofar as they respect specified structure. Functoriality, naturality, and universal properties function as global constraints that govern what transformations are meaningful.

From this viewpoint, a program denotes not a sequence of operations but a morphism in a category whose objects encode types, states, or contexts. Composition is admissible only when domains and codomains align, and semantic coherence is guaranteed by commutativity conditions rather than by execution traces. The correctness of composition follows from the impossibility of composing incompatible morphisms.

Universal constructions exemplify the compression power of constraint-first semantics. Products, coproducts, limits, and colimits define objects implicitly through their relationships rather than through explicit construction. Once the universal property is fixed, all implementations that satisfy it are equivalent up to unique isomorphism. The space of admissible realizations is constrained so tightly that explicit enumeration becomes unnecessary.

This perspective clarifies why category-theoretic semantics often feels abstract yet economical. The abstraction is not a loss of detail but a relocation of detail into constraint. By specifying what must commute, factor, or universalize, one defines behavior without prescribing mechanism. Implementation becomes an interchangeable realization of a constrained semantic role.

Programs as Sections of Constrained Semantic Spaces

Taken together, type theory, logic programming, and category-theoretic semantics converge on a unified picture of programming as navigation within constrained semantic spaces. A program selects a section of such a space by satisfying a network of constraints encoded as types, relations, and morphisms. Execution corresponds to finding or realizing such a section, not to unfolding a predetermined script.

In this picture, imperative and procedural code appears as one possible coordinatization of the underlying constraint structure. Control flow, state mutation, and iteration provide a local chart on a space whose global shape is determined by constraints that remain invariant across implementations. Making these constraints explicit reduces the need for detailed coordination, because coherence is enforced structurally rather than procedurally.

The expressive advantage of constraint-first programming thus lies not in abandoning procedures, but in subordinating them to semantic boundaries that do the primary organizational work. Programs remain flexible because execution strategies can vary, yet they remain stable because admissibility conditions do not. Complexity is managed not by micromanaging behavior, but by shaping the space in which behavior is allowed to occur.

Under this interpretation, constraint-first programming is not a specialized paradigm but a clarification of the semantic foundations already present in mature formal systems. Type theory, logic programming, and category-theoretic semantics each make visible a different facet of the same principle: that computation becomes intelligible, scalable, and composable when boundaries are defined before actions, and when structure is enforced by constraint rather than reconstructed through control.

Type-Theoretic Constraint as Semantic Delimitation

In type theory, constraint-first reasoning appears as the explicit delimitation of admissible behavior through semantic boundaries. A type does not merely classify values; it defines what transformations are allowed and which interactions are forbidden. Computation proceeds only insofar as these constraints are respected, and many potential errors are rendered impossible rather than corrected after the fact.

An everyday analogue can be found in systems of physical access control. A keycard does not instruct a person on how to walk through a building, nor does it dictate their path once inside. It simply determines which doors may open and which cannot. Within the permitted region, movement is flexible; outside it, movement is impossible. The card functions as a constraint on admissible trajectories rather than as a procedural guide. Similarly, a type constrains the space of meaningful computations without prescribing how those computations unfold.

More sophisticated type systems mirror more restrictive access regimes. Dependent or refinement types resemble credentials that grant access only under additional conditions, such as time windows or contextual authorization. Linear types resemble library books that must be returned before they can be reused, encoding resource discipline directly into the system. In each case, correct behavior emerges not because users are constantly reminded of the rules, but because violating them is structurally blocked.

The expressive power of type-theoretic constraint lies in this relocation of responsibility. By tightening semantic boundaries, one reduces the need for explicit behavioral specification. Programs become shorter and more reliable not because they do less, but because fewer behaviors are permitted to exist.

Logic Programming and Satisfaction-Based Computation

Logic programming embodies constraint-first computation by organizing execution around satisfaction rather than instruction. Programs specify relations that must hold, while control flow emerges from the process of narrowing possibilities until a consistent assignment is found. The system does not ask what to do next, but what remains possible.

This logic is familiar from everyday scheduling. When coordinating a meeting, participants rarely issue procedural commands about who should move when or how calendars should be scanned. Instead, constraints are stated: certain people must attend, specific times are unavailable, and the meeting must last a fixed duration. The eventual meeting time is not computed by following a script but discovered by eliminating impossibilities until a viable slot remains. The process succeeds when all constraints are satisfied simultaneously.

Traffic flow provides another example. Drivers do not receive explicit instructions for every movement. Instead, constraints such as lane boundaries, traffic signals, and right-of-way rules delimit what actions are admissible. Motion emerges from the interaction of these constraints rather than from centralized control. The system functions precisely because individual behavior is constrained enough to allow collective coherence.

Logic programming formalizes this pattern computationally. Variables are progressively restricted through unification, and execution corresponds to the elimination of inconsistency. Behavior is generated implicitly by constraint interaction, reducing the need for explicit procedural detail and allowing many outcomes to be handled by the same relational structure.

Category-Theoretic Semantics and Constraint Preservation

Category-theoretic semantics expresses constraint-first reasoning through the preservation of structure under transformation. Objects are characterized by their relationships, and morphisms are admissible only if they respect those relationships. Meaning is maintained not by tracking internal composition, but by enforcing coherence conditions on how transformations compose.

A familiar example appears in modular furniture systems. Individual components are not defined by their material composition alone, but by standardized interfaces. Shelves, brackets, and frames can be rearranged freely so long as connection points align. The designer does not specify how every possible configuration must be assembled. Instead, compatibility

constraints ensure that any assembly respecting the interfaces will be structurally sound. The space of valid constructions is defined by what fits, not by explicit assembly instructions.

Legal contracts offer a further illustration. A contract specifies obligations and rights that must be preserved across actions taken by different parties. It does not prescribe the internal procedures each party must follow, only that certain relationships hold. Amendments and subcontracts are admissible only if they preserve the original contractual structure. The contract functions as a constraint on admissible transformations of obligation rather than as a script for behavior.

Category-theoretic semantics generalizes this intuition. Universal properties define objects implicitly by their relationships, guaranteeing equivalence across implementations that satisfy the same constraints. Behavior is interchangeable because structure, not mechanism, carries meaning.

Programs as Sections of Constrained Semantic Spaces

Taken together, these frameworks support a view of programs as selections from constrained semantic spaces rather than as explicit instruction sequences. A program identifies a region of admissible behavior defined by types, relations, and structural preservation, and execution corresponds to realizing a path within that region.

Everyday navigation illustrates this perspective. A subway map does not instruct riders when to step forward or how to balance on a platform. It defines stations, lines, and transfer points. Any journey that respects those constraints is valid, and many distinct paths can satisfy the same origin and destination requirements. The map constrains possibility space; travel emerges from choice within that space.

Cooking provides another example. A recipe that specifies dietary restrictions, ingredient availability, and desired outcome may allow multiple preparation methods. The constraints define what the dish must satisfy, not the exact sequence of actions required. Different cooks can arrive at equivalent results through distinct procedures, all admissible under the same boundary conditions.

Constraint-first programming operates in this manner. Procedural code becomes one coordinatization of a deeper semantic structure defined by constraints. By shaping the space of admissible behavior, one minimizes the need to specify execution paths explicitly. Correctness and coherence follow from structural exclusion rather than from exhaustive instruction.

Under this view, the power of constraint-first methodology lies in its ability to externalize structure. Whether in everyday coordination or formal computation, systems remain

intelligible and adaptable when boundaries are defined clearly and behavior is allowed to emerge within them.

Natural Constraint Regimes and the Emergence of Sparse Cognition

Constraint-first reasoning does not require artificial imposition to operate effectively. In many systems, constraints arise naturally from material, energetic, and social conditions, shaping cognition long before explicit abstraction occurs. Scarcity and abundance, deprivation and privilege, each define distinct constraint regimes that structure attention by delimiting the space of admissible actions. These regimes alter not only what can be done, but what must be considered.

Conditions of material limitation impose hard boundaries on acquisition, agency, and contingency planning. When resources are scarce, options collapse rapidly, and cognition is forced into sparse regimes in which only a small subset of actions remains viable. This reduction in option space lowers cognitive load by eliminating speculative branching. Attention is stabilized not through abundance of choice, but through the necessity of relevance. Decisions become consequential because alternatives are few, and structure emerges from exclusion rather than deliberation.

Conversely, conditions of sustained privilege generate a different but equally powerful constraint regime. When certain tasks never need to be performed, when particular risks are structurally absent, and when access is guaranteed rather than negotiated, entire regions of the cognitive space are pruned away. The individual does not merely choose not to engage with these domains; they are rendered invisible as possibilities. Cognitive load is reduced not by scarcity, but by insulation. Attention narrows because many contingencies never arise.

In both cases, cognition becomes sparse, though through opposite mechanisms. Limitation constrains by necessity, while privilege constrains by exemption. What unites them is not their moral valence but their structural effect: both reduce the dimensionality of the decision landscape, making certain distinctions salient and others irrelevant. Sparse cognition is thus not an anomaly but a predictable consequence of living within bounded regimes.

Energetic Pressure and the Natural Sparsity Principle

Biological systems provide a canonical illustration of how sparsity emerges without explicit optimization. Neural, cellular, and metabolic processes operate under strict energetic con-

straints, where activity incurs measurable costs in ATP consumption, heat dissipation, and chemical replenishment. These pressures favor sparse activation patterns not by decree, but by inevitability. Dense, continuous activation is unsustainable; only selective firing persists.

Signal processing in biological environments further reinforces sparsity. High levels of noise and signal overlap amplify the utility of rare, high-salience events. Weak, diffuse signals are drowned out, while sharp contrasts propagate. Thermodynamic gradients drive systems toward states in which energy differentials are resolved efficiently, producing low-entropy configurations characterized by structured absence as much as structured presence.

This Natural Sparsity Principle explains why biological cognition relies so heavily on heuristics, proxies, and compressed representations. Rather than computing exhaustive models of the environment, organisms navigate using sparse cues that track gradients of relevance. Attention is allocated where energetic payoff is highest, and vast regions of possibility space are ignored without loss of function. Sparsity is not a heuristic added on top of cognition; it is the substrate on which cognition operates.

Geometric Bayesianism and Sparse Heuristic Navigation

Within this context, Geometric Bayesianism with Sparse Heuristics can be understood as a formal articulation of constraint-driven cognition. Belief updating does not occur over a flat probability space, but over a structured manifold shaped by energetic, informational, and environmental constraints. Priors are not arbitrary distributions but reflections of lived sparsity: regions of the manifold that are rarely visited carry negligible weight, while frequently traversed gradients become dominant axes of inference.

Sparse heuristics function as low-dimensional projections of this manifold. Rather than evaluating all hypotheses, the system navigates using proxy variables that preserve directional information while discarding extraneous detail. These proxies are not approximations in the pejorative sense; they are structurally sufficient coordinates for action under constraint. In noisy or resource-limited environments, such sparsity enhances robustness by preventing overfitting to transient fluctuations.

This geometric interpretation aligns naturally with constraint-first methodology. Constraints define curvature; curvature defines gradient; gradient defines motion. Cognition proceeds not by enumerating possibilities, but by descending along constrained informational slopes. The resulting behavior appears adaptive not because it is globally optimal, but because it remains dynamically stable under irreversible conditions.

Constraint, Class, and Cognitive Load

Social and economic conditions modulate these dynamics by shaping which constraints are encountered repeatedly and which are never faced. Persistent poverty enforces sparsity through enforced tradeoffs, delayed gratification, and continual exposure to consequence. Persistent wealth enforces sparsity through delegation, abstraction, and removal from material contingencies. In both cases, cognition adapts by compressing the decision space.

What differs is not the presence of constraint, but its topology. In deprivation regimes, constraints are sharp and immediate, producing steep gradients and rapid learning at the cost of fragility. In privileged regimes, constraints are smooth and buffered, producing shallow gradients and slower adaptation but greater stability. Neither regime is cognitively unconstrained. Both sculpt attention by eliminating vast classes of possibility from consideration.

This observation reframes debates about cognitive load and decision-making. Complexity does not scale with number of resources, but with the dimensionality of the option space that remains live. Reducing options—whether through necessity or insulation—can stabilize cognition, sometimes enhancing clarity, sometimes inducing blind spots. The effect is structural, not moral, and must be understood in terms of constraint geometry rather than individual merit or deficit.

Sparse Constraint as a Unifying Principle

Across biological systems, learning ecologies, programming methodologies, and social conditions, the same pattern recurs. Systems remain adaptive and intelligible when constraints are sufficiently articulated to induce sparsity. Dense option spaces overwhelm; sparse spaces differentiate. Whether constraints arise from metabolism, material conditions, semantic boundaries, or institutional structure, their primary function is to shape the geometry of possibility so that motion becomes meaningful.

Geometric Bayesianism with Sparse Heuristics formalizes this intuition, but the intuition itself is older and broader. Cognition persists where gradients exist, attention stabilizes where distinctions matter, and boredom emerges where constraint fails to differentiate. The absence of boredom, like the efficiency of biological inference, is not a product of abundance but of structured limitation.

Under this view, constraint-first methodology is not an abstract preference but a descriptive claim about how real systems survive under irreversible conditions. Sparsity is not imposed; it is discovered. It emerges wherever energy, time, and agency are finite, and it remains the quiet engine behind sustained attention, adaptive inference, and coherent action.

Bayesian Inference as Motion on a Constrained Manifold

Bayesian inference can be interpreted geometrically as motion on a probability manifold whose coordinates correspond not to propositions in the abstract, but to admissible states of belief under constraint. In this view, priors define an initial distribution over the manifold, likelihoods introduce curvature by weighting directions of motion, and posteriors emerge as regions of increased measure along gradients induced by evidence. In unconstrained settings, this manifold is high-dimensional and weakly curved, allowing belief mass to diffuse broadly without strong directional commitment.

Constraint-first regimes alter this geometry fundamentally. Energetic, material, and informational constraints reduce the effective dimensionality of the manifold by collapsing entire directions of motion. Many hypotheses become unreachable not because they are explicitly ruled out, but because the system lacks the capacity to traverse the paths required to evaluate them. The prior is therefore not merely a subjective belief but a geometric fact about which regions of the manifold are accessible at all.

Inference in such regimes proceeds not by exhaustive Bayesian updating, but by descent along a sparse set of dominant gradients. Belief mass concentrates rapidly because curvature is high in a small number of directions, while the remaining dimensions are effectively flat or absent. What appears as heuristic reasoning is thus a consequence of manifold compression rather than a deviation from Bayesian rationality.

Sparse Priors as Encoded Constraint Histories

Sparse priors arise naturally when the history of a system repeatedly restricts motion through belief space. Each encounter with energetic cost, delayed feedback, or irreversible consequence deforms the manifold, sharpening curvature along frequently traversed paths and flattening others. Over time, this produces priors that place almost all probability mass on a small subset of states, not through explicit selection, but through accumulated infeasibility elsewhere.

In biological cognition, this process is driven by metabolic cost. Neural activations that are energetically expensive but informationally redundant are pruned, while circuits that track high-yield gradients are reinforced. The resulting priors encode not abstract expectations, but the geometry of survivable inference. In social and material contexts, analogous effects occur when repeated exposure to constraint—whether scarcity or insulation—renders certain possibilities effectively invisible.

Such sparsity should not be understood as bias in the pejorative sense. It is a compression of belief space that preserves action-relevant structure under constraint. Sparse priors reduce variance not by suppressing uncertainty, but by acknowledging that many dimensions cannot be explored without unacceptable cost. Bayesian optimality is thus redefined relative to a constrained geometry rather than an idealized hypothesis space.

Heuristics as Low-Dimensional Coordinate Charts

Sparse heuristics function as low-dimensional coordinate charts on a constrained belief manifold. Rather than representing the full posterior distribution, they preserve directional information along dominant gradients while discarding orthogonal detail. A heuristic such as salience, familiarity, or trust operates by projecting inference onto a single coordinate that tracks accumulated curvature.

Everyday decision-making illustrates this clearly. A person navigating an unfamiliar city does not maintain a full probabilistic model of all possible routes. Instead, a small number of landmarks define a reduced coordinate system that is sufficient for orientation. The belief manifold is locally approximated by a chart that preserves navigational gradients while ignoring irrelevant dimensions. Errors occur when curvature changes abruptly, but efficiency is vastly improved under normal conditions.

In geometric Bayesian terms, heuristics are not shortcuts around inference but approximations to geodesic flow under dimensional constraint. They follow the steepest descent available within the reduced manifold. Their reliability depends not on their universality, but on the stability of the underlying constraint geometry.

Irreversibility and Posterior Lock-In

Irreversibility introduces hysteresis into Bayesian updating. Once belief mass descends into a narrow basin of attraction defined by constraint, returning to alternative hypotheses becomes energetically or informationally prohibitive. This produces posterior lock-in, where beliefs persist not because they are globally optimal, but because the cost of exiting the basin exceeds available resources.

This phenomenon is observable across scales. In biological systems, developmental pathways constrain future inference by fixing representational architecture. In economic and social systems, class position shapes which beliefs are revisable and which are effectively fixed. In learning systems, early abstractions define coordinate systems that bias subsequent interpretation.

From a constraint-first perspective, such lock-in is not a failure mode but a predictable outcome of irreversible descent. Stability emerges because belief space has been reshaped by constraint. Boredom, in this context, corresponds to regions of belief space where curvature has vanished and no further descent is possible. Engagement persists only where gradients remain.

Geometric Bayesianism with Sparse Heuristics

Geometric Bayesianism with Sparse Heuristics formalizes these observations by treating inference as constrained motion rather than computation over an idealized distribution. Beliefs evolve on manifolds whose geometry is shaped by energetic cost, informational noise, and structural limitation. Sparse heuristics are emergent coordinate systems adapted to this geometry, enabling robust navigation without exhaustive evaluation.

Under this framework, rationality is no longer defined by conformity to an abstract Bayesian ideal, but by coherence with the constraint geometry of the system. Efficient inference minimizes wasted motion in flat or inaccessible regions of belief space, concentrating effort along gradients that remain actionable. What appears as heuristic reasoning is therefore a manifestation of geometric adaptation rather than epistemic compromise.

This interpretation aligns naturally with constraint-first methodology more broadly. Constraints define geometry; geometry defines flow; flow defines inference. Sparse cognition is not imposed but discovered wherever systems operate under irreversible conditions. The persistence of attention, the stability of belief, and the apparent efficiency of heuristic reasoning all follow from the same structural fact: that real inference occurs on manifolds whose shape is determined by constraint, not by ideal freedom.

Asynchronous Computation and Explicit Constraint Encoding

Work on asynchronous and clockless computation provides a concrete technological analogue of constraint-first cognition. In particular, null convention logic and related self-timed circuit architectures demonstrate how reliable computation can emerge without centralized temporal control, provided that constraints are made explicit at the level of representation and signaling.

In synchronous digital systems, a global clock supplies an external ordering principle. Operations are forced into uniform temporal alignment, and correctness depends on meeting

timing assumptions that are often implicit and brittle. By contrast, asynchronous systems abandon global synchronization in favor of local completion constraints. Computation advances only when signals satisfy explicit conditions of validity, and ordering emerges from causality rather than prescription.

This shift mirrors the distinction developed earlier between externally orchestrated stimulation and internally generated structure. Clock-driven systems resemble overstimulated learning environments: activity proceeds continuously, but meaning depends on an external pacing mechanism. Constraint-driven systems resemble didactically framed learning: progress occurs only when conditions are satisfied, and idle states are structurally meaningful rather than pathological.

Null convention logic makes this explicit by encoding the absence of information as a first-class state. Signals are not merely present or absent by accident; null states delimit admissible transitions and prevent premature propagation. Computation is sparse by design. Only stabilized, constraint-satisfying states advance the system. This enforced sparsity reduces spurious activity, lowers energetic cost, and increases robustness under noise.

Cognitively, the same principle applies. Attention stabilizes not through constant activation, but through well-defined null states in which inference is suspended until constraints are met. Boredom corresponds not to nullity itself, but to nullity without structure. Where null states are meaningful, waiting becomes productive. Where they are not, disengagement emerges.

Asynchronous logic thus exemplifies a general principle: when constraints are explicit and local, systems do not require continuous external control to remain coherent. Structure replaces scheduling. Meaning replaces motion. The relevance to constraint-first learning is not metaphorical but structural. Both depend on the same inversion: correctness and engagement arise from boundary conditions rather than from procedural enforcement.

Asynchronous Constraint and Causality Without Prescription

Juarrero's account of causality as constraint provides a precise philosophical framework for understanding why asynchronous computation, as developed in Fant's work, is not merely an engineering alternative but a fundamentally different causal regime. In Juarrero's formulation, causes do not push effects forward through linear chains of events; instead, they constrain the space of admissible trajectories within which events may unfold. Causation operates by exclusion rather than by instruction.

Null convention logic exemplifies this form of causality in a computational setting. Rather than prescribing a sequence of operations governed by an external clock, asynchronous circuits advance only when local constraints are satisfied. Signal transitions are permitted or blocked based on validity conditions encoded directly into the logic. Nothing compels the system to move forward except the satisfaction of these constraints. Progress emerges from the release of inhibition, not from the application of force.

This structure maps cleanly onto Juarrero’s notion of enabling constraints. The causal work is done not by active commands, but by the shaping of possibility space. Certain transitions are made impossible; others are rendered inevitable once preconditions are met. The absence of a global clock is not a lack, but a refusal of an extrinsic causal driver. Temporal order becomes an emergent property of constraint satisfaction rather than an imposed sequence.

In this sense, Fant’s critique of algorithm-as-procedure aligns with Juarrero’s rejection of efficient causation as the primary explanatory mode for complex systems. Both replace step-wise execution with admissibility. Computation, like intentional action, is not the unfolding of a script but the navigation of a constrained state space. The system behaves coherently because its constraints are articulated, local, and irreversible, not because it is continuously directed.

This convergence clarifies why constraint-first systems are robust under noise, delay, and partial information. When causality operates through constraint rather than command, coherence does not depend on precise timing or complete specification. It depends on the stability of the boundaries that define what may happen next.

Null States, Entropy Descent, and Field-Theoretic Inhibition

Null convention logic assigns explicit semantic meaning to the absence of signal. A null state is not a transient error or a lack of information, but a deliberate boundary condition that prevents premature propagation. Computation proceeds only when signals leave the null state in a coordinated, constraint-satisfying manner. In this way, null states function as inhibitory regions that stabilize the system until sufficient structure has accumulated.

This logic admits a natural interpretation in thermodynamic and field-theoretic terms. Null states correspond to local minima or plateaus in an entropy landscape, regions where no admissible descent direction yet exists. Activity is suppressed not by force, but by the absence of gradient. Only when constraints reshape the field—by introducing asymmetry,

coupling, or sufficient potential difference—does motion resume.

Within an RSVP-style scalar–vector–entropy framework, null states can be understood as regions of high entropy symmetry where vector flow is locally quenched. Scalar potential remains undifferentiated, vector directions cancel, and entropy gradients vanish. These regions are not inert; they are reservoirs of possibility awaiting constraint-induced differentiation. Entropy descent does not occur everywhere continuously. It occurs where constraint curvature has been introduced.

Seen this way, null convention logic is a discrete analogue of continuous entropy-regulated field dynamics. Both systems enforce a discipline of waiting. Motion is not permitted simply because time has passed or energy is available. It is permitted only when configuration has changed sufficiently to create a meaningful gradient. This suppresses noise-driven fluctuation and ensures that transitions correspond to genuine structural change.

The relevance to cognition and attention is direct. Null states correspond to cognitively idle but structurally meaningful periods in which inference is suspended. These are not failures of engagement, but prerequisites for coherent descent. Boredom arises not from nullity itself, but from nullity without constraint-induced curvature. Where null states are embedded within a constraint-regulated field, waiting becomes productive, and subsequent motion is informed rather than arbitrary.

By encoding nullity as a first-class state, asynchronous logic and entropy-descent field theories converge on the same principle: inhibition is causal. Structure emerges not from constant activity, but from the selective release of constraint. Computation, cognition, and physical dynamics remain coherent because they allow nothing to happen until something must.

Null Regions as a Cross-Scale Structural Motif

Across the physical, inferential, and cognitive domains examined in this work, a common structural motif recurs: the presence of null or flat regions in which activity is suspended not by prohibition, but by the absence of meaningful gradient. In RSVP-style field descriptions, such regions appear as zones of undifferentiated scalar potential and quenched vector flow, where entropy gradients vanish and no directed motion is yet admissible. These field nulls are not inert gaps in dynamics but reservoirs of latent possibility, awaiting constraint-induced curvature before descent can occur.

An analogous structure appears in geometric Bayesian inference. Flat regions of the belief manifold correspond to areas of negligible curvature in which evidence fails to differentiate hypotheses. In these regions, posterior mass diffuses without direction, and inference stalls.

Motion resumes only when constraints—energetic, informational, or structural—reshape the manifold, introducing gradients along which belief can descend. Flatness here is not epistemic failure but a faithful reflection of insufficient structure in the evidential field.

Cognitive boredom occupies the same structural position. It is the phenomenological correlate of inhabiting an option space in which distinctions do not yet matter. Attention is suspended because no internal or external constraint has generated a direction of descent. Like field nulls and Bayesian flat regions, boredom is not merely the absence of activity but the absence of admissible differentiation. It signals a regime in which further motion would be arbitrary rather than informative.

What unifies these cases is that nullity is not opposed to structure but precedes it. Across scales, coherent dynamics depend on the disciplined presence of null regions that prevent premature motion. Constraint-first systems do not seek to eliminate such regions through constant activation or forced progression. Instead, they preserve them as stabilizing intervals in which noise is suppressed and readiness is maintained.

This alignment clarifies why constraint-first methodologies consistently privilege inhibition, waiting, and sparsity. Whether in physical fields, probabilistic inference, or attention, motion becomes meaningful only when constraints have reshaped the space of possibility. Null regions are therefore not pathologies to be optimized away, but structural necessities that ensure subsequent descent is coherent. The persistence of engagement, the stability of belief, and the emergence of structure all depend on allowing nothing to happen until something must.

Dependency Resolution and the Discipline of Waiting

A further way to unify the preceding accounts is to observe that coherent systems advance only after their most constrained dependencies have resolved. In any structured process, some operations are contingent upon others whose completion cannot be accelerated without loss of correctness. Progress therefore requires waiting—not arbitrarily, but selectively—for the slowest or deepest obligation to settle before dependent activity may proceed.

This principle appears wherever nested structure governs composition. Inner scopes must stabilize before outer scopes can meaningfully interact with them. Attempting to proceed prematurely introduces ambiguity, duplication, or contradiction, forcing later retraction or repair. By contrast, when resolution proceeds from the most constrained interior outward, higher-level organization inherits stability rather than uncertainty.

In physical field terms, this corresponds to local relaxation preceding global flow. Regions of high constraint must equilibrate before larger-scale gradients can propagate without

distortion. In probabilistic inference, latent variables with the tightest coupling must effectively collapse before marginal beliefs can update coherently. In cognition, attention stalls not because nothing is happening, but because prerequisite distinctions have not yet resolved into usable form.

What is often experienced subjectively as waiting or idleness is, under this interpretation, a necessary synchronization with the deepest unresolved structure in the system. Motion elsewhere would be ungrounded. The apparent inefficiency of waiting is therefore deceptive: it prevents wasted computation, spurious branching, and the proliferation of unstable representations.

This sheds further light on boredom as a structural phenomenon. Boredom is not the presence of waiting, but waiting without recognized dependency. When the system does not know what it is waiting for, null states lose meaning and become aversive. When dependencies are legible, waiting acquires purpose. The system remains engaged because it is aligned with the order in which resolution must occur.

Across domains, the same discipline recurs. Coherent progression requires honoring the hierarchy of constraints embedded in nested structure. The deepest obligation resolves first, not because it is privileged, but because everything else depends on it. Waiting, in this sense, is not a pause in computation but the computation itself, occurring at the only scale where progress is currently possible.

Constraint, Sparsity, and the Ecology of Attention

The earlier analysis of constraint-driven learning, voluntary limitation, and generality can now be situated within a more unified account of attention as a sparse, path-dependent process operating under irreversible conditions. What appears phenomenologically as sustained interest corresponds structurally to the maintenance of informational gradients within a constrained space of possibilities. Attention persists not because stimulation is abundant, but because the geometry of the option space continues to differentiate.

Didactic framing, voluntary handicapping, and generality-seeking function as mechanisms for shaping this geometry. By narrowing admissible transformations, they increase curvature along a limited set of dimensions, ensuring that movement through the space remains informative. In contrast, overstimulated or underconstrained environments flatten the landscape. When distinctions no longer matter, inference stalls, and boredom emerges as the subjective correlate of vanishing gradient.

The geometric Bayesian perspective clarifies why this dynamic is robust across domains. Sparse priors, heuristic navigation, and posterior lock-in are not add-ons to cognition but

reflections of how real systems adapt to constraint. Attention, like inference, operates by descending along the steepest available gradients within a compressed manifold. The practices described earlier in the essay—treating difficulty as information, limiting tools, privileging integration over completion—are ways of actively maintaining such gradients rather than allowing them to dissipate.

This reframing also resolves a potential tension between personal methodology and formal theory. The mythology of never being bored does not rely on exceptional motivation or unlimited curiosity. It reflects an ecology in which constraint is sufficiently articulated to keep the attentional system out of equilibrium. Boredom is avoided not through constant motion, but through structured descent. The learner remains engaged because there is always another direction in which constraint can be tightened and structure extracted.

Understood this way, the essay’s themes converge. Boredom, sparsity, constraint-first learning, and geometric inference are not separate topics but different descriptions of the same underlying phenomenon: the organization of finite attention in a world where freedom is costly and history matters.

Conclusion

The claim of never being bored is best understood not as a statement about temperament, but as a compressed description of a constraint-driven learning ecology. Boredom emerges when option spaces are underconstrained, distinctions fail to matter, and attention lacks a mechanism for generating internal structure. Its absence, by contrast, reflects the successful internalization of practices that convert limitation into information and difficulty into generative friction.

Throughout this work, boredom has been treated not as an adversary to be eliminated through stimulation, but as a diagnostic signal of structural failure. Didactic framing, voluntary handicapping, generality-seeking, and sustained exposure to unstructured time together form a coherent strategy for stabilizing attention under conditions of irreversibility and finite capacity. These practices do not remove difficulty; they reorganize it so that engagement persists and inference remains directional.

When viewed through the lens of sparsity and geometric Bayesian reasoning, this stabilization acquires a deeper coherence. Attention behaves like constrained inference on a manifold shaped by energetic, informational, and historical limits. Interest persists where gradients remain; boredom appears where curvature collapses. The learner who is never bored is not exempt from these dynamics, but embedded within them in a way that actively preserves structure.

The deeper claim, then, is not that boredom is defeated once and for all, but that the same structural inversions that prevent it in learning can be deployed deliberately in the design of cognitive, computational, and institutional systems. When constraint, irreversibility, and integration are treated as defaults rather than inconveniences, engagement ceases to depend on novelty and becomes a function of structure.

The mythology of never being bored thus serves not as a boast, but as evidence. It demonstrates that attention can be organized sustainably when limitation is treated as primary rather than as a problem to be solved away. In a world of finite energy, finite time, and irreversible paths, boredom is not inevitable. It is contingent on how possibility spaces are shaped, and on whether constraint is allowed to do the work it has always done in successful systems: making distinctions matter.

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What appears subjectively as patience or waiting is, under this interpretation, a form of alignment with unresolved dependency. Coherent systems do not advance uniformly across all scales at once. They proceed by allowing the most constrained or deeply nested obligations to resolve before dependent activity becomes meaningful. Attention stalls not because

nothing is happening, but because further motion would be premature. Where the order of resolution is legible, waiting acquires structure; where it is not, nullity becomes aversive and boredom ensues.

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The mythology of never being bored thus serves not as a boast, but as evidence. It demonstrates that attention can be organized sustainably when limitation is treated as primary rather than as a problem to be solved away. In a world of finite energy, finite time, and irreversible paths, boredom is not inevitable. It is contingent on how possibility spaces are shaped, on whether dependency is respected, and on whether constraint is allowed to do the work it has always done in successful systems: making distinctions matter before motion proceeds.

Epilogue: Constraint as an Ethics of Design

Read in retrospect, the argument of this essay can be understood as advancing not merely a theory of boredom or learning, but an implicit ethic of design. Systems that demand continuous activity, constant novelty, or premature resolution erode their own capacity for meaning by flattening the structure that makes motion informative. By contrast, systems that respect constraint, dependency, and irreversible order cultivate coherence by allowing resolution to occur where it must occur first.

This ethic applies wherever attention, inference, or coordination are at stake. It counsels against forcing progress in regions that are not yet structurally prepared, and against mistaking motion for advancement. It treats waiting not as failure but as fidelity to constraint, and difficulty not as an obstacle but as a signal that structure is actively forming.

Under this view, the design of learning environments, computational systems, and institutions converges on a shared principle: do not remove constraint in the name of efficiency. Articulate it. Make it legible. Allow it to shape the order in which resolution unfolds. Engagement, sustainability, and intelligibility follow not from abundance of choice, but from the disciplined recognition of what must resolve before anything else can meaningfully proceed.

Appendices

Appendix: Formalizing Dependency Order and Constraint-First Resolution

This appendix provides a neutral formal sketch of the dependency-order principle implicit in the main text. The goal is not to introduce a new formalism, but to make explicit the minimal mathematical structure shared by the physical, inferential, computational, and cognitive cases discussed.

Consider a system whose states form a space X , equipped with a partial order \preceq encoding dependency. For states $x, y \in X$, the relation $x \preceq y$ indicates that resolution or stabilization at x is a prerequisite for meaningful evolution at y . This order need not be total; incomparability corresponds to independent or weakly coupled components.

Let \mathcal{C} denote a family of constraints, each constraint $c \in \mathcal{C}$ restricting admissible transitions by specifying a subset $A_c \subseteq X \times X$. The admissible dynamics of the system are then given by

$$\mathcal{D} = \bigcap_{c \in \mathcal{C}} A_c,$$

so that transitions occur only when all relevant constraints are satisfied. Causation operates by exclusion: transitions outside \mathcal{D} are not delayed but impossible.

Resolution is modeled as a monotone process $\rho : X \rightarrow X$ satisfying

$$x \preceq y \Rightarrow \rho(x) \preceq \rho(y),$$

with the additional property that there exists a subset $X_{\text{stable}} \subseteq X$ such that $\rho(x) = x$ for all $x \in X_{\text{stable}}$. These are the stabilized or resolved states. Progress elsewhere is admissible only when the restriction of ρ to prerequisite states has reached X_{stable} .

In probabilistic terms, let (X, g) be a statistical manifold equipped with a metric g induced by an information geometry. Define a potential $\Phi : X \rightarrow \mathbb{R}$ whose gradient encodes inferential direction. Flat regions satisfy

$$\nabla \Phi(x) = 0,$$

corresponding to null or undecidable regions. Constraint introduction deforms g or Φ , creating curvature and enabling descent. Dependency order specifies which deformations must occur before others become meaningful.

In computational terms, this corresponds to an evaluation order on a directed acyclic graph (V, E) , where vertices represent subcomputations and edges encode dependency. A node v may transition from unresolved to resolved only when all incoming neighbors have resolved. Any attempt to evaluate a successor before its predecessors yields indeterminacy or rework, not speed.

Cognitively, attention can be modeled as a resource-limited traversal of X . Boredom corresponds to occupation of regions where admissible transitions are empty or flat relative to current constraints. Engagement resumes when constraint reshaping introduces new gradients aligned with unresolved dependencies. Waiting, in this formal sense, is the state in which the system correctly refrains from motion because no admissible transition respects the dependency order.

Across these interpretations, the same structural claim holds. Coherent systems evolve by resolving the most constrained elements first. Constraint-first resolution is not an optimization heuristic layered atop dynamics, but the condition under which dynamics remain meaningful at all. This formal sketch captures the shared logic without committing to any single domain-specific implementation.

Appendix: Constraint as Operator in Do-Calculus

This appendix draws an explicit parallel between the constraint-first framework developed in the main text and the operator-based interpretation of intervention in causal inference, particularly as formalized in do-calculus. The purpose is not to reduce constraint-first reasoning to causal graphs, but to show that both frameworks share a common structural intuition: causal influence is exerted not by propagating force, but by modifying the space of admissible dependencies.

Let $G = (V, E)$ be a directed acyclic graph representing causal relationships among variables V . In standard probabilistic inference, joint distributions are evaluated by conditioning on observations. Conditioning, however, leaves the underlying causal structure intact. The do-operator, written $\text{do}(X = x)$, differs in that it performs a structural intervention: it severs incoming edges into X and replaces the variable’s generating mechanism with a fixed value. Causal influence is therefore enacted by constraint, not by signal transmission.

This operation can be reinterpreted as a constraint operator acting on the admissible model space. Let \mathcal{M} denote the set of all causal models compatible with a given graph. An intervention induces a restricted subset

$$\mathcal{M}_{\text{do}(X=x)} \subset \mathcal{M},$$

by excluding all models in which X is generated by its former parents. The causal effect of the intervention arises from this exclusion. No new causal pathway is introduced; rather, entire classes of trajectories are rendered impossible.

This mirrors the constraint-first account of causality developed earlier. In Juarrero’s terms, causes operate by shaping the space of admissible futures. In asynchronous computation, constraint satisfaction gates progression. In RSVP-style field descriptions, entropy descent proceeds only where gradients exist. In all cases, change is enacted by modifying the conditions under which motion may occur, not by injecting additional activity.

Viewed through this lens, the do-operator functions as a boundary-setting operator on a dependency structure. It alters the topology of the causal manifold by removing degrees of freedom. Downstream variables respond not because they are pushed, but because the set of possible configurations consistent with the constraints has changed. Causal effect is therefore a geometric property of the restricted space.

The analogy extends to boredom and attention. External stimulation that merely adds observations corresponds to conditioning: it updates beliefs without restructuring dependency. By contrast, didactic framing, voluntary handicapping, or institutional rules operate like interventions. They remove options, block pathways, and redefine what transitions are admissible. Engagement emerges when attention operates within a reshaped causal space where gradients have been restored.

Finally, this perspective clarifies why constraint-first systems resist overfitting and instability. Because interventions operate by exclusion, they simplify the dependency structure rather than complicate it. The do-operator reduces causal ambiguity by eliminating upstream variability. Constraint-first design achieves robustness in the same way: by making causal structure explicit and narrowing the space of admissible trajectories until inference, action, or computation becomes well-posed.

Understood as an operator on possibility rather than a force on events, do-calculus fits naturally into the broader framework developed here. It provides a formal example of how causation, learning, and control can be unified under a single principle: meaningful change arises from altering what is allowed to happen, not from demanding that something happen next.

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