Beyond Symbolic Mind: Re-evaluating the Logical Model of Intelligence

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Abstract

Symbolic logic has long been treated as a model of intelligence, motivating rule-based inference and classical approaches to artificial intelligence. Yet systems built on explicit symbolic derivation have proven difficult to optimize, brittle under variation, and unable to generalize beyond tightly specified domains. These limitations are not merely engineering obstacles. The validity of long-chain symbolic inference depends on conditions that the world rarely affords: each step requires jointly realizable states and transition relations that must remain constructible throughout the chain. When any such condition cannot be instantiated, collapse is systemic rather than local. Human cognition, by contrast, operates under partial information, indeterminate predicates, and incomplete state specification, functioning without the requirement that all intermediate relations be jointly defined. This work re-evaluates the long-standing assumption that logical form constitutes the operative architecture of intelligence and clarifies why symbolic inference, though formally coherent, cannot serve as an operative account of cognition.

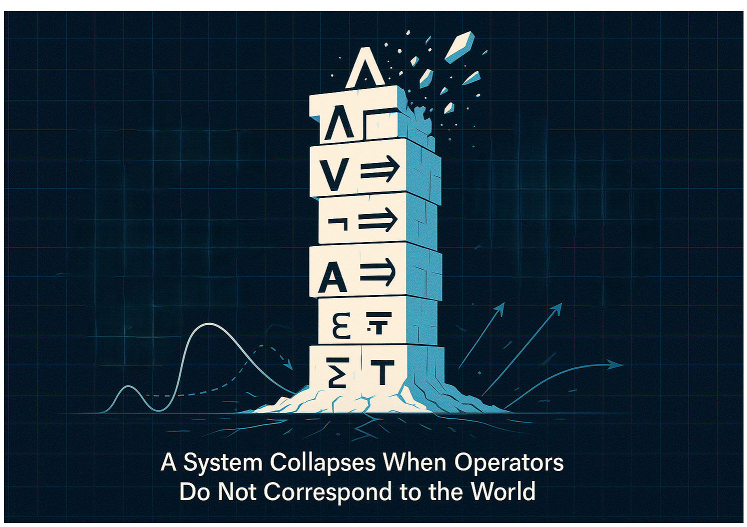

Figure 1: Symbolic inference collapses under two conditions: (i) conjunctive states in a long-chain derivation fail to exist, and (ii) operators lack generative grounding. Formal validity alone therefore cannot ensure real-world validity.

1 Introduction

For much of intellectual history, logical inference and symbolic computation have been treated as the emblem of rationality. From early analytic philosophy to formal AI, intelligence was equated with the capacity to manipulate explicit propositions through rule-governed operations Frege et al. [1879], Russell [2019], Newell and Simon [2007]. In this view, reasoning is a procedure of syntactic precision: the more faithful the derivation, the closer it approaches ideal cognition.

Yet across both AI development and cognitive practice, symbolic systems have proven notoriously brittle. Their optimization demands exhaustive specification, their generalization remains narrow, and their operational success depends on conditions far more complete than those available in realistic environments. Human cognition itself does not resemble such systems: everyday reasoning does not proceed by enumerating formal operators but by navigating incomplete, ambiguous, and partially grounded worlds. The purity attributed to symbolic computation is largely a product of notation rather than behavior.

The difficulty is not merely computational cost but ontological feasibility. A symbolic chain is valid only if every intermediate state is jointly realizable, and if every operator preserves a constructible transition in the world. When even one condition fails to map onto actual generative structure, the breakdown is not localized but systemic. Classical logic assumes that symbols remain stable under inference; real environments do not. What appears as formal consistency at the syntactic level can represent semantic impossibility at the level of world grounding.

This work revisits the grounding conditions that symbolic inference presupposes and makes explicit why those conditions rarely hold outside idealized abstraction. In doing so, we argue that intelligence cannot be defined as symbolic manipulation, however refined. Its validity depends not on internal closure but on alignment with states the world can in fact make real.

Our contribution. This work revisits the grounding conditions required for logical inference and symbolic computation to hold beyond abstraction. We show that their primary failure mode is ontological rather than computational: each inferential step presupposes jointly realizable states and world-valid operator transitions, and collapse follows when any such state cannot exist.

We further demonstrate, through behavioral and cognitive evidence, that human reasoning does not operate as long-chain symbolic derivation and does not require exhaustive specification of intermediate conditions. This analysis clarifies why symbolic computation remains formally coherent yet empirically fragile, and establishes that intelligence cannot be equated with symbolic chaining even in its ideal formulation.

2 The General Framework of Formal Logic and Symbolic Computation

Formal logic and symbolic computation jointly define a system in which inference is evaluated through explicitly specified representations and transformation rules. Classical formulations, beginning with Aristotle's syllogistic structures, were formalised in propositional and predicate calculi Frege et al. [1879], Whitehead and Russell [1927], and subsequently extended through higher-order systems and the development of symbolic programming architectures McCarthy [1960], Newell and Simon [2007]. Across these developments, the core objective has remained constant: to determine when a conclusion follows from stated premises through rule-governed manipulation.

In propositional logic, statements are represented as atomic units assigned fixed truth values, with connectives defining the admissible modes of combination. Predicate logic introduces quantification to express relations, identity constraints, and variable binding within a formally delimited domain. Symbolic computation extends these formalisms by encoding operators and derivation procedures into executable symbolic systems, enabling algorithmic manipulation of well-defined representations under syntactic rules.

Across classical logic and symbolic computation, refinement has primarily concerned symbolic precision, operator definition, and proof procedures. These expansions increased expressive range—allowing modality, identity conditions, and relational specification—while maintaining the central requirement that inference proceed under explicitly defined transformation rules within a formal representational space.

Table 1: Standard Operators and Their Formal Definitions

Operator	Symbol	Definition
Conjunction	$A \wedge B$	True iff both A and B are true
Disjunction	$A \vee B$	True iff at least one of A or B is true
Negation	$\neg A$	True iff A is false
Implication	$A \rightarrow B$	False only when A is true and B is false
Biconditional	$A \leftrightarrow B$	True iff A and B share truth value
Universal Quantifier	$\forall x\, P(x)$	Predicate holds for all elements in the domain
Existential Quantifier	$\exists x\, P(x)$	Predicate holds for at least one element in the domain

3 The Two Long-Unarticulated Premises of Logical Entailment

Although widely framed as issues of scalability or computational expansion, the core difficulty of symbolic inference arises at the level of definability rather than implementation. For multi-step entailment to count as entailment, two structural premises must hold simultaneously. These are the conditions that make rule-governed inference possible:

1. **Joint Specifiability.**
   Distinct propositions must admit a coherent joint state within the same formal representational space ($A \wedge B$ must be definable, not merely individually well-formed).
2. **Determinable Transition.**
   Successive symbolic states must be linked by an operator-governed rule of transformation, rather than by formal succession alone ($A \rightarrow B$ must correspond to a determinable derivation rule).

These premises rarely appear explicitly because they function as background commitments rather than articulated conditions. The following sections clarify how they operate as the very terms under which symbolic entailment is possible across extended derivations.

Table 2: Constructibility Failure Modes of Symbolic Inference

Formal Operation	Syntactic Status	Ontic Failure Condition
$p \rightarrow q$	valid	q not uniquely realizable by p
$\neg q \rightarrow \neg p$ (contraposition)	valid	absence of q does not imply absence of p
$p \wedge r$ (conjunction)	valid	joint state not constructible in the world
$\neg p$ (global negation)	valid	world lacks generative operator for full complement
$p \rightarrow q \rightarrow r \rightarrow s$	valid	any non-admissible step collapses entire chain

3.1 Event Co-Realizability: When Joint Propositions Must Exist in the World

For symbolic inference to extend beyond a single step, distinct propositional states must admit a jointly realizable configuration within the same formal space. That is, if A and B are to appear in an entailment sequence, then $A \wedge B$ must constitute an admissible state rather than a merely formal conjunction. This requirement concerns joint realizability: propositions must be not only individually well-formed but capable of standing together within a single derivational framework.

When this joint condition is not met, the resulting expressions may remain syntactically valid while lacking any realizable state within the inferential space. In such instances, extended entailment continues to proceed formally, yet does so without corresponding instantiation.

3.2 Operational Constructibility: When Logical Operators Must Correspond to Real Generative States

A second condition for the extension of symbolic inference is that transitions between propositional states be licensed by a determinable operator. In an entailment sequence, $A \rightarrow B$ must correspond to a rule-governed transformation rather than mere syntactic succession. The transition must be constructible within the formal system in the sense that a defined operator can account for how the state associated with A yields the state associated with B.

When such constructibility is absent, expressions may remain syntactically permissible while no determinate transformation can be assigned to connect A with B. In these instances, derivation proceeds formally but without an operational pathway.

4 The Accumulation Problem in Long-Chain Derivation

Within symbolic traditions, the capacity for extended inference has often been treated as the defining marker of rational competence. Yet the feasibility of such extension rests not on computational endurance but on the continued instantiability of each inferential step. A derivation requires that successive propositions remain jointly assignable and that the transition between them remain operator-governed. As the chain extends, these conditions do not merely increase in number; they compound.

Failure at any point does not merely impair the subsequent step but collapses the entire structure of admissibility: a single non-instantiable transition eliminates the possibility of a world in which the chain can hold at all. What remains is syntactic form without feasible grounding. Long-chain derivation thus encounters a structural accumulation problem: the likelihood that joint admissibility and operator constructibility can be simultaneously maintained declines with each added step. What appears as inferential continuity at the syntactic level becomes, at the level of applicability, non-formable.

> **Intuitive Motivation.** When we reason step by step, it is easy to assume that if each part works, the whole chain should work too. In practice, however, the conditions invoked by different steps cannot always be satisfied together. As a chain grows, its requirements accumulate faster than they can be jointly upheld. The issue is not error but the simple fact that extended inference rarely remains fully instantiable.

5 Why Human Cognition Rarely Executes Formal Inference

The difficulty of long-chain derivation, previously established as a matter of instantiability rather than computational growth, directly entails that human cognition seldom realizes such forms. To execute formal inference, states must remain jointly assignable and operator-governed across successive steps. Yet ordinary cognition is seldom situated in informational conditions that deliver complete state specification. Most situations present partial, intermittent, or non-exhaustive data, and memory does not retain fully articulated intermediate configurations across extended sequences. In such environments, long-chain derivation does not arise as a practical mode of cognition: the informational and mnemonic conditions that would necessitate it are rarely furnished.

Human reasoning does not stand in opposition to logical norms; it simply operates under informational and mnemonic conditions that are rarely complete. What psychology has long documented—heuristics Gigerenzer and Goldstein [1996], post-hoc fitting Ross [1977], representation bias Kahneman et al. [2002]—does not mark departure from formal inference but reflects how cognition functions where full specification and sustained state retention are not given. Logic presupposes articulated and continuously maintainable states, whereas ordinary cognition is seldom furnished with, and has no need to preserve, such conditions.

> **Intuitive Motivation.** Long chains of logical inference are rare not because humans fail at logic, but because real situations seldom provide complete information or enough memory to hold every intermediate state at once.

6 Why Symbolic Operations Do Not Constitute Intelligence

Symbolic inference only functions when all semantic conditions are already satisfied: joint realizability, operator grounding, and mechanism-preserving transitions. Under such completeness, the informational gain of symbolic chaining becomes narrowly combinatorial—it yields rearrangements of known constraints, not expansion into genuinely uncertain space. The system can produce new forms of expression, but only within the finite closure already guaranteed by its premises. Intelligence cannot be defined by a mode of operation that requires near-complete condition satisfaction before any inferential move is admissible.

In contrast, pattern-based architectures operate under partial information. They do not require exhaustive specification of every predicate or causal condition; instead, they generalize from limited, structurally adjacent evidence to unseen regimes. Their success is not accidental looseness but a functional property: generalization requires tolerance of missing constraints, not their full satisfaction. Where symbolic methods collapse once a single grounding fails, pattern systems degrade gracefully, still producing usable approximations.

7 Discussion

7.1 Intelligence as World-Grounded Constructibility

Intelligence is often equated with expanding computational capacity—greater logical depth, representational precision, or algorithmic scale. The present account clarifies a different boundary: inference cannot surpass the grounding of its operators in the world. When one step in a derivation lacks correspondence to how things actually operate, the failure is systemic rather than local, because formal validity remains indifferent to real constraints.

True intelligence requires grounding in the conditions it aims to describe. Computation or simulation, however extensive, is insufficient when it lacks alignment with the mechanisms it invokes. Grounding is not an accessory but the basic condition that prevents intelligence from devolving into internally coherent yet externally irrelevant formulation.

7.2 Externalization as the Condition for Extended Inference

Extended logical inference exceeds what human cognition can internally maintain. As chains lengthen, intermediate states outstrip both available information and memory capacity. For this reason, long-form inference is rarely executed in isolation and requires continual calibration through peers, texts, and formal expertise. The same limitation explains why we write steps down, segment reasoning, and externalize intermediate states; without such stabilization, extended inference does not hold.

8 Conclusion

This work examined the feasibility conditions required for symbolic inference to function beyond formal isolation. Systems that rely on explicit derivational chains must presuppose that each intermediate state remains jointly realizable and that every transition relation is constructible in the world. We showed that these requirements, rather than computational cost alone, underlie the brittleness, limited generalization, and optimization difficulty widely observed in symbolic approaches. When a single condition cannot be instantiated, failure is not incremental but global, eliminating the possibility of a world in which the chain can hold.

Human cognition, by contrast, operates without dependence on fully specified predicates or exhaustively defined intermediate relations, and succeeds under partial grounding rather than complete semantic closure. The historical identification of intelligence with symbolic entailment is therefore misplaced: logic provides a formal description of resolved states, not the operative mechanism of reasoning. Symbolic inference may remain central to formal systems, but it cannot constitute the architecture through which cognition functions in non-ideal, underspecified environments.

Declaration of LLM Usage

The authors used OpenAI's ChatGPT to assist in refining phrasing and improving clarity. All theoretical arguments and interpretations are original and authored by the researchers.

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