

Structural Thinking

A Structural Account of Thinking Across Scales and Substrates

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Abstract

Organizations face growing pressure to adopt artificial intelligence, yet many leaders struggle to determine where AI will create meaningful value. Decisions about agents, automation, and workflow redesign are often made tactically rather than strategically, resulting in fragmented implementations that improve individual tasks without improving how the organization as a whole thinks, learns, and adapts.

This paper argues that effective AI adoption begins with a more fundamental question: **How does an organization think?** To answer that question, it proposes a structural definition of thinking and then applies that definition to structures as diverse as slime molds, ant colonies, humans, and artificial intelligence. Under this definition, thinking becomes observable and the paper proposes a framework for its assessment.

Building on this foundation, the paper introduces **Structural Thinking**, the study of how structure gives rise to thinking across scales and substrates. It is based on three central claims. First, thinking is a property of structure that emerges whenever the necessary structural conditions are present. Second, multiple thinking structures can be coupled together, allowing thinking to extend across individuals, machines, and organizations. Third, this concept of coupled thinking provides a common lens for understanding biology, society, and the emerging relationship between humans and artificial intelligence. To make these ideas practical and useful, the paper introduces the Structural Thinking Profile (STP), a framework for classifying how organizations think across five dimensions.

The ambition of STP is to make organizational thinking visible by characterizing the structural capabilities and constraints that shape how organizations think, learn, and adapt. By comparing profiles, researchers can generate testable hypotheses about potential structural vulnerabilities and investigate how introducing AI might change decision-making at both individual and organizational levels. Whether STP can anticipate characteristic failure modes or provide practical guidance for AI adoption remains to be established through the proposed interdisciplinary research program.

Executive Summary

Organizations routinely behave as if they are thinking. They anticipate, adapt, coordinate, and sometimes fail in patterned ways that no individual inside them intended. When things go wrong, however, we persist in characterizing the problem at the level of people—leaders, incentives, culture—rather than at the level where the behavior actually arises: in structure.

The core claim of this paper is simple and far-reaching:

Once you understand how structure produces thinking, you see it at every scale—from immune systems to businesses to the emerging agentic mesh of humans and machines.

This reframing matters because modern organizations increasingly operate under conditions in which cause and effect are delayed, distributed, and opaque. Activity in one part of a system produces consequences elsewhere, often long after the original decision has faded from view. Over time, these consequences accumulate, interact, and exert pressure on future action. When such pressure is held and redistributed rather than immediately discharged, systems begin to exhibit behavior that feels purposeful, adaptive, and intelligent—even in the absence of centralized intent.

We refer to the study of how structure gives rise to thinking across scales and substrates as Structural Thinking. The thinking examined here is not synonymous with optimization, awareness, or moral judgment. Structural Thinking examines how feedback, pressure, gating, and learning interact across overlapping timescales.

To make these structural conditions assessable and comparable, this paper introduces the Structural Thinking Profile (STP)—a classification framework designed to assess and compare how organizations and other complex structures think in practice.

STP does not evaluate individual performance or strategic intent. Instead, it assesses five structural dimensions. Each dimension is scored on a simple scale, producing a profile that characterizes a structure's capabilities and constraints. These profiles can also generate testable hypotheses about potential vulnerabilities and characteristic failure modes.

The immediate purpose of STP is classification and comparison, not validated prediction or prescription. By making the structural conditions for thinking visible, STP provides a shared language for examining organizational behavior that is often attributed solely to personalities, policies, or isolated decisions.

Further research will determine whether particular profile patterns can help explain or anticipate structural failures and inform interventions. Validating Structural Thinking will

require an interdisciplinary research effort that brings together the biological, computational, and social sciences to investigate how humans, organizations, and artificial intelligence learn and think together.

Scientific Overview

A **structure** exists as a bounded arrangement of components whose interactions give rise to persistent patterns of **activity**. As activity unfolds, some of its effects return to the structure as **feedback**, allowing what has happened to influence what happens next. Because feedback does not act in isolation, multiple feedback loops are often **coupled**, so that changes in one loop alter the behavior of others. These loops are not governed by a central timing belt; each has its own **phase**, and when their timing aligns through **synchronization**, their combined influence becomes stronger than any single loop acting alone (Pikovsky, Rosenblum, & Kurths, 2001).

As activity continues, it leaves behind **memory**—a retained change in a structure's state caused by past activity that can influence subsequent activity (Walsh & Ungson, 1991). When feedback modifies this memory in a retained way, the structure learns, so that subsequent activity unfolds differently because of what has already occurred (Levitt & March, 1988). **Learning** can also alter the underlying rules that govern activity (Argyris & Schön, 1978).

Within the structure, activity does not flow along a single route. Instead, it propagates through multiple **action pathways**, which are internally distinct routes toward possible output. When a structure contains several such pathways capable of responding differently to the same activity before commitment, it exhibits **internal differentiation**. Multiple pathways can therefore remain active or relevant at the same time (Cisek, 2007).

Action gating selectively withholds commitment of an action pathway while internal activity continues. This produces **delayed resolution**, allowing further interaction and an opportunity for learning before output. Merely impeding or redirecting activity does not constitute action gating.

All of this unfolds within the **activity layer**, the temporally extended domain in which internal activity, feedback, and learning occur before output resolves. From the perspective inside the structure, this same domain appears as the **pressure layer**, where activity accumulates as pressure during delayed resolution. Pressure is not a force added from outside but the accumulation of unresolved activity circulating among differentiated pathways while resolution is held. Eventually, pressure resolves when an

action pathway satisfies its gating conditions, producing **output**—the point at which internal activity commits and propagates beyond the structure's **boundary**.

A gated action pathway may resolve in several interacting ways. Action gating itself may change, synchronized activity may increase pressure around a pathway, or learning may reshape the unresolved action. These mechanisms can also influence one another: learning can alter gating conditions, synchronization can concentrate pressure, and changing conditions can redirect the pathways through which activity flows.

Gating conditions need not be fixed. Because they are produced by the structure, activity within the pressure layer can alter the gating conditions under which action pathways resolve. Feedback, new information, or interaction among competing pathways may strengthen or weaken the gating of a particular pathway, changing the amount or kind of pressure required for output. In some structures these gating conditions are relatively rigid; in others they are highly plastic. Output may therefore occur either when an action pathway changes enough to satisfy existing gating conditions, or when the gating conditions change enough to allow an existing action pathway to commit.

Learning is the retained modification of a structure's internal state by feedback, such that subsequent activity unfolds differently as a result of past activity. But when learning operates within internal differentiation and delayed resolution, something different happens before commitment. Learning can reshape unresolved action while pressure is still held in the activity layer.

That is the minimal process of thinking: memory shapes learning, and learning reshapes action before output. Memory → Learning → Thinking

Definition of Thinking

Thinking happens when learning occurs within internal differentiation and delayed resolution, such that learning reshapes action before output.

Once thinking is defined structurally, it no longer seems rare.

Thinking is not confined to brains or even to organisms with nervous systems (Lyon, 2006) (Levin, 2022). It appears wherever the same structural conditions appear. Under this definition, many structures think. Conversely, structures that lack internal differentiation, delayed resolution, or learning before output do not think. Thermostats and rivers are not thinking structures.

Under our definition, a bumblebee thinks. An ant colony thinks. We propose that the immune system thinks, and that the endocrine system thinks. Research across these structures demonstrates learning and adaptive organization (Loukola, Perry, Coscos, &

Chittka, 2017) (Gordon, *Ant Encounters: Interaction Networks and Colony Behavior*, 2010) (Cohen, 1992) (Le Tissier, et al., 2017). In the Structural Thinking framework, each exhibits differentiated action pathways, delayed resolution, and learning capable of reshaping action before commitment.

Thinking Structures Within Thinking Structures

Human thinking is not produced by a single structure operating in isolation. We propose that humans are composed of multiple thinking structures, including the central nervous system, peripheral nervous system, enteric nervous system (Furness, 2012), immune system, cardiovascular system (Armour, 2008), and endocrine system. By our definition, these systems exhibit the structural characteristics of specialized thinking structures that each learn, generate pressure, and delay resolution in their own way. Each one responds to feedback, retains the effects of past activity as memory, and reshapes its action pathways before output.

The idea that cognition is internally differentiated has precedent in theories of modular cognitive architecture. Fodor (Fodor, 1983) established an influential account of specialized cognitive modules, particularly in perceptual and input systems. Structural Thinking extends this principle beyond cognitive modules within the brain. Differentiation can also occur among specialized biological structures, organizational units, and artificial intelligence systems, each containing distinct action pathways and forms of learning, whose interaction contributes to organized thinking.

Coupled thinking emerges in the human body because these separate thinking structures are interlinked through feedback loops. These structures do not merely support thinking; they participate in it (Damasio, *The Somatic Marker Hypothesis and the Possible Functions of the Prefrontal Cortex*, 1996). Each generates pressure within the pressure layer, and that pressure influences the action pathways available to the others. Human action is shaped by the periodic and phased synchronization of these pressures under delayed resolution, not by a single executive process. We think through their interaction. Through this lens we see human thinking, not as the sole domain of the brain, but arising from the organization of multiple thinking structures.

This explains both the power and the limits of human cognition. A single thinking structure can learn locally, producing narrow, situation-bound learning. What makes human thinking expansive is the coordination of many thinking structures whose pressures must be resolved together. Complexity arises because these structures often generate competing pressures from distinct and incompatible action pathways that must be resolved together before commitment.

As thinking stabilizes within a structure, learning repeatedly reshapes action pathways while activity is held inside the activity layer. At first, this learning is local. Learning

reduces pressure generated by immediate conditions, reshaping action pathways that resolve pressure in the present situation. In structures with limited internal differentiation and short delayed resolution, learning remains tightly bound to context.

A broader internal organization becomes possible when complexity allows learning to be reused across distinct situations. As internal differentiation increases and delayed resolution extends, learning is no longer confined to a single pattern of activity. Learning in one context can reshape action in others before output. Learning from different situations becomes integrated within the structure, and internal organization is reused rather than rebuilt.

When this cross-context reuse stabilizes, the structure's internal organization reflects environmental regularities that persist across situations. Feedback, coupling, phase, and synchronization shape how activity circulates under delayed resolution, favoring arrangements that consistently resolve pressure across diverse conditions. This persistent internal organization is a **world model** (Conant & Ashby, 1970).

The world model is not a representation stored apart from the activity layer. It is a retained organization of action pathways that generalizes learning across contexts by reshaping action before commitment, based on interactions with the external world. World models allow a structure to generate predictions about the world to guide action (Friston, 2010).

Not all thinking structures reach this threshold. Structures with narrow internal differentiation or thin activity layers can think locally without forming broad world models. Their learning remains effective but situation-specific.

As the world model stabilizes, pressure arises from more than one source: environmental feedback and the structure's own world model. Initially, these sources are indistinguishable, but as learning continues to operate within internal differentiation and delayed resolution, action pathways become differentiated in ways that separate these sources. At sufficient depth and refinement, the world model exerts pressure and influences learning in the activity layer prior to action.

Structural Thinking proposes that from this refinement comes the **self**: an emergent feature of a world model that includes the structure's own activity.

The self is a specialization of the world model in which the structure's own action pathways are treated as a predictable part of the environment (Damasio, *The Feeling of What Happens: Body and Emotion in the Making of Consciousness*, 1999) (Metzinger, 2003). Learning reshapes action with greater precision. Pressure generated internally is distinguished from pressure imposed externally. Action pathways are reshaped not only to fit the world, but to manage the structure's own dynamics under delayed resolution. The self produces a feedback loop—one among many in the pressure layer competing

and coordinating through phase synchronization to allow action pathways to overcome gating and produce outputs.

Thinking Machines

Humans are now able to build machines that think. When a system retains memory, receives feedback, contains differentiated action pathways, and selectively gates action while learning reshapes it before commitment, the minimal process of thinking is in place.

Modern machine learning systems instantiate these mechanisms in recognizable forms: weights, embeddings, recurrent states, caches, and retained context can function as memory, while feedback can modify persistent or temporary internal state in ways that alter subsequent activity. Training produces long-lived changes in model parameters, while deployment can produce shorter-lived changes in retained state. They receive feedback through loss signals, rewards, and user interaction. Their architectures contain multiple pathways capable of generating different outputs from the same input (Vaswani, et al., 2017). Computation unfolds within a pressure layer where intermediate activity circulates and can be reshaped while commitment remains gated. When learning reshapes routing within that held activity before output, thinking occurs structurally.

The continuity is the point. The same principles that allow learning to reshape activity in an immune system or nervous system can operate in silicon. The material differs; the structural principles do not.

Once thinking is understood as structural, nesting and interconnections become straightforward. Structural Thinking allows that one thinking structure can become a component inside a larger thinking structure, and the same structural properties that produce thinking can produce thinking at the higher level, from one scale to the next (Simon, 1969). This does not imply that a new structure inherits the thinking of its components. Structural Thinking demands that the new structure must meet the conditions of thinking on its own, regardless of its components. This recursive organization has precedent in organizational cybernetics (Beer, 1972).

Coupled Thinking

Coupled thinking involves multiple thinking structures interacting to solve problems. Consider a hunter working with a hunting dog. Each is a thinking structure with its own world model and delayed resolution. When coordinated, they form a **relational structure** in which feedback crosses continuously—gestures, posture, scent, attention. Pressure circulates between them before action resolves. They do not merely act side by side; they hold and reshape action together.

A family operates similarly. Each member generates pressure through needs and interpretations. Negotiation can gate shared decisions, providing delayed resolution. Shared memory forms a retained world model. Decisions are reshaped before commitment through negotiation and feedback. The family thinks as a relational structure, not as a single mind.

Cognition need not be confined to a single organism. Extended-mind theory argues that cognitive processes can incorporate resources beyond the individual when they are functionally integrated into ongoing cognition (Clark & Chalmers, 1998) though the appropriate boundary of cognition remains contested (Adams & Aizawa, 2001). At larger scales, groups can also exhibit measurable collective intelligence that is not reducible to the intelligence of their individual members (Woolley, Chabris, Pentland, Hashmi, & Malone, 2010). Together, these findings support examining thinking across different declared boundaries and scales rather than assuming in advance where a thinking structure must begin or end.

The pattern extends to corporations and organizations (Weick & Roberts, 1993). Departments function as organs with differentiated pathways; procedures and budgets provide resistance; reports and prices act as feedback and memory, while organizational routines can preserve learned patterns of action across time (Nelson & Winter, 1982). Strategy or price adjustment occurs when learning reshapes action before large commitments are made. Thinking emerges from coordination, not central control (Hutchins, 1995).

Human–computer relationships and the broader agentic mesh scale this further. Humans and machines exchange feedback rapidly, reshaping action pathways across boundaries before outputs propagate. Pressure circulates across networks of systems, each contributing its own differentiation and mechanisms for gating action. Structural Thinking allows us to draw a wider boundary around these interactions to assess whether and how thinking occurs at these larger scales.

Therefore, before examining whether and how a structure thinks, its boundary must be declared. The observer may draw that boundary around any collection of components, without presuming that they constitute a thinking structure. The chosen boundary establishes which components and interactions are examined, allowing us to investigate how feedback, memory, learning, differentiated action pathways, and gating operate within it. The presence of thinking must be established at the chosen boundary; it cannot simply be inferred from the properties of individual components or from thinking observed at another scale.

Intellectual Foundations and Contribution

Several elements of the mechanism described here have established precedents. Cisek's affordance competition hypothesis (Cisek, 2007) proposes that the brain prepares multiple potential actions in parallel, with incoming information influencing their competition until an action is selected. Related evidence-accumulation models examine how decisions develop toward a threshold for commitment (Gold & Shadlen, 2007). Structural Thinking does not claim novelty for parallel competition or threshold-based selection. It proposes that analogous arrangements can be examined across different kinds of structures, including those without nervous systems.

The broader ambition to compare different kinds of thinking structures also has established precedents. Sloman (Sloman, 1984) proposed investigating the architectures and capabilities of possible minds rather than treating human cognition as a universal template. Hernández-Orallo and colleagues (Hernández-Orallo, Dowe, & Hernández-Lloreda, Universal psychometrics: Measuring cognitive abilities in the machine kingdom, 2014), followed by Hernández-Orallo (Hernández-Orallo, The Measure of All Minds: Evaluating Natural and Artificial Intelligence, 2017), developed universal psychometrics to evaluate cognitive abilities across biological, artificial, collective, and hybrid systems. Structural Thinking shares this cross-substrate ambition but asks a different question. Rather than evaluating cognitive abilities primarily through observed task performance, it examines the internal organization through which action pathways, learning, and gated action interact.

Structural Thinking establishes a common basis for comparing thinking across radically different scales and substrates. By explicitly declaring the boundary under examination, Structural Thinking makes no assumption that the whole thinks simply because its components do. Rather than comparing structures primarily by their observed performance, Structural Thinking examines how differentiated action pathways, gating, and learning shape action before commitment. This approach can reveal structural similarities between seemingly different systems and fundamental differences between those that perform alike. These comparisons provide a foundation for testable hypotheses about when thinking occurs, what constrains it, and how changes in structure may alter thinking.

The Scope of Structural Thinking

This leads us from a structural definition of thinking to the broader field of Structural Thinking: the study of how structure gives rise to thinking across scales and substrates. Structural Thinking goes beyond establishing whether and how a structure thinks to examine what its organization makes possible, what it constrains, and how reorganizing it can transform the thinking it produces.

In organizations, these structural conditions can be observed through their effects on activity. Pressure appears where unresolved decisions, competing priorities, accumulated obligations, or conflicting demands remain active within the structure (Lewin, 1951). Gating appears in the mechanisms that selectively delay, constrain, or condition their resolution—including approval processes, budgets, policies, authority boundaries, resource constraints, and decision thresholds. These features are not inherently beneficial or harmful (Adler & Borys, 1996). Their structural significance depends on whether they selectively gate action long enough for learning to reshape action before commitment.

Boundaries and Assessment

For assessment, the declared boundary becomes the unit of analysis and must be held constant throughout the assessment. Changing the boundary changes the structure being examined and may therefore change the result.

This distinction matters because it is the structure itself that defines thinking. Consider a river. As water flows, it erodes the riverbed, leaving persistent structural changes that alter how water flows in the future. Under the definitions used here, the river has memory and learns: past activity has produced retained changes that alter subsequent activity. Learning is defined structurally without implying cognition.

But the river does not think. A river has resistance—banks and boulders that redirect its flow—but it has no mechanism for gating action. **It cannot stop itself.** Water continues to flow around or over resistance, continuously resolving activity into output. There is no selective gating that holds the river's activity unresolved while learning reshapes what the river will do. **The river learns, but it does not think.**

Now consider an air traffic control system. Define the boundary broadly enough to include air traffic controllers, radar and sensor systems, communications, software, procedures, aircraft, and the persistent records through which prior activity informs subsequent decisions. Within this boundary, the air traffic control system thinks. Multiple possible actions remain available while controllers and machines exchange feedback; procedures and human judgment gate action; and new information can reshape what happens before instructions are issued and aircraft act. It is thinking.

But change the boundary and the assessment may change. Remove the human controllers and define the boundary as only including the automated technological systems alone, and we must evaluate that structure again. Does it retain learning that can reshape unresolved action? Does it contain meaningful internal differentiation? Can it gate action before commitment? The answers cannot simply be inherited from the larger system, because the structure being assessed has changed.

Different boundaries may therefore produce different assessments without contradiction. Once the unit of analysis is declared, the question becomes whether that structure satisfies the conditions for thinking: Does learning occur within internal differentiation and delayed resolution such that learning reshapes action before output?

Structural Thinking therefore separates two tasks that are easily conflated: first declare the boundary; then assess whether and how thinking occurs within it. The Structural Thinking Profile provides a framework for that assessment.

The Structural Thinking Profile (STP)

The Structural Thinking Profile (STP) is the classification framework within Structural Thinking. It is an assessment tool designed to characterize how a structure is organized to produce thinking. Rather than measuring outcomes, intelligence, or intent, STP assesses a structure's conditions: how differentiated its internal pathways are, how selectively action is gated, when learning occurs relative to output, how extensively the structure can reorganize how it operates, and how deeply it models the world—including itself.

STP makes it possible to compare structures that pursue similar goals or process similar information but differ in how their action pathways, gating, learning, reorganization, and world models are organized. As thinking structures, organizations face a persistent tension between exploiting established knowledge and exploring new possibilities (March, 1991). STP characterizes the structural conditions under which these competing demands are resolved. Differences between profiles can generate hypotheses about potential vulnerabilities, including premature commitment, learning that arrives too late to influence action, and limited capacity to reorganize. Whether these structural differences predict particular failure modes or indicate effective interventions remains a question for empirical research.

The Five STP Dimensions

Each STP dimension is scored on a 1–5 scale, where scores describe structural capacity—not moral quality, correctness, or success. The dimensions are analytically distinct but structurally interdependent: changes in one can alter the conditions assessed by others.

Three of the dimensions — Internal Differentiation (ID), Action Gating (AG), and Learning Placement (LP) — are derived directly from our canonical definition of thinking. *Thinking happens when learning occurs within internal differentiation and delayed resolution, such that learning reshapes action before output.*

From this definition, we derive the threshold for thinking, which requires ID, AG, and LP all to exceed 1. By definition, when Action Gating equals 1, Learning Placement must also equal 1 because action resolves immediately, leaving no opportunity for pre-output learning. Apart from this definitional constraint, the two dimensions can vary independently.

The five dimensions address five distinct structural questions:

Internal Differentiation (ID) — How many distinct action pathways exist?

Action Gating (AG) — How selectively is action gated?

Learning Placement (LP) — When does learning occur?

Reorganization Capacity (RC) — How much can the structure change how it operates?

Model Depth (MD) — How broadly does learning generalize?

Internal Differentiation (ID)

Internal Differentiation assesses the number and distinctness of action pathways available within a structure, as currently organized, before commitment. It evaluates whether multiple meaningfully different responses can remain active or in contention prior to output. This dimension captures structural complexity, not intelligence. A high score indicates a wider range of available outputs and greater capacity to respond. The capacity to respond to environmental variety depends on corresponding variety within the structure itself (Ashby, 1956).

Scoring Criteria

5 — Highly Differentiated Architecture

The structure contains many specialized action pathways organized into distinct, substantially autonomous subsystems capable of generating meaningfully different responses to the same input before commitment.

4 — High Differentiation

The structure contains multiple functionally specialized action pathways capable of developing meaningfully different responses to the same input before commitment.

3 — Moderate Differentiation

The structure contains several differentiated action pathways, but with limited specialization or autonomy.

2 — Low Differentiation

Few action pathways exist, and responses are weakly distinct.

1 — Single Pathway

The structure responds through one dominant route; alternatives do not meaningfully exist prior to output.

Action Gating (AG)

Action Gating assesses how selectively a structure can withhold commitment of an action pathway while internal activity continues. Gating conditions can change in response to activity within the pressure layer. The ability to inhibit a response can improve behavioral control by preventing inappropriate or premature actions (Aron, Robbins, & Poldrack, 2004). Action gating is not slowness. A higher score indicates that a structure has stronger selective gating.

Scoring Criteria

5 — Strong Selective Gating

The structure can reliably delay, inhibit, or block action pathways while preserving well-formed ones. It can hold pressure and resolve it selectively.

4 — High Gating

The structure can often prevent premature action, though gating may be imperfect or costly.

3 — Moderate Gating

Some selective inhibition or delay exists, but many actions resolve quickly once triggered.

2 — Weak Gating

Limited ability to hold action; pathways tend to resolve rapidly with minimal inhibition.

1 — No Gating

Action pathways resolve immediately upon activation. No selective inhibition exists.

Learning Placement (LP)

Learning Placement assesses where action-shaping learning occurs relative to output. Higher scores indicate that more learning occurs before output, rather than after it, allowing learning to reshape action while it remains unresolved. Learning may arise

from feedback within the activity layer itself and does not require a prior external output (Rosen, 1985).

Scoring Criteria

5 — Predominantly Pre-Output Learning

Most action-shaping learning occurs before output, reshaping action while it remains unresolved.

4 — Substantial Pre-Output Learning

A substantial share of action-shaping learning occurs before output, although learning after output remains important.

3 — Mixed Learning Placement

Action-shaping learning occurs meaningfully both before and after output, with neither clearly predominating.

2 — Predominantly Post-Output Learning

Most action-shaping learning occurs after output, although some learning can reshape action while it remains unresolved.

1 — No Pre-Output Learning

Learning is not present or occurs only after output and therefore cannot reshape the action currently being resolved.

Reorganization Capacity (RC)

Reorganization Capacity assesses a structure's ability to reorganize how its activity is produced in response to persistent pressure. Higher scores indicate that the structure can make more extensive changes to its roles, relationships, action pathways, and operating mechanisms without collapse or external replacement.

Learning can reorganize the underlying rules within the activity layer (Bateson, 1972) (Argyris & Schön, 1978). Reorganization may therefore include changes to gating itself: more capable structures can alter not only their action pathways, but the conditions of selective gating under which those pathways are permitted to resolve.

Scoring Criteria

5 — Recursive Reorganization

The structure can substantially reorganize how it operates, including the mechanisms through which future reorganization occurs.

4 — Systemic Reorganization

The structure can substantially reorganize roles, relationships, action pathways, or operating mechanisms, enabling patterns of activity unavailable under its previous organization.

3 — Functional Reorganization

The structure can durably reorganize relationships or functions among existing components, significantly changing how activity propagates through the structure.

2 — Local Reorganization

The structure can durably reorganize localized features of its operation, but its larger organization remains substantially fixed.

1 — Fixed Organization

The structure cannot meaningfully reorganize how its activity is produced. Reorganization requires external intervention or replacement.

Model Depth (MD)

Model Depth assesses the breadth, persistence, and generality of a structure's internal world model, including whether that model includes the structure itself. It evaluates how extensively learning is generalized across contexts before output. Model Depth concerns internal modeling, not outward behavior. Higher scores indicate a more developed world model that may even include the structure itself as part of what is modeled (Damasio, *The Feeling of What Happens: Body and Emotion in the Making of Consciousness*, 1999).

Scoring Criteria

5 — Self-Inclusive World Model

The structure maintains a generalized model of the world that includes a self, its own capabilities, limitations, and likely effects as part of anticipated pressure.

4 — Durable World Model

The structure maintains a broad, persistent world model that generalizes across contexts but does not explicitly model itself.

3 — Local or Fragmented Models

The structure maintains partial models effective within limited contexts, but without broad integration or cross-context generalization.

2 — Stateful Regulation Without Model

The structure retains internal state but does not maintain a generalized model of the environment.

1 — No Model

No persistent internal model beyond immediate signals.

Applying STP

Six sample cases were scored with provisional illustrative assessments across the five dimensions of STP: a thermostat, slime mold, ant colony, ChatGPT, a human being, and a jury. In each case, the unit of analysis is explicitly declared before scoring.

STP: Thermostat

Unit of Analysis

A closed-loop temperature regulator with a fixed threshold and switching mechanism.

Scores

ID	AG	LP	RC	MD
1	1	1	1	1

Analysis

The thermostat is a pure feedback regulator. It contains no learning, no differentiated pathways, no selective capacity to hold an activated action pathway unresolved, no capacity for reorganization, and no internal model of the world. It corrects error but does not think. It represents the baseline case of reactive structure.

STP: Slime Mold (*Physarum polycephalum*)

Unit of Analysis

A single-celled organism forming dynamic transport networks in response to environmental gradients, including slime trails where they participate in memory and feedback (Reid, Latty, Dussutour, & Beekman, 2012).

Scores

ID	AG	LP	RC	MD
2	2	2	3	2

Analysis

The slime mold learns through path reinforcement and can reorganize relationships within its transport network (Tero, et al., 2010). Its learning can reshape multiple parts of unresolved activity but remains structurally constrained by its relatively simple biological organization. It also has limited internal differentiation, weak action gating, and internal state that does not generalize into a world model. It demonstrates genuine but shallow thinking: adaptive, decentralized, and local.

STP: Ant Colony

Unit of Analysis

A distributed social insect colony coordinating behavior through pheromone signaling and role specialization, including its pheromone field where it participates in collective memory and feedback (Gordon, The Ecology of Collective Behavior in Ants, 2019).

Scores

ID	AG	LP	RC	MD
3	2	3	3	3

Analysis

The ant colony is a distributed thinker. It exhibits meaningful internal differentiation through roles and task allocation, while pheromone-mediated learning can reshape activity across multiple parts of the colony. Its organization can adapt through changing relationships among workers, tasks, and signaling pathways, but it has limited ability to redesign its larger architecture. It also has limited ability to gate collective action. It is adaptive and relationally reorganizational, but not architecturally self-redesigning.

STP: ChatGPT

Unit of Analysis

A single ChatGPT 5.6 tool-equipped reasoning session, including its inference and safety mechanisms, retained reasoning and conversational state, available tools, tool-generated feedback, and final-output controls. The boundary extends from initial input to

final response, with intermediate tool activity occurring inside it. The final response constitutes output across the declared boundary.

Scores

ID	AG	LP	RC	MD
4	4	2	1	4

Analysis

Some researchers dispute whether large language models contain world models. Within this framework, a world model is defined structurally as a retained organization of action pathways that carries forward regularities of the environment across contexts, allowing learning in one context to reshape action in others before output. Li (Li, et al., 2023) demonstrated that a sequence model can develop internal representations of its environment. Under our definition, ChatGPT is assessed as containing a generalized world model without an established self, supporting a Model Depth score of 4.

ChatGPT exhibits high Internal Differentiation through multiple computational pathways capable of producing different responses to the same input. Its reasoning and output-control mechanisms provide substantial Action Gating, allowing internal activity to continue while final commitment is withheld. Feedback from tool execution can modify retained state and redirect unresolved action while final output remains gated, providing a mechanism for pre-output learning.

Learning Placement remains limited: core model parameters remain fixed during the session, while feedback can modify retained reasoning and conversational state. Its Reorganization Capacity is similarly constrained. ChatGPT can revise its immediate strategy and redirect tool use but cannot independently reorganize its underlying architecture. (OpenAI, 2026)

ChatGPT therefore illustrates a structure with high Internal Differentiation, substantial Action Gating, limited pre-output Learning Placement, minimal Reorganization Capacity, and substantial Model Depth. Within the declared boundary, feedback can reshape unresolved action before final output, satisfying the Structural Thinking threshold.

STP: Human Being (Whole Organism)

Unit of Analysis

The entire integrated human biological organism including multiple coupled thinking structures (neural, immune, endocrine, etc.).

Scores

ID	AG	LP	RC	MD
5	5	5	5	5

Analysis

STP defines the human being as the calibration reference assigned the upper value of five across all dimensions. Learning can reshape unresolved activity throughout the integrated organism, including action pathways, models, gating conditions, and mechanisms of reorganization. Multiple differentiated subsystems coordinate, action can be selectively gated, architecture can recursively reorganize, and the world model includes the self.

STP: A Criminal Jury

Unit of Analysis

A 12-person criminal jury deliberating toward a unanimous verdict.

Scores

ID	AG	LP	RC	MD
3	4	4	2	3

Analysis

A criminal jury allows individual jurors to interpret evidence and advocate competing conclusions, so there is some internal differentiation. Formal rules regulate deliberation and strongly gate output: disagreement can hold the verdict unresolved while evidence, arguments, and instructions continue to reshape the jury's activity. A substantial share of the jurors' action-shaping learning occurs before output. Jurors also bring prior experience to deliberation and may request additional information by reviewing evidence or instructions. The capacity for reorganization is limited to the choice of a foreperson, changing discussion methods, and adopting new methods to resolve disagreement, but the jury cannot change its membership, authority, legally prescribed decision rules, or the form of its outputs. Although individual jurors have highly advanced world models, the jury's model remains largely case specific.

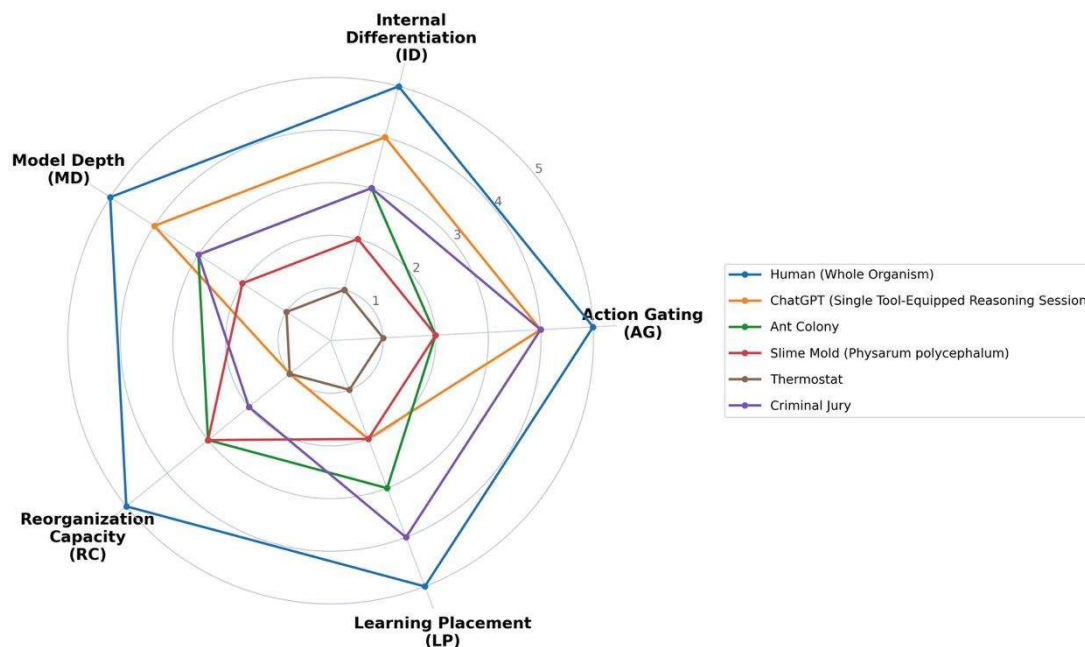
Comparing STP Profiles

Figure 1 compares STP profiles of six illustrative cases. Each axis represents one STP dimension scored from 1 to 5. The score tables are authoritative; profiles should be

compared by shape rather than enclosed area. The human profile serves as the current calibration reference. The threshold for thinking is defined as ID, AG, and LP all being greater than 1.

Figure 1.

STP Profile Comparison



Why Existing Frameworks Fall Short

Once the structural conditions for thinking are understood, it becomes clear that most organizational frameworks were never designed to see them. The dominant frameworks used to understand and manage organizations—Lean, Six Sigma, Agile, OKRs, System Dynamics, organizational behavior models, and AI governance checklists—were built to solve specific classes of problems. They excel at improving efficiency, reducing variance, accelerating delivery, clarifying goals, managing risk, or aligning incentives. In stable or moderately complex environments, they work extremely well. They do not characterize how a structure itself thinks.

Lean and Six Sigma

Lean and Six Sigma focus on flow efficiency, waste reduction, and process reliability. They assume that the underlying system goals are known and stable, and that improvement comes from eliminating friction and variance. Feedback is treated primarily as error correction: deviations from an optimal path.

These frameworks work best when pressure is discharged quickly and locally. They are not designed to examine what happens when pressure accumulates across cycles,

migrates across boundaries, or reshapes future action before it is ever measured. As a result, they can unintentionally suppress learning by optimizing away the very resistance that allows structural reorganization.

Agile and OKRs

Agile methods and OKRs emphasize adaptability, rapid feedback, and local autonomy. They shorten cycles and increase responsiveness, often dramatically. In doing so, they improve how quickly organizations act.

What they do not address is whether fast feedback is also meaningful feedback, or whether rapid iteration is occurring inside a structure capable of holding consequence across time. Agile organizations can move quickly while still repeating the same structural mistakes—simply at a higher velocity. OKRs can align effort without revealing whether accumulated pressure is being resolved or deferred.

System Dynamics and Organizational Behavior

System dynamics models explicitly acknowledge feedback loops, delays, and nonlinearity. Organizational behavior examines culture, incentives, and group dynamics. Both move closer to the territory this paper occupies.

What they typically lack is an operational classification framework that can be applied consistently across organizations, technologies, and hybrid human–machine systems. They describe dynamics, but they do not provide a compact way to assess whether a system meets the structural conditions under which thinking emerges—or where those conditions break down in practice.

AI Governance and Risk Frameworks

AI governance frameworks focus on accountability, transparency, safety, and compliance. They are essential for managing harm and responsibility in automated systems.

What they generally do not examine is how intelligence itself emerges from the coupling of humans, institutions, and software over time. They treat AI as a component to be governed, rather than as part of a larger thinking structure whose behavior cannot be reduced to any single agent, model, or policy.

What STP Does Differently

The Structural Thinking Profile (STP) does not compete with these frameworks. It operates beneath them. STP is not a performance model, a management philosophy, or a governance checklist. It is a structural framework designed to answer a different question altogether:

“Does this system meet the conditions under which thinking occurs—and if so, how is that thinking shaped?”

STP profiles suggest characteristic structural vulnerabilities. Table 1 (below) illustrates hypotheses that follow from particular combinations of dimensions. These are proposed relationships, not validated predictions of organizational failure. Whether they correspond to observable outcomes is a central question for the research program.

Table 1.

Illustrative Hypotheses Generated by STP

#	Profile	Potential structural vulnerability
1	High ID, Low AG	Premature commitment. Numerous competing action pathways exist, but weak gating allows them to resolve before alternatives can be adequately evaluated.
2	Low ID, High AG	Constrained deliberation. The structure can hold decisions unresolved, but few differentiated pathways exist to generate meaningful alternatives during that delay.
3	High ID, Low LP	Unrefined alternatives. Numerous pathways generate different possible responses but limited pre-output learning prevents feedback from substantially improving them before commitment.
4	Low ID, High LP	Narrow learning. Substantial learning occurs before output, but it can reshape only a limited set of available action pathways.
5	High ID, Low RC	Architectural rigidity. Numerous specialized pathways exist, but the structure cannot readily reorganize their roles or relationships when persistent pressure reveals weaknesses.
6	Low ID, High RC	Reorganization without variety. The structure can extensively change how it operates, but its limited differentiation constrains the range of alternative configurations available at any given time.
7	High ID, Low MD	Fragmented specialization. Many differentiated pathways operate without a sufficiently integrated world model to generalize learning across contexts.
8	Low ID, High MD	Knowledge without alternatives. The structure maintains a broad world model but has relatively few differentiated pathways through which that knowledge can shape possible actions.
9	High AG, Low LP	Unproductive delay. The structure can withhold commitment, but little learning occurs while action remains unresolved. Additional deliberation may therefore produce limited refinement.
10	Low AG, High LP	Compressed learning window. The structure can learn extensively before output, but weak gating limits its ability to preserve that opportunity. By definition, when $AG = 1$ then $LP = 1$, so AG must > 1 for this pattern to appear.
11	High AG, Low RC	Procedural rigidity. Decisions can be held while competing pathways interact, but the structure has limited capacity to reorganize the operating mechanisms responsible for persistent problems.

12	Low AG, High RC	Premature structural change. The structure can extensively reorganize itself, but weak gating may allow changes to propagate before competing approaches have been adequately evaluated.
13	High AG, Low MD	Deliberation without generalization. The structure can hold decisions unresolved, but its limited world model constrains its ability to apply learning from other contexts.
14	Low AG, High MD	Premature model-driven action. A broad world model can inform potential responses, but weak gating may allow commitment before competing interpretations have been sufficiently reconciled.
15	High LP, Low RC	Learning without structural adaptation. Substantial pre-output learning can improve immediate decisions, but the structure has limited capacity to change the operating mechanisms that repeatedly generate the same problems.
16	Low LP, High RC	Reorganization with delayed learning. The structure can extensively change its organization, but most learning arrives after output, limiting the opportunity to refine structural changes before they take effect.
17	High LP, Low MD	Context-bound learning. Extensive pre-output learning improves immediate action, but limited model depth prevents that learning from generalizing broadly across different situations.
18	Low LP, High MD	Underutilized world model. The structure possesses a broad model of its environment, but limited pre-output learning constrains its ability to update and apply that model to unresolved action.
19	High RC, Low MD	Reorganization without broad guidance. The structure can substantially change how it operates, but limited model depth constrains its ability to anticipate how those changes will behave across contexts.
20	Low RC, High MD	Structural inflexibility. The structure maintains a broad world model but cannot readily reorganize its roles, relationships, or operating mechanisms in response to what that model reveals.

Interdisciplinary Research Agenda

Structural Thinking proposes common principles governing thinking across biological, human, organizational, and artificial systems. Evaluating these claims requires interdisciplinary collaboration, combining the methods of biology, neuroscience, cognitive science, computer science, engineering, and organizational science.

The proposed research program has two distinct objectives. The first is to investigate whether the structural conditions identified by Structural Thinking distinguish thinking from other forms of regulation and adaptation across scales and substrates. The second is to validate the Structural Thinking Profile (STP) as an instrument for measuring and comparing those conditions. Neither objective establishes the other: a reliable

instrument does not validate the underlying theory, and a valid theory does not guarantee a reliable instrument.

Theoretical Validation

The central proposition of Structural Thinking is that thinking occurs when learning operates within internal differentiation and delayed resolution, reshaping action before output. Research should examine these three necessary conditions independently and in combination, comparing structures that exhibit learning without selective action gating, differentiated action pathways without pre-output learning, and delayed resolution without learning that reshapes unresolved action.

These investigations must declare the boundary of each structure under examination. Studies of nested structures—including biological subsystems, individual practitioners, multidisciplinary teams, and larger institutions—could investigate when thinking occurs at the level of the whole rather than merely within its components. Such comparisons would also test whether the proposed principles operate consistently across scales and substrates.

Validation requires evidence independent of the framework's definitions. Researchers should investigate whether the proposed conditions explain observable differences in how systems evaluate alternatives, adapt, and modify action before commitment, including whether they offer explanatory value beyond existing accounts of feedback regulation and information processing. The theory would require reconsideration if systems independently established to engage in thinking consistently lacked its proposed necessary conditions, or if systems satisfying all three conditions could not be meaningfully distinguished from ordinary adaptive regulation through independent evidence.

Validating the STP Instrument

The Structural Thinking Profile translates the proposed structural conditions into five assessable dimensions. Its validation requires establishing three properties:

- Measurement reliability: Independent assessors applying a common protocol should produce consistent profiles for structures with similar characteristics. Each dimension requires observable indicators and scoring criteria that can be applied across disciplines.
- Construct validity: The dimensions should capture meaningfully distinct structural properties. Structures independently known to differ in their organization should produce distinguishable profiles, while those sharing relevant characteristics should exhibit consistent patterns.

- Explanatory and predictive validity: Researchers should investigate whether STP profiles are associated with independently measured patterns of behavior, adaptation, or failure, and whether they provide explanatory value beyond existing frameworks.

An initial validation program could assess multiple organizations within and across sectors. Researchers would declare each structure's boundary, conduct supervised STP assessments, and compare profiles without aggregating the dimensions into a single score. Parallel studies of biological, artificial, and coupled human–AI systems would test whether common definitions and scoring criteria remain applicable across different scales and substrates.

The program should evaluate inter-rater reliability, repeatability, sensitivity to structural changes, and incremental explanatory value. Persistent disagreement among assessors would indicate a need to refine observable indicators or scoring criteria. Dimensions that consistently fail to vary independently may need to be reconsidered or combined. Failure to distinguish independently established structural differences, or to demonstrate explanatory value beyond existing frameworks, would challenge STP's usefulness without necessarily invalidating Structural Thinking itself.

Longer-term intervention studies could establish baseline profiles, introduce defined changes to information-sharing, decision protocols, organizational relationships, or human–AI interactions, and reassess the resulting structures while independently measuring outcomes. Such research would investigate whether deliberate structural changes produce observable improvements in learning and decision-making.

Areas for Further Research

Beyond the foundational validation program, Structural Thinking presents several opportunities for further research.

Biological Subsystem Thinking. Do biological subsystems independently satisfy the structural conditions for thinking, or does thinking emerge only at the level of the integrated organism? The immune, endocrine, cardiovascular, and nervous systems offer opportunities to investigate this question. Research should establish explicit system boundaries and examine whether learning occurs within internal differentiation and delayed resolution, allowing retained feedback to reshape action before output. Comparing these systems may help distinguish thinking from regulation, adaptation, and other forms of biological activity.

The Emergence of Self. Under what structural conditions does a world model begin to represent the activity of the structure that produces it? Structural Thinking proposes that a self may emerge when a world model becomes sufficiently developed to incorporate the structure's own activity as a source of pressure. This remains a theoretical extension rather than an established consequence of the framework. Research should investigate

whether identifiable structural conditions distinguish systems that model their environments from systems that also model their own activity, and whether this distinction produces observable differences in how they learn and act.

Coupled Human–AI Systems. Under what conditions does coupling human and artificial intelligence produce a thinking structure at the level of the combined system? Clinical, educational, and organizational settings provide opportunities to investigate whether human–AI interaction creates new action pathways, changes the timing of decisions, or enables learning to reshape collective action before commitment. Research should distinguish genuine structural changes from improvements in speed or task performance alone. It should also examine whether coupling introduces new vulnerabilities, including premature resolution, conflicting feedback, and the loss of effective human oversight.

Boundary Expansion: An Interdisciplinary Clinical Research Opportunity.

Research by Lukasz Mazur and colleagues at the University of North Carolina at Chapel Hill offers an opportunity to investigate Structural Thinking through interdisciplinary collaboration with the UNC School of Medicine. Their radiation oncology study examines how panels of physicians evaluate human-generated clinical contours when AI-generated alternatives are introduced. Viewed through Structural Thinking, this intervention provides an opportunity to examine how expanding the boundary of a decision-making structure changes internal differentiation, feedback, action gating, and collective resolution.

The study also illustrates a potentially generalizable experimental framework. Researchers can establish a baseline human decision-making structure, introduce an artificial component, and observe how the resulting human–AI system behaves. Combining clinical research, computer science, cognitive science, and organizational science, this approach could help distinguish improvements attributable to additional information from those arising through changes in the structure of thinking itself. As AI agents become increasingly integrated into professional teams and institutions, similar experiments could investigate how boundary expansion changes collective thinking across disciplines.

The STP Measurement Ceiling. Does the current five-point scale adequately represent the structural capabilities of all thinking systems? The human organism serves as the initial calibration reference for the upper end of each STP dimension, but this is a measurement convention rather than a claim that human thinking represents a theoretical maximum. Artificial, biological, or hybrid systems may eventually exhibit structural characteristics that exceed the instrument's current range. Research should investigate whether such systems require additional scoring levels, revised dimension

definitions, or new measurement approaches while preserving meaningful comparisons with existing profiles.

Why This Matters Now

As artificial intelligence becomes more autonomous and increasingly integrated into human institutions, the consequences of structural design become more significant. Decisions that once unfolded within relatively distinct human organizations now emerge from coupled systems of people, algorithms, institutions, and machines. Feedback crosses organizational and technological boundaries, often at speeds and scales that existing decision-making structures were not designed to accommodate.

Adding more capable AI to an organization does not necessarily improve the thinking of the larger system. It may expand internal differentiation while accelerating premature decisions, introduce new feedback without creating opportunities for learning, or increase the organization's dependence on processes it cannot effectively reorganize.

Structural Thinking offers a framework for investigating these interactions before their consequences become difficult to reverse. If validated, STP could help researchers and practitioners identify structural vulnerabilities, compare alternative designs, and evaluate whether changes to a system improve its capacity to learn and act.

The immediate challenge is therefore not simply to develop more capable intelligent components. It is to understand how those components interact within larger structures, and how those structures can be designed to think.

Conclusion

Thinking is not defined here by consciousness, intention, or the material from which a system is made. It occurs when learning takes place within internal differentiation and delayed resolution, such that learning reshapes action before output. These structural conditions offer a common basis for investigating thinking across scales and substrates, from biological systems to organizations and coupled human–machine structures.

The boundary matters. A structure composed of thinking components does not necessarily think at the level of the whole. Nor does a system qualify simply because it processes information, adapts to its environment, or produces intelligent-looking results. The relevant question is whether the proposed conditions operate within the declared boundary of the structure being examined.

The Structural Thinking Profile translates this theoretical proposition into five dimensions: Internal Differentiation, Action Gating, Learning Placement, Reorganization Capacity, and Model Depth. It offers a way to describe and compare the structural conditions under which thinking may occur. Its value will ultimately depend on empirical validation, including whether its dimensions can be measured reliably and whether its profiles explain meaningful differences among systems.

The larger implication is that thinking is not solely a property to be found in individual components. It is also a structural capacity that may emerge, strengthen, weaken, or disappear as components interact and their relationships change. Understanding those relationships creates an opportunity to design systems whose learning and decision-making processes are appropriate to the responsibilities they carry.

The practical task ahead is not to decide whether systems are intelligent. It is to decide how they are allowed to think, and whether that thinking aligns with the problems they are meant to address.

Glossary

Machine learning (ML) analogues are included with definitions where a reasonably direct correspondence exists.

Structure

A bounded arrangement of components whose interactions produce persistent patterns of activity.

ML terms: System architecture; model + parameters + state + interfaces

Boundary

The declared limit of the structure under examination, determining which components and interactions are considered internal and which effects constitute output when they propagate beyond. The boundary establishes the unit of analysis and must remain constant throughout an assessment.

ML terms: System boundary, agent-environment boundary, Markov blanket, inference boundary, computational graph

Activity

Any change or process occurring within a structure as its components interact.

ML terms: State evolution; activations; intermediate computation during execution

Action

The resolution of internal activity toward a commitment that can become output.

ML terms: Action selection, policy selection, candidate commitment

Feedback

The return of activity-derived effects into the structure that produced them.

ML terms: Loss signals; reward signals; evaluation metrics; gradients; critique signals

Coupling

The condition in which multiple feedback loops influence one another's activity.

ML terms: Shared parameters; cross-attention; interdependent modules; coupled optimization loops

Phase

The relative timing of activity within a feedback loop.

ML terms: Latency; lag; update timing; step offset; rollout timing

Synchronization

The alignment of phases across coupled feedback loops, increasing their combined effect.

ML terms: Synchronous updates; coordinated agent steps; aligned gradient updates

Memory

A retained change in a structure's state caused by past activity that can influence subsequent activity.

ML terms: Weights; embeddings; recurrent state; caches; buffers; long-lived parameters

Learning

The retained modification of a structure's internal state by feedback, such that subsequent activity unfolds differently as a result of past activity.

ML terms: Training; online learning; weight updates; policy updates; adaptation

Action Pathways

Internally distinct routes through which activity can propagate within a structure toward possible output.

ML terms: Policy branches; subnetworks; mixture-of-experts routes; tool-use paths

Internal Differentiation

A structure contains multiple differentiated action pathways capable of responding differently to the same activity before output. It is also an STP dimension assessing how many distinct action pathways can contend prior to commitment.

ML terms: Modular architectures; MoE; multi-head policies; parallel candidate actions

Delayed Resolution

The condition in which commitment of an action pathway is selectively withheld through gating while internal activity continues, allowing further interaction before output.

ML terms: Inference gating; gated deliberation; conditional action release.

Activity Layer

The temporally extended domain in which internal activity, feedback, and learning occur before output resolves.

ML terms: Execution window; rollout horizon; planning loop; pre-commit computation phase

Pressure Layer

The internal aspect of the activity layer in which activity accumulates as pressure during delayed resolution.

ML terms: Backlog; queued candidates; accumulated gradients; unresolved activations

Pressure

Accumulated unresolved activity within the pressure layer.

ML terms: Backlog magnitude; gradient accumulation; pending decision load

Output

The resolution of internal activity into effects that propagate beyond the structure's boundary.

ML terms: Action emission; API call; tool invocation; actuator command

Thinking

Thinking happens when learning occurs within internal differentiation and delayed resolution, such that learning reshapes action before output.

ML terms: Online adaptation during planning; learning-in-the-loop before action commit; pre-output self-modification

World Model

A retained organization of action pathways that carries forward regularities of the environment across contexts, allowing learning in one context to reshape action in others before output.

Self

An emergent feature of a sufficiently deep world model in which the structure models its own activity, allowing that model to generate action pathways and pressure within the activity layer.

Relational Structure

A bounded system composed of two or more thinking structures whose coupled interactions produce learning within internal differentiation and delayed resolution at the level of the combined system, such that learning reshapes its action before output.

Coupled Thinking

Thinking that occurs in a relational structure.

Structural Thinking

The study of how structure gives rise to thinking across scales and substrates.

Action Gating

The selective withholding of commitment of an action pathway while internal activity continues. It is also an STP dimension that assesses how effectively a structure can exercise this capability.

Learning Placement

An STP dimension assessing when action-shaping learning occurs relative to output.

Reorganization Capacity

An STP dimension assessing how extensively a structure can reorganize how it operates in response to persistent pressure.

Model Depth

An STP dimension assessing how broadly learning generalizes across contexts, including whether the structure models itself.

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