

ED and Agency: How Adaptive Behavior Becomes Directed Action

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February 2026

Abstract

Agency emerges when autopoietic systems begin selecting among multiple possible actions to preserve or enhance their internal ED regime. In the ED ontology, adaptive behavior provides responsiveness, but agency requires action selection: the structural resolution of competing internal gradients into a single enacted behavior. This paper develops the biology → agency threshold, showing how sensing becomes evaluation, response becomes selection, movement becomes directedness, and regulation becomes strategy. As internal ED dynamics come to reflect environmental regularities, minimal cognition emerges as the internalization of structure for the sake of more effective action. The result is the formation of a behavioral self — an individuated center of action whose identity is maintained through directed behavior. Agency is presented not as a psychological leap but as the next architectural consequence of autopoietic systems acting in a world of possibilities, setting the stage for the transition to mind.

1. Introduction — Why Agency Is the Next ED Threshold

The biology arc established the first domain in which ED motifs do more than reinforce themselves. Living systems produce and maintain the very structures that allow their becoming to continue. But self-production is not yet self-direction. Autopoiesis gives a system identity; adaptive behavior gives it responsiveness. Agency begins when these capacities converge into something new: the ability to select among possible actions in order to preserve or enhance the system's internal ED regime.

In the ED ontology, this transition is not psychological. It is architectural. Agency emerges when a system's internal organization becomes rich enough that multiple responses to a perturbation are possible, and when the system's internal ED dynamics determine which response is enacted. This is the moment where behavior becomes choice-structured — not in the deliberative sense, but in the structural sense that the system evaluates, selects, and acts in ways that sustain its own becoming.

Biology provides the prerequisites for this threshold:

- a maintained boundary
- a self-producing metabolism
- internal functional differentiation
- sensitivity to environmental gradients
- adaptive modulation of internal processes

But these capacities alone do not constitute agency. They create the conditions under which agency becomes possible. Agency begins when:

- sensing becomes evaluation
- response becomes selection
- movement becomes directedness
- regulation becomes strategy
- adaptive behavior becomes action choice

In this paper, we develop the biology → agency bridge. We show how autopoietic systems begin to select among

possible actions, how internal ED tensions become behavioral priorities, how environmental coupling becomes evaluation, and how the first forms of minimal cognition arise as the internalization of regularities that guide action.

Agency is not a departure from the ED program.

It is the next threshold in the architecture of becoming.

It is the first domain where a system's persistence depends not only on producing itself, but on choosing how to act in a world that offers multiple paths forward.

2. From Adaptive Behavior to Directed Action

The threshold where self-maintenance becomes action selection

Adaptive behavior allows a living system to modulate its activity in response to environmental conditions. But adaptive behavior alone does not constitute agency. A system becomes an agent when it can select among multiple possible actions, choosing the one that best preserves or enhances its internal ED regime. This is the moment where behavior becomes directed, not merely reactive.

In the ED ontology, this transition is not psychological. It is architectural. Agency emerges when the internal organization of an autopoietic system becomes rich enough that:

- multiple responses are possible
- these responses differ in their consequences
- internal ED tensions bias the system toward some responses over others
- behavior reflects this internal prioritization

This is the first time the universe produces systems whose actions are shaped by internal evaluation rather than direct environmental triggering.

2.1 When Sensing Becomes Evaluation

In adaptive behavior, sensing is the modulation of internal gradients by external conditions. In agency, sensing becomes evaluation: the system interprets perturbations in terms of their impact on its internal ED regime.

Evaluation is not deliberation. It is the architectural coupling between:

- internal metabolic priorities
- external environmental gradients
- the system's current state

In ED terms: Evaluation is the internal weighting of possible responses based on their expected effect on the system's persistence.

This is the first appearance of internal prioritization.

2.2 When Response Becomes Selection

Adaptive behavior produces responses. Agency produces selections.

A selection occurs when:

- multiple responses are possible
- internal ED dynamics favor one response over the others
- the chosen response best preserves the system's organization

Selection is not a mental act. It is the structural consequence of competing internal gradients.

In ED terms: Selection is the resolution of internal ED tensions into a single enacted behavior.

This is the first time the universe produces systems that *choose*.

2.3 When Movement Becomes Directedness

Movement in adaptive systems is a reaction to gradients. Movement in agents is directed toward or away from conditions that affect the system's persistence.

Directedness emerges when:

- the system evaluates environmental gradients
- selects among possible movements
- enacts the one that best supports its internal ED regime

This is not intention. It is architectural orientation.

In ED terms: Directedness is movement shaped by internal evaluation rather than external triggering.

This is the first time the universe produces systems that pursue and avoid in a structured way.

2.4 When Regulation Becomes Strategy

In adaptive behavior, regulation is reactive. In agency, regulation becomes strategy: the system modulates its internal processes in ways that anticipate or mitigate future perturbations.

Strategy emerges when:

- internal organization encodes regularities
- past perturbations shape future responses
- behavior reflects learned patterns of interaction

This is the earliest form of proto-planning.

In ED terms: Strategy is regulation informed by the system's history of interactions.

This is the first time the universe produces systems that behave as if they "know" something about the world.

2.5 The Architectural Meaning of Directed Action

The transition from adaptive behavior to directed action is the moment where:

- sensing becomes evaluation
- response becomes selection
- movement becomes directedness
- regulation becomes strategy
- behavior becomes choice-structured

In ED terms: Directed action is the enactment of behavior selected to preserve the system's internal ED regime.

This is the architecture of minimal agency.

It is not yet cognition.

But it is the substrate cognition will inherit.

3. The Architecture of Action Selection

How ED gradients become behavioral choice

Directed action requires more than movement and more than adaptive response. It requires a system that can select among multiple possible behaviors based on their expected impact on its internal ED regime. Action selection is the architecture that makes agency possible. It is the moment where internal ED dynamics begin to shape not only how a system responds, but which response it enacts.

In the ED ontology, action selection is not deliberation. It is not symbolic reasoning. It is the structural resolution of competing internal gradients into a single enacted behavior. The system “chooses” in the sense that its internal organization evaluates possibilities and biases itself toward the one that best preserves its autopoietic integrity.

This is the first time the universe produces systems whose actions are shaped by internal priorities rather than direct environmental triggering.

3.1 Competing Internal Gradients

A living system is never in a single state of need. It is a nexus of simultaneous metabolic demands:

- energy acquisition
- membrane repair
- component synthesis
- waste removal
- gradient regulation

Each demand corresponds to an internal ED tension. These tensions compete. They pull the system toward different possible actions.

In ED terms: Competing internal gradients are the architectural substrate of behavioral options.

The system has multiple ways to act because it has multiple tensions seeking resolution.

3.2 Environmental Coupling as Behavioral Context

Internal gradients alone do not determine behavior. They are modulated by external ED structure:

- nutrient gradients
- temperature shifts
- chemical signals
- obstacles and opportunities
- threats and perturbations

Environmental coupling transforms internal tensions into context-sensitive priorities. The same internal need may

produce different actions depending on the external landscape.

In ED terms: Environmental coupling is the modulation of internal ED priorities by external ED gradients.

This is the first time the universe produces systems whose behavior depends on context.

3.3 Behavioral Attractors

As internal and external gradients interact, certain patterns of action become stable. These are behavioral attractors — recurring, self-reinforcing patterns of directed behavior:

- approach
- avoidance
- exploration
- retreat
- foraging
- sheltering

These are not instincts. They are stable ED motifs in the space of possible actions.

In ED terms: A behavioral attractor is a stable pattern of action that resolves internal ED tensions in a reliable way.

This is the first time the universe produces systems with recognizable behavioral tendencies.

3.4 Selection Dynamics

Action selection occurs when:

1. internal gradients generate multiple possible actions
2. environmental coupling modulates their relative priority
3. behavioral attractors provide stable patterns for resolving tensions
4. the system enacts the action that best preserves its internal ED regime

Selection is not a mental act. It is the resolution of competing ED tensions into a single behavioral trajectory.

In ED terms: Action selection is the collapse of behavioral possibilities into the action that optimally sustains the system's autopoiesis.

This is the architecture of minimal agency.

3.5 The Architectural Meaning of Action Selection

Action selection is the moment where:

- internal tensions become options
- environmental coupling becomes context
- behavioral attractors become strategies
- response becomes choice
- directedness becomes agency

In ED terms: Action selection is the structural mechanism by which an autopoietic system directs its own becoming.

This is the first full expression of agency in the ED program.

It is not yet cognition.

But cognition will emerge from the internalization of these selection dynamics.

4. Minimal Cognition as Extended Agency

When action selection becomes world-modeling

Action selection gives a system the ability to choose among possible behaviors. But agency becomes something deeper when these choices begin to reflect not only the system's current state, but its history of interactions and its expectations about what will happen next. This is the architecture of minimal cognition — the moment where the system's internal organization begins to encode regularities in the environment and use them to guide action.

In the ED ontology, cognition is not representation in the symbolic sense. It is not thought, deliberation, or introspection. It is the internalization of environmental structure for the sake of more effective action selection.

Cognition begins when the system's internal ED dynamics come to reflect patterns in the world, allowing it to anticipate perturbations and act preemptively to preserve its autopoiesis.

This is the first time the universe produces systems that behave as if they *know* something about the world.

4.1 Regularity Extraction: When History Shapes Behavior

A system that repeatedly encounters the same environmental patterns begins to internalize them. This internalization is not memory in the psychological sense. It is the gradual shaping of internal ED dynamics by repeated interactions.

Examples:

- nutrient gradients that recur in similar locations
- threats that follow predictable cues
- cycles of light, temperature, or chemical availability

Over time, these regularities become embedded in the system's metabolic and behavioral organization.

In ED terms: Regularity extraction is the stabilization of internal ED patterns that reflect recurring features of the environment.

This is the first appearance of learning.

4.2 Anticipation: When Behavior Looks Forward

Once regularities are internalized, the system can begin to anticipate. Anticipation is not foresight. It is the system acting in ways that reflect expected future conditions based on past patterns.

Examples:

- moving toward a location where nutrients are usually found
- avoiding cues that previously preceded harmful conditions

- adjusting metabolic activity before a predictable shift

In ED terms: Anticipation is the modulation of action selection by internalized environmental regularities.

This is the first time the universe produces systems that act *before* perturbation occurs.

4.3 Internal Models Without Representation

Minimal cognition does not require symbols or maps. It requires internal organization that mirrors the structure of the world.

These internal structures are:

- dynamic
- distributed
- non-symbolic
- action-oriented

They are not “models” in the classical sense. They are patterns of ED tension that encode:

- what tends to happen
- what tends to follow
- what tends to threaten
- what tends to support persistence

In ED terms: An internal model is a stable ED motif that reflects environmental regularities and guides action selection.

This is the architecture of cognition without representation.

4.4 Consequence-Sensitive Action Selection

As internal models develop, action selection becomes consequence-sensitive. The system chooses actions not only based on current conditions but based on the expected outcomes of those actions.

This is the moment where:

- approach becomes seeking
- avoidance becomes risk management
- exploration becomes information gathering
- retreat becomes damage mitigation

In ED terms: Consequence-sensitive action selection is the use of internalized regularities to bias behavior toward outcomes that preserve the system’s autopoiesis.

This is the first time the universe produces systems that behave as if they understand consequences.

4.5 The Emergence of Minimal Cognition

Minimal cognition is the architectural layer where:

- regularity extraction becomes learning
- anticipation becomes prediction
- internal ED motifs become world-mirroring structures

- action selection becomes consequence-sensitive
- behavior becomes informed rather than merely reactive

In ED terms: Minimal cognition is agency extended through the internalization of environmental structure. It is not yet mind.

But it is the substrate mind will inherit.

5. Individuation, Identity, and the Emergence of a Behavioral Self

How agency stabilizes a center of action

Agency gives a system the ability to select among possible actions. Minimal cognition gives it the ability to internalize regularities and anticipate consequences. But agency becomes something deeper when these capacities begin to stabilize into a coherent center of action — a persistent locus from which behavior is organized, evaluated, and enacted. This is the emergence of a behavioral self.

In the ED ontology, the behavioral self is not a metaphysical entity. It is not a subject, a mind, or an ego. It is the organizational coherence that arises when an autopoietic system with action-selection capacities maintains a stable internal ED regime across changing contexts. The system becomes a *someone* in the minimal architectural sense: a unified source of directed behavior.

This is the first time the universe produces systems that act as a single, persistent agent.

5.1 Individuation as a Center of Action

Biological individuation gives a system a maintained internal identity. Agency transforms this identity into a behavioral center — a stable point from which actions originate.

A system becomes a center of action when:

- its internal ED regime persists across diverse contexts
- its action selection is organized around preserving that regime
- its behavior reflects a unified set of internal priorities
- its responses are coordinated rather than fragmented

In ED terms: A center of action is an individuated ED regime that organizes behavior around its own persistence.

This is the architectural root of the behavioral self.

5.2 Functional Differentiation Becomes Behavioral Differentiation

In biological systems, functional differentiation supports metabolic coherence. In agents, this differentiation extends into behavioral specialization:

- some subsystems support exploration
- others support avoidance
- others support energy acquisition
- others support repair and recovery

These behavioral subsystems are not modules. They are patterns of ED tension that bias the system toward

different classes of action.

In ED terms: Behavioral differentiation is functional differentiation extended into the space of possible actions.

This is the first time the universe produces systems with distinct behavioral modes.

5.3 Coherence Across Contexts

A behavioral self is not defined by what it does in a single moment, but by its coherence across situations. This coherence emerges when:

- internal priorities remain stable
- action selection reflects consistent tendencies
- internal models guide behavior across contexts
- the system maintains identity despite perturbation

This coherence is not psychological consistency. It is organizational stability.

In ED terms: Behavioral coherence is the persistence of action-generating ED structure across environmental variation.

This is the architecture of a stable agent.

5.4 Memory as Stabilized Action Tendencies

Minimal cognition internalizes environmental regularities. Agency uses these internalizations to stabilize behavioral tendencies:

- learned avoidance
- learned approach
- learned strategies
- learned expectations

These tendencies are not stored as symbols. They are stable ED motifs that bias future action selection.

In ED terms: Memory is the persistence of ED patterns that influence future behavior.

This is the first time the universe produces systems whose actions reflect their past.

5.5 Identity as Behavioral Continuity

A behavioral self emerges when:

- the system's actions reflect its internal organization
- its internal organization reflects its history
- its history shapes its future actions
- its future actions preserve its identity

Identity is not a narrative. It is not introspective. It is the continuity of action selection across time.

In ED terms: Identity is the persistence of a coherent action-generating ED regime.

This is the minimal architectural form of selfhood.

5.6 The Architectural Meaning of the Behavioral Self

The behavioral self is the moment where:

- individuation becomes a locus of action
- functional differentiation becomes behavioral specialization
- internal models become behavioral guidance
- coherence becomes identity
- action selection becomes self-directed behavior

In ED terms: The behavioral self is an autopoietic, action-selecting ED regime that maintains its identity through directed behavior.

This is the architecture that makes mind possible.

It is not yet mind.

But it is the substrate mind will inherit.

6. The ED Architecture of Agency

Agency is not an add-on to biology. It is the next structural consequence of autopoietic systems that must act in a world filled with gradients, perturbations, and opportunities. When a living system becomes capable of selecting among multiple possible actions, its behavior becomes choice-structured, and its persistence becomes self-directed. This is the architecture of agency.

The transition can be stated cleanly:

- biology → autopoiesis
- autopoiesis → adaptive behavior
- adaptive behavior → directed action
- directed action → action selection
- action selection → minimal cognition
- minimal cognition → a behavioral self

This is the ED ladder from life to agency.

In the ED ontology, agency is the first domain where:

- becoming becomes self-directed
- sensing becomes evaluation
- response becomes selection
- movement becomes directedness
- regulation becomes strategy
- behavior becomes consequence-sensitive
- internal models become world-mirroring ED motifs
- individuation becomes a center of action

These transitions are not optional. They are the structural consequences of systems that:

- maintain internal ED gradients
- internalize environmental regularities

- evaluate perturbations in terms of their impact on persistence
- select actions that preserve or enhance their autopoiesis
- stabilize behavioral tendencies across contexts
- maintain identity through directed behavior

Agency is the first ED regime where persistence depends not only on producing oneself, but on choosing how to act in a world of possibilities.

In ED terms: An agent is an autopoietic, action-selecting ED regime whose internal organization directs its own becoming.

This is the architectural meaning of agency.

Agency is the hinge between biology and mind. It is the domain where:

- action becomes choice
- choice becomes anticipation
- anticipation becomes internal modeling
- internal modeling becomes the substrate for representation

These capacities do not yet constitute mind.

But they form the organizational foundation from which mind becomes possible.

Paper 15 will develop the next transition:

how agency becomes cognition, how cognition becomes representation, and how representation becomes the ED regime where becoming becomes self-interpreting.

7. Conclusion — Agency as ED's First Self-Directed Threshold

Agency marks the moment where the architecture of becoming acquires a new capacity: the ability to select among possible actions in order to preserve or enhance the system's internal ED regime. Biology gave the universe self-producing systems. Agency gives it self-directing systems. This is the decisive threshold where behavior becomes choice-structured, where internal priorities shape outward action, and where the system's persistence depends on how it navigates a world of possibilities.

The agency arc has shown that directed behavior arises when:

- sensing becomes evaluation
- response becomes selection
- movement becomes directedness
- regulation becomes strategy
- adaptive behavior becomes action choice
- internalized regularities become minimal cognition
- biological individuation becomes a center of action

These transitions are not optional. They are the structural consequences of autopoietic systems that must act in environments filled with gradients, threats, and opportunities. Agency is the first ED regime where persistence is achieved not only through self-production but through self-directed behavior.

In ED terms: An agent is an autopoietic, action-selecting ED regime whose internal organization directs its own becoming.

This is the architectural meaning of agency.

Agency is the hinge between biology and mind. It is the domain where:

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