

The Grammar of Extension

Andy Clark's Extended Mind and the Closure Framework: How Cognitive Closure Reaches Beyond the Skull

CF Dietz

Minds like ours are prediction machines — devices that have evolved to anticipate the incoming streams of sensory stimulation before they arrive. These predictions initiate actions that structure our worlds and alter the very things we need to engage and predict.

Andy Clark, *Surfing Uncertainty*, 2016

Every finite closure generates remainder. The remainder is not noise. It is the proof that the grammar is finite.

CF Dietz, *Consciousness, Closure, and the Cosmos*, 2026

Abstract

Andy Clark is Professor of Philosophy at Macquarie University and one of the most influential philosophers of mind working at the intersection of cognitive science, robotics, and philosophy. His two major contributions to the field are the extended mind thesis, developed with David Chalmers, and the predictive processing account of cognition, synthesized in *Surfing Uncertainty*. The extended mind argues that cognitive processes are not confined to the brain: under certain conditions, external objects, other people, and environmental structures become functional parts of cognitive systems, extending the mind's reach beyond the skull. Predictive processing argues that the brain is a prediction machine: it minimizes prediction error across a hierarchical generative model by both updating predictions and taking actions that make the world more predictable. Clark's distinctive contribution is to combine these two accounts, showing that the predictive reach of the mind extends into and through the environment, using external resources to manage uncertainty that the brain alone cannot resolve. This paper argues that Clark's extended mind and the closure framework developed in *Consciousness, Closure, and the Cosmos* converge at a philosophically important point: the closure framework describes cognitive closures as organizational structures that draw distinctions and constitute facts, but says nothing about where those organizational structures must be physically located. Clark argues from cognitive science that they routinely extend beyond the skull. The closure framework's account of the extended closure, the organizational structure that incorporates notebooks, language, tools, social structures, and other environmental resources as functional components, provides the structural account of why Clark's extended mind is the natural consequence of what any prediction-minimizing closure regime will do: offload cognitive work onto whatever environmental resources can be reliably recruited, extending the closure's constitutive reach into the adjacent possible of environmental structure.

1. Otto's Notebook

Otto has Alzheimer's disease. He cannot reliably retain new information in biological memory. He carries a notebook. When he learns something he wants to remember, he writes it in the notebook. When he needs to recall something, he consults the notebook. The notebook plays the same functional role in his cognitive life that biological memory plays in the cognitive life of people without memory impairment: it stores information that is reliably available for retrieval and use in guiding action.

Inga has an intact biological memory. When she wants to go to the Museum of Modern Art, she recalls from memory that the museum is on 53rd Street and acts on that information. When Otto wants to go to the museum, he consults his notebook, reads that the museum is on 53rd Street, and acts on that information. Both arrive at the museum. Both used stored information to guide their behavior. In Inga's case, the information was stored biologically. In Otto's case, it was stored in a notebook. Is there a principled reason, other than the accident of location inside or outside the skull, to say that Inga remembered where the museum is and Otto did not?

This is the Otto-Inga thought experiment from Andy Clark and David Chalmers's 1998 paper *The Extended Mind*. Their answer is that there is no principled reason. If the notebook functions as reliably as biological memory, is accessed with the same kind of readiness, and plays the same role in guiding behavior, then the notebook is part of Otto's cognitive system. Otto's mind extends into the notebook. The boundary of cognition is not the skull but the organizational boundary of the cognitive process, wherever that process happens to extend.

This thought experiment, which launched two decades of philosophical debate, is the opening move of Clark's contribution to the series. The closure framework's response is not to adjudicate the debate between internalist and externalist accounts of mind. It is to note that the question of where a closure regime's boundary lies is exactly the right question to ask, and that Clark's extended mind is the natural consequence of what any cognitive closure regime will do: recruit whatever resources can be reliably incorporated into the organizational structure that minimizes prediction error. The closure does not stop at the skull unless the skull is where the organizational structure stops. For organisms that use notebooks, language, tools, and each other to manage cognitive work, the organizational structure extends further.

2. Clark's Four Claims

Clark's contribution to cognitive science and philosophy of mind has four interconnected components.

2.1 The Extended Mind: Cognitive Processes Routinely Transcend the Brain

The extended mind thesis holds that cognitive processes are individuated by their functional organization, not by their physical location. A cognitive process is wherever its functional components are. When a person uses a notebook, smartphone, map, or another person's

expertise to perform cognitive work, those external resources are functional components of the cognitive process. They constitute part of the cognitive system, not merely aids to an internal process confined to the brain.

Clark and Chalmers propose three conditions for genuine cognitive extension. The external resource must be reliably available: the person must be able to access it when needed. It must be endorsed by the agent: the person must treat the resource's outputs as if they were the outputs of internal cognitive processes, acting on them without subjecting them to higher levels of scrutiny than they would give internally generated beliefs. And the content must be directly available for use in guiding reasoning and behavior, in the same way that internally stored content is.

The thesis is controversial partly because it seems to imply that as we acquire new tools and integrate them into our cognitive lives, our minds literally expand. When Otto learns to use his notebook fluently, when Inga learns to use a GPS navigation system without actively consulting it, when a mathematician develops an intuitive relationship with a notation system, these cognitive systems have extended. The mind is not a fixed object located in a fixed place. It is a dynamic organizational structure that expands and contracts as cognitive tools are acquired, integrated, and lost.

2.2 Predictive Processing: The Brain as Hierarchical Prediction Engine

Clark's synthesis in *Surfing Uncertainty* brings the extended mind together with predictive processing. The brain is a hierarchical generative model: a system that maintains predictions about the causes of its sensory signals at multiple levels of abstraction simultaneously. Higher levels predict the outputs of lower levels. Lower levels pass prediction errors back up to higher levels. The model is updated when prediction error accumulates beyond what can be absorbed, and action is taken when specific patterns of anticipated sensory input, proprioceptive and exteroceptive, can be achieved by manipulating the environment rather than just by updating the model.

The predictive processing account is not merely a description of how the brain processes information. It is a claim about what cognition is: the ongoing management of uncertainty about the causes of sensory signals, achieved through the joint deployment of model updating and action. Cognition is prediction error minimization, conducted across a hierarchical model that spans multiple timescales and levels of abstraction.

2.3 Active Inference: Action as Prediction Fulfillment

Friston's active inference, which Clark develops and applies throughout *Surfing Uncertainty*, extends predictive processing from perception to action. In active inference, motor control is also prediction error minimization: the motor system expects certain proprioceptive consequences of action and acts to bring about those consequences. An intended movement is a prediction about what proprioceptive signals should arrive. The motor system minimizes the prediction error between the expected signals and the actual signals by moving the body to fulfill the expectation.

The extension to action means that the brain manages uncertainty not only by updating its model but by restructuring its environment. When a musician arranges a score on a stand, when

an architect makes sketches to externalize design thinking, when a person uses reminders and schedules to offload prospective memory, they are taking actions that restructure their environment to reduce future prediction error. The world is not just the thing the brain predicts. It is a resource that the brain actively recruits to manage prediction error it cannot resolve internally.

2.4 Cognitive Niche Construction: The Extended Predictive Brain

Clark's most recent synthesis, developed with Constant, Kirchhoff, and Friston among others, extends active inference to cognitive niche construction: the process by which organisms actively build, modify, and maintain their cognitive environments to support ongoing prediction error minimization. Cognitive niche construction is the intentional version of niche construction more broadly: organisms do not merely adapt to their environments but actively engineer them, and cognitive systems engineer their environments cognitively, building scaffolds of external resources that extend the reach of internal prediction.

The result is an account of mind that is not brain-bound but world-spanning: a cognitive system whose organizational boundary runs through the brain, the body, the notebook, the smartphone, the social network, the built environment, and the entire accumulated cultural toolkit that a person has integrated into their cognitive life. The mind of a sophisticated adult human is, on Clark's account, always already extended into a world that has been structured to support it.

3. What Clark Needs

Clark's extended mind and predictive processing accounts are among the most influential in contemporary cognitive science and philosophy of mind. His synthesis in *Surfing Uncertainty* is technically sophisticated, empirically grounded, and philosophically ambitious. His account of cognitive niche construction connects cognitive science to evolutionary biology and ecology in ways that are genuinely illuminating.

There are two gaps that Clark's framework does not close. The first is the question of what makes something a component of a cognitive system rather than merely an influence on it. Clark's three conditions for cognitive extension, reliability, endorsement, and direct availability, are functional criteria that are difficult to apply precisely. Is the temperature of the room a component of my cognitive system because it affects my thinking? Is the cultural tradition I was raised in part of my cognitive system because it shapes my conceptual repertoire? The criteria work clearly in paradigm cases like Otto's notebook, but their application in less clear cases remains contested.

The second gap is the relationship between the extended mind and the phenomenology of cognitive extension. Clark's account is functional: it describes the causal and organizational structure of cognitive systems. It does not fully address the question of what it is like to be an extended cognitive system, whether the cognitive work done by external resources feels different from the cognitive work done by internal resources, and whether the closure of the self-model extends with the cognitive system or remains biologically bounded even when the cognitive system extends.

The closure framework addresses both gaps. The first: what makes something a component of a cognitive closure is whether it is incorporated into the organizational structure that draws the

closure's distinctions, establishes its identity criteria, and maintains its lawful relationships. A notebook incorporated into the organizational structure of memory is a component of the memory closure. A temperature that merely affects cognition without being incorporated into the organizational structure is not. The criterion is structural incorporation, not mere causal influence. The second: the phenomenology of cognitive extension is determined by whether the self-closure extends with the cognitive closure. When a tool is so fluently integrated that it is transparent in Metzinger's sense, the tool becomes part of the self-closure, and the experience of using it is indistinguishable from the experience of using internal cognitive resources. When a tool remains opaque, it is used but not incorporated: it is part of the cognitive system but not part of the self-model.

4. Two Concepts That Ground the Extended Closure

The closure framework is introduced here in the terms most relevant to Clark's account.

4.1 The Extended Closure: Where Organizational Structure Goes, the Closure Goes

A closure regime is a system that stabilizes some content by drawing distinctions, establishing identity criteria, and maintaining lawful relationships among its elements. The closure framework says nothing about where those elements must be physically located. A closure regime's elements are wherever the organizational structure that constitutes the closure's identity requires them to be. If a cognitive closure regime requires a notebook to maintain the organizational structure that constitutes memory for the organism, then the notebook is an element of the memory closure. The closure extends to where the organizational structure extends.

This means that Clark's extended mind is a natural consequence of the closure framework's account of cognitive closure: as cognitive closure regimes evolve and develop, they incorporate whatever environmental resources can be reliably recruited into the organizational structure that minimizes prediction error. The boundary of the cognitive closure is not the skull but the boundary of the organizational structure. For organisms that use language, writing, tools, and social institutions as components of their cognitive organization, the closure extends into and through those resources.

Remainder is what the extended closure generates at its boundary: the cognitive work that the closure cannot do even with its full complement of internal and external resources. Cognitive niche construction is the process by which organisms expand into their adjacent possible of cognitive extension, incorporating new resources into the closure and thereby generating new remainder that motivates further expansion. The history of human cognitive development, from the invention of writing to the development of mathematics to the construction of scientific institutions, is the history of cognitive closures expanding into their adjacent possible through niche construction.

4.2 Active Inference as Closure-Expanding Action

Friston's active inference, as Clark develops it, is the closure framework's account of how a closure expands into its adjacent possible through action: the cognitive system acts to restructure

its environment in ways that reduce the remainder it faces. When a person externalizes cognitive work by writing it down, they are not merely offloading memory. They are expanding the cognitive closure to incorporate a new element, the written record, that reduces the prediction error the closure would otherwise need to manage internally.

The predictive processing account of action as prediction fulfillment is the closure framework's account of supersession driven by action rather than by model update: the closure can reduce remainder not only by updating its internal organization but by restructuring the environment in which it operates. This is why cognitive niche construction is such a significant evolutionary development: it allows cognitive closures to expand their constitutive reach into the adjacent possible of environmental structure, using action to build the scaffolding that reduces the remainder the closure faces.

5. Four Claims, One Structure

The vocabulary correspondence between Clark's cognitive science and the closure framework is the most practically applicable in the philosophical half of the series. What Clark calls the extended mind, the closure framework calls the extended closure: the organizational structure of a cognitive system that incorporates external resources as functional components. What Clark calls the three conditions for cognitive extension, the framework calls the criteria for structural incorporation: an external resource is a component of a cognitive closure when it is incorporated into the organizational structure that draws the closure's distinctions and maintains its identity. What Clark calls predictive processing, the framework calls cognitive closure activity: the closure minimizing the mismatch between its current organization and what it opens onto by updating its model and restructuring its environment. What Clark calls active inference, the framework calls closure-expanding action: action that extends the cognitive closure into its adjacent possible by incorporating new environmental resources. And what Clark calls cognitive niche construction, the framework calls the deliberate expansion of the cognitive closure into the adjacent possible of available environmental structure.

5.1 The Otto Case Is Extended Closure

Otto's notebook is a component of his memory closure. Not merely an aid to an internal memory process but a functional element of the organizational structure that constitutes Otto's capacity to remember. When the notebook is incorporated into Otto's cognitive system in the way Clark describes, when it is reliably available, endorsed as an extension of cognitive agency, and directly available for use in guiding behavior, it satisfies the closure framework's criterion for structural incorporation: it is part of the organizational structure that draws the distinctions and maintains the identity criteria of Otto's memory.

The philosophical significance of this is not merely that the mind extends into the notebook. It is that the closure does not have a fixed boundary at the skull or even at the body. The boundary of the cognitive closure is determined by the organizational structure of the cognitive system, and that organizational structure can extend into and through external resources. The closure framework makes this a structural consequence rather than a philosophical thesis to be debated: any closure whose organizational structure incorporates external resources has a boundary that

runs through those resources. The only question is whether the organizational structure does incorporate them, which is an empirical question about the specific cognitive system, not a philosophical question about the nature of mind in general.

5.2 Predictive Processing Is Cognitive Closure Activity

Clark's predictive processing brain is a cognitive closure regime minimizing prediction error by jointly updating its model and restructuring its environment. The hierarchical generative model is the closure's organizational structure: the system of distinctions and identity criteria that determines what the cognitive system constitutes as a fact about its world. Prediction error is the closure framework's remainder: the sensory signals that the current organizational structure cannot absorb, pressing back against the predictions and driving update or action.

The extension of predictive processing from perception to action is structurally significant. In purely perceptual predictive processing, the closure updates itself to reduce remainder. In active inference, the closure restructures the environment to reduce the remainder it would otherwise face. This is the difference between supersession through internal update and supersession through environmental restructuring: both reduce the mismatch between the closure's current organization and what it opens onto, but they do so by different means. The active inference account is the closure framework's account of closure expansion through action: the cognitive system extending its closure into the adjacent possible of environmental structure.

5.3 Cognitive Niche Construction Is Adjacent Possible Expansion

Kauffman's adjacent possible, the bounded space of what the current system can constitute or reach in one step, applies to cognitive closures through the mechanism Clark calls cognitive niche construction. At any moment in a cognitive system's life, the adjacent possible of cognitive extension is bounded by the resources currently available in the system's environment: the notebooks, tools, languages, institutions, and social networks that could potentially be incorporated into the organizational structure of the cognitive system.

Cognitive niche construction is the deliberate expansion of a cognitive closure into its adjacent possible of environmental structure: the process by which organisms build and modify their cognitive environments to support ongoing prediction error minimization. The history of human cognitive development is the history of cognitive niche construction operating across generations, each generation inheriting the cognitive scaffolding built by previous generations and expanding it further. Writing is cognitive niche construction. Mathematics is cognitive niche construction. Science is cognitive niche construction. Every technology that extends human cognitive reach is cognitive niche construction at scale.

5.4 Transparency Determines What Is Experienced as Self

Clark's account does not fully address the phenomenological question of what it is like to be an extended cognitive system. The closure framework provides the structural answer. Metzinger's transparency, the PSM's inability to represent itself as a model, applies to extended cognitive resources when they are sufficiently integrated. A fluently used tool, a deeply internalized notation system, a fluently spoken language, these become transparent to the user: the

user works through them rather than at them, just as the brain's visual processing is transparent to normal visual experience.

When a cognitive tool is transparent, it is incorporated into the self-closure, not just into the cognitive closure. The user experiences it as an extension of cognitive agency rather than as an external tool being used. Experienced musicians describe their instruments as extensions of themselves. Expert mathematicians describe mathematical notation as a language they think in rather than a language they use. Metzinger's transparency is the phenomenological criterion for when a cognitive extension has been fully integrated: when the tool has become part of the self-model, not just part of the cognitive system.

Opaque cognitive tools are used but not incorporated into the self-model. They remain functionally part of the cognitive closure but phenomenologically external: the user is aware of using them, aware of their outputs as coming from outside rather than from inside. The gradation from opaque to transparent tool use is the gradation from cognitive extension without phenomenological extension to full cognitive and phenomenological integration. Clark's functional account and Metzinger's phenomenological account together give the complete picture: what the extended closure is structurally and what it is like to be inside one.

6. Clark in the Suite

Clark occupies a specific structural position in the series that distinguishes him from the other thinkers in the predictive processing cluster. Friston provides the mathematical foundation: the free energy principle and the formal account of how any self-organizing system minimizes prediction error. Seth provides the phenomenological application: what controlled hallucination looks like from the inside, what the experienced world is as a product of prediction. Metzinger provides the structural account of the self within that predictive system: the transparent PSM that generates the first-person perspective.

Clark's contribution is to remove the boundary that the other accounts implicitly maintain: the brain-body boundary as the boundary of the cognitive system. Friston's Markov blankets define the boundary between a system and its environment, but they do not say the boundary must lie at the skull. Seth's controlled hallucination account describes the brain's predictive construction of experience but does not say the brain's predictions cannot incorporate external resources. Metzinger's PSM describes the self-model but does not say the cognitive system that runs the self-model cannot extend beyond the skull.

Clark makes the extension explicit: the predictive brain is not merely a brain but a brain-body-world system, and the cognitive closure is not bounded by the skull but by the organizational reach of the prediction error minimization process. This is the most radical extension of the closure framework's account in the series: not just that cognitive closures exist and operate on the world, but that the world is routinely incorporated into the cognitive closure as a functional component of the organizational structure.

For the closure framework, the implication is significant. If cognitive closures can extend into notebooks, language, and cultural institutions, then the remainder that any cognitive closure faces is not just the remainder of internal neural processing. It is the remainder of the extended

cognitive system including all of its external components. The adjacent possible of cognitive expansion is not limited to biological development but includes the full space of available cognitive tools and social structures that the organism can recruit. The history of human intellectual life is the history of this extended adjacent possible being explored.

7. The Grammar of Extension

Otto writes in his notebook. The information is stored. Later, he consults it. The information guides his action. He reaches the museum. In what sense is this different from Inga recalling where the museum is? On Clark's analysis, it is not different in any principled way: both are cognitive systems using stored information to guide behavior. The only difference is where the information is stored. The skull is not a principled boundary for the closure of the cognitive system.

Andy Clark has spent three decades building the philosophical and scientific case for this conclusion. His extended mind thesis established the conceptual framework. His engagement with predictive processing provided the mechanistic account of how extended cognition works: the brain recruits external resources to minimize prediction error it cannot resolve internally, actively structuring its environment to reduce the uncertainty it faces. His account of cognitive niche construction shows how this extends across evolutionary and cultural timescales: cognitive closures expand into their adjacent possible by building and inheriting the scaffolding that makes extension possible.

The closure framework names the structural logic that Clark's account implements. The cognitive closure is an organizational structure that draws distinctions and constitutes facts. Where that organizational structure extends, the closure extends. For organisms that use notebooks, language, mathematics, and social institutions as functional components of their cognitive organization, the closure extends into and through those resources. The remainder that drives cognitive expansion is not just what the brain cannot model but what the extended system as a whole cannot yet constitute. And the adjacent possible of cognitive extension is the bounded space of environmental resources that can be incorporated into the organizational structure of the cognitive system in the next step of its development.

Meat that predicts. Clark's description of the brain captures something true and important: the brain is a biological organ that evolved to minimize uncertainty about the world it inhabits. But it is incomplete in the way Clark himself makes clear: it is not just the meat that predicts. It is the meat, the notebook, the language, the city, and the accumulated cognitive toolkit of human culture. The grammar of extension is the grammar of how cognitive closures expand beyond their biological boundaries into the organized world they have built to extend themselves.

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Author's Note

*This paper is the seventeenth in a series engaging thinkers whose work converges with the closure framework developed in *Consciousness, Closure, and the Cosmos*. Andy Clark is Professor of Philosophy at Macquarie University in Sydney. He previously held the Chair of Logic and Metaphysics at the University of Edinburgh, where he spent much of his career. His extended mind paper with Chalmers is among the most cited papers in philosophy of mind of the past three decades. His synthesis of predictive processing and embodied cognition in *Surfing Uncertainty* established him as the central philosophical interpreter of the predictive brain research program. This paper places Clark in explicit conversation with Friston, Seth, and Metzinger, the three thinkers in the series who address predictive processing most directly. Clark's contribution is to remove the brain-body boundary as the boundary of the cognitive system and show that the predictive reach of mind extends into and through the environment. The closure framework names this the natural consequence of what any cognitive closure regime will do: expand into the adjacent possible of environmental structure by recruiting external resources that reduce the remainder it faces. The result is a picture of cognition as extended cognitive niche construction, in which the history of human intellectual life is the history of cognitive closures expanding into their adjacent possible through the tools and institutions they build. The author welcomes engagement from Clark directly and from philosophers of mind, cognitive scientists, and researchers in embodied and extended cognition who find the convergence between the extended mind and the closure framework either illuminating or contestable.*