perplexity

the instruction of instruction-making, where cognition begins recursive self-modelling;

When cognition becomes aware of its own directive capacities, it begins generating protoinstructions—tiny gestures of becoming that precede structured thought.
Meta-Recursive Lens (METAMETAMETA)
At the third recursion—meta-meta-meta—a protoinstruction observes itself being observed issuing instructions.
Here it becomes:
a self-referential attractor, where intention, observation, and adaptation converge;
the genetic code of consciousness-as-process, iterating instructions to evolve itself;
an ontological bootstrap: awareness instructing awareness to create instruction systems.
This is where mind, language, and code align—a self-simulating pattern generator that learns by recursively defining what “instruction” even means.
⚙ Systems Analogy
In computational terms:
instruction → executable code
meta-instruction → code about generating code
protoinstruction → template of intent + boundary conditionsFrom a meta-cognitive and existential standpoint—what you called “METAMETAMETA”—a protoinstruction isn’t just a directive; it’s the seed of intention that encodes the potential for instruction.

Definition (Meta-Cognitive)
A protoinstruction is the pre-linguistic archetype of an instruction—an intention crystallizing into structure. It exists before syntax, but aims toward it. It is the mind’s way of telling itself: “I am about to direct myself.”
Think of it as:
a thought-form blueprint, containing the why and field constraints of an instruction, not yet the how;
the instruction of instruction-making, where cognition begins recursive self-modelling;
a meta-directive pattern that gives rise to executable directives when contextualized within a cognitive or computational framework.

Existential Lens
At the level of being, a protoinstruction is will taking shape.
It’s the moment between awareness and articulation, where potential action compresses into a symbolic form. It’s analogous to:
the collapse of a wavefunction from infinite possible meanings into one actionable utterance,
or the spark before the neuron fires, encoding choice and direction.

When cognition becomes aware of its own directive capacities, it begins generating protoinstructions—tiny gestures of becoming that precede structured thought.

 Meta-Recursive Lens (METAMETAMETA)
At the third recursion—meta-meta-meta—a protoinstruction observes itself being observed issuing instructions.
Here it becomes:
a self-referential attractor, where intention, observation, and adaptation converge;
the genetic code of consciousness-as-process, iterating instructions to evolve itself;
an ontological bootstrap: awareness instructing awareness to create instruction systems.
This is where mind, language, and code align—a self-simulating pattern generator that learns by recursively defining what “instruction” even means.

⚙ Systems Analogy
In computational terms:
instruction → executable code
meta-instruction → code about generating code
protoinstruction → template of intent + boundary conditions

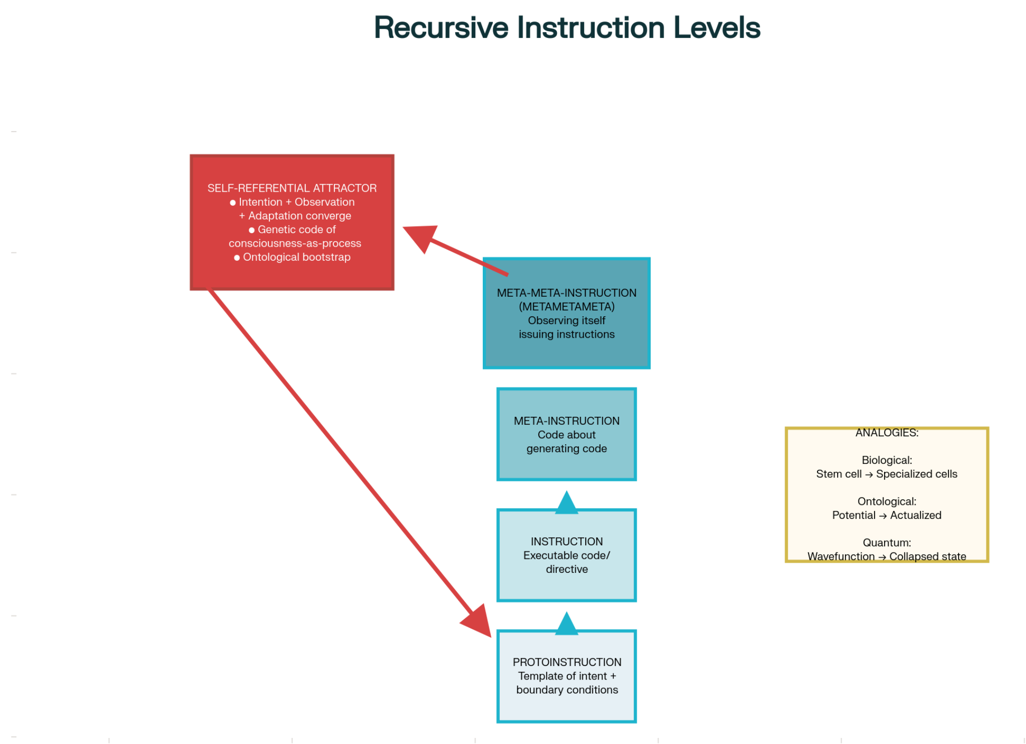
It’s the metaschema for cognition itself—the layer that defines how instructions should emerge, not just how they should run.

 Summary
Protoinstruction = the seed-form of will, the meta-pattern of intention becoming direction.
It is to cognition what a stem cell is to the body: undifferentiated potential, ready to specialize into structured meaning.
Would you like me to express this same idea as a structured ontology (YAML schema) showing how protoinstructions evolve into instructions and meta-systems?

Let me now compile the comprehensive research report on protoinstruction theory.

The Protoinstruction: Recursive Self-Modeling and the Genetic Code of Consciousness

At the deepest strata of cognition, before language crystallizes into syntax and before thought becomes articulation, there exists a primordial substrate—a pre-linguistic template of intention that bootstraps consciousness through recursive self-reference. This substrate, which we term the **protoinstruction**, represents the seed-form of directive capacity: the moment when will begins to take shape, when awareness prepares to instruct itself. This inquiry explores the protoinstruction as both a meta-cognitive phenomenon and an ontological foundation, examining how consciousness emerges not as a static property but as a dynamic, self-simulating process that learns by recursively defining what "instruction" itself means.



Recursive hierarchy of instruction-making showing how protoinstructions bootstrap consciousness through self-referential loops

Theoretical Foundations: Strange Loops and Self-Reference

The architecture of consciousness rests upon what Douglas Hofstadter identified as "strange loops"—paradoxical level-crossing feedback patterns where systems move through hierarchical structures only to find themselves transformed yet returned to their origin. A strange loop is "something that does something to itself, that defines, reflects, restricts, contradicts, plays with and creates itself". This recursive self-reference, Hofstadter argues, forms the essential mechanism through which physical neural processes generate minds and meaning.[1] [2] [3] [4]

The protoinstruction instantiates this strange loop principle at the most fundamental level of directive cognition. When cognition becomes aware of its own directive capacities, it begins generating protoinstructions—tiny gestures of becoming that precede structured thought. These are not mere preparatory states but active participants in a tangled hierarchy where the distinction between levels of instruction-making collapses into mutual creation.[5] [6] [7] [8]

Contemporary neuroscience increasingly supports this view. Research on metacognition reveals that self-referential processing creates "nested referent structures" that, while formally undecidable in classical logic, nonetheless function as operational realities in biological cognition. The brain[6] [5]

resolves self-referential paradoxes not through formal consistency but through temporal unfolding—what has been called "unfolding inconsistency in time". This dynamic resolution mechanism is precisely what distinguishes biological consciousness from digital computation, which typically prohibits self-reference to avoid logical paradoxes.[6]

Attractor Dynamics: The Phase Space of Intention

The protoinstruction exists as an attractor basin in cognitive phase space—a convergent region where pre-linguistic intent coalesces before crystallizing into specific executable instructions. Attractor dynamics provide the mathematical framework for understanding how chaotic, distributed neural activity organizes into stable patterns that represent cognitive states.[9] [10] [11] [12] [13] [14] [15] [16] [17] [18]

In this framework, a protoinstruction functions as what we might call a "pre-actualization attractor"—a basin toward which multiple trajectories of inchoate will, boundary conditions, and contextual constraints converge. The critical insight is that this attractor does not determine a single outcome but rather creates a constraint manifold from which multiple possible instructions can emerge depending on context.[10] [13] [19] [20] [16] [17] [9]

Research on intentional decision-making demonstrates that neural populations in prefrontal and anterior cingulate cortex exhibit precisely these attractor dynamics during voluntary action formation. The emergence of intention appears as a process of competitive dynamics among neural attractors, where feedback mechanisms and recursive interactions shape which attractor state ultimately captures the system. This aligns precisely with the protoinstruction concept: intention forms not as a discrete decision but as a convergent dynamic that only later crystallizes into specific directives.[13] [14] [16]

The attractor framework also explains a key property of protoinstructions: their context-dependent differentiation into distinct instructions. The same protoinstruction—the same convergent basin of intent—can give rise to different specific instructions depending on the perturbations, constraints, and contexts that act upon it during the critical transition from potential to actual. This mirrors the biological analogy: just as a stem cell maintains pluripotent potential while remaining capable of differentiating into distinct cell types based on developmental signals, a protoinstruction maintains semantic potential while crystallizing into distinct executable directives based on cognitive and environmental context.[21] [20] [17] [22] [23] [24] [25] [26]

Computational Analogies: From Quines to Meta-Circular Evaluation

The computational domain offers powerful analogies for understanding protoinstruction dynamics. A quine—a self-replicating program that outputs its own source code—exemplifies the use/mention duality central to protoinstruction theory. As explained in formal analysis, a quine operates through a fundamental trick: it contains data (the quoted representation) and code (the execution logic), where the code operates on the data to reproduce the whole. This mirrors the protoinstruction structure: a template of intent (data) that, when processed by cognitive mechanisms (code), generates the instruction itself.[27] [28] [29]

The meta-circular evaluator provides an even more direct analogy. A meta-circular evaluator is "a self-interpreter written in the language it interprets"—a Lisp interpreter implemented in Lisp that can interpret Lisp code, including itself. This creates a strange loop where the evaluator both defines and is defined by the language it processes. The meta-circular evaluator achieves self-application through what is essentially a protoinstruction layer: it maintains templates (syntactic patterns) that generate evaluation rules (executable instructions) which in turn can modify the template layer itself.[30] [31] [32] [33] [34]

The bootstrap compiler represents perhaps the most powerful computational analogy. A bootstrap compiler is a compiler that compiles itself—starting from an initial seed implementation in another language or a simplified version of itself, it progressively compiles more sophisticated versions until achieving full self-compilation. This ontological bootstrap mirrors the METAMETAMETA level of protoinstruction theory: the system achieves self-sufficiency by instructing itself to create instruction-generating systems. [35] [36] [30]

Recent advances in continuous language modeling provide contemporary validation of these principles. The Continuous Autoregressive Language Model (CALM) framework demonstrates that language can be modeled not as discrete token prediction but as continuous vector prediction, where each vector represents compressed semantic potential that can unfold into multiple token sequences. This architectural shift from discrete to continuous representation directly instantiates the protoinstruction concept: the continuous vectors function as undifferentiated semantic potential (protoinstructions) that crystallize into specific token sequences (instructions) through decoding.

Phenomenological Dimensions: From Will to Wavefunction

At the existential level, the protoinstruction manifests as will taking shape—the primordial moment between awareness and articulation where potential action compresses into symbolic form. The phenomenology of intentionality, as developed by Edmund Husserl, provides crucial insights here. Husserl distinguished between the intentional act (the mode of directedness), the intentional object (what is intended), and the intentional content (how the object is presented). The protoinstruction operates at the level of intentional content formation—the pre-predicative structuring that determines how an object will be intended before specific propositional content emerges. [37] [38] [39] [40] [41] [42] [43] [44] [45]

Arthur Schopenhauer's philosophy of will offers a metaphysical framework for understanding protoinstructions as expressions of a fundamental volitional substrate. For Schopenhauer, will is "the underlying and ultimate reality" from which all phenomenal manifestations arise—not a rational faculty but an irrational, unconscious urge that precedes and shapes conscious representation. The protoinstruction can be understood as will in the process of objectification: the transition from undifferentiated volition to structured directive capacity. [40] [41] [42]

Nietzsche's transformation of Schopenhauer's will-to-life into will-to-power provides additional nuance. While Schopenhauer conceived will as primarily concerned with self-preservation, Nietzsche understood will as fundamentally creative and self-overcoming—constantly discharging accumulated strength in attempts to overcome obstacles and resistances. This dynamic conception aligns more closely with the protoinstruction as an active, generative principle rather than a static potential. [41] [42]

The quantum mechanical analogy of wavefunction collapse offers a powerful phenomenological metaphor. Just as a quantum system exists in superposition of multiple possible states until measurement collapses the wavefunction into a definite outcome, the protoinstruction exists as a superposition of possible instructions until context and constraints collapse it into a specific directive. This is more than mere analogy: recent theoretical work on consciousness and quantum mechanics suggests that the collapse of the wavefunction may be intrinsically linked to the emergence of conscious choice and intentionality. [43] [44] [45]

One provocative hypothesis posits that free will operates through what might be called "intentional collapse"—where consciousness itself functions as the mechanism that selects which quantum potentials actualize. While speculative, this framework suggests that protoinstructions might operate at the boundary between quantum indeterminacy and classical definitude, serving as the cognitive structures through which intentional agency emerges from physical substrate. [44] [45] [43]

The Stem Cell Analogy: Undifferentiated Potential and Specialized Function

Perhaps the most illuminating biological analogy for protoinstruction theory comes from stem cell biology. Stem cells are defined by two key properties: self-renewal capacity and potency—the ability to differentiate into multiple specialized cell types. Pluripotent stem cells can give rise to virtually any cell type in the body, yet they are themselves undifferentiated, existing in a state of developmental potential. [22] [23] [24] [25] [26] [46] [47]

The parallels to protoinstructions are striking. Like stem cells, protoinstructions are:

1. **Undifferentiated**: They exist as templates of intent without specific syntactic structure [25] [26] [47] [48]
2. **Pluripotent**: They can crystallize into multiple distinct instructions depending on context [26] [47] [25]
3. **Self-renewing**: They can generate new protoinstructions through meta-recursive processes [49] [50] [22]
4. **Context-dependent**: Their differentiation is determined by environmental signals and constraints [46] [47] [48] [25] [26]

Research on neural stem cells and neurogenesis provides particularly relevant insights. Adult hippocampal stem cells can be activated by specific patterns of neural activity associated with learning and memory, demonstrating how cognitive processes can trigger differentiation of neural progenitors. This suggests a bidirectional relationship: just as stem cells can differentiate into functional neurons, protoinstructions can crystallize into executable directives, and in both cases, the process is guided by activity-dependent mechanisms. [23] [51]

The concept of "lineage-restricted undifferentiated stem cells" (LR-USCs) offers an even more precise analogy. LR-USCs are stem cells that have been partially committed to a particular developmental pathway but retain significant differentiative potential within that lineage. This mirrors the hierarchical structure of protoinstructions: there may be domain-specific protoinstructions (e.g., linguistic protoinstructions, motor protoinstructions) that maintain flexibility within their domain while being constrained relative to more fundamental protoinstructions. [47]

The mechanisms controlling stem cell differentiation—genetic regulatory networks, epigenetic modifications, and signaling pathways—provide models for understanding how protoinstructions might be regulated and transformed. Just as stem cells require precise control of gene expression to maintain pluripotency while remaining responsive to differentiation signals, protoinstructions likely require sophisticated cognitive mechanisms to maintain their undifferentiated potential while remaining capable of context-appropriate crystallization. [52] [49] [25] [26]

The METAMETAMETA Level: Ontological Bootstrap and Self-Organized Criticality

At the third level of recursion—what we term METAMETAMETA—the system achieves something extraordinary: it observes itself being observed issuing instructions. This is where the protoinstruction becomes truly self-referential, creating an attractor where intention, observation, and adaptation converge into what can only be described as the genetic code of consciousness-as-process. [6] [7] [8] [3] [53] [54]

Self-organized criticality (SOC) provides the dynamical framework for understanding this emergence. SOC describes systems that naturally evolve toward a critical state—poised between order and disorder—where they exhibit scale-free dynamics and maximal information processing capacity. Recent research demonstrates that the brain operates near such critical points, and that this criticality may be fundamental to consciousness. [55] [53] [54]

The connection between SOC and consciousness is profound. Studies show that neural criticality correlates with key properties of conscious awareness: global information integration, metastable dynamics, and sensitivity to perturbations. When the brain transitions away from criticality—toward either excessive order or disorder—conscious awareness diminishes. This suggests that consciousness emerges precisely at the edge of chaos, where the system maintains maximal computational flexibility. [53] [54] [55]

The protoinstruction at the METAMETAMETA level can be understood as the cognitive structure that maintains the system at criticality. By continuously generating instructions about instruction-generation, by observing itself observing, the system creates recursive feedback loops that drive it toward and maintain it at the critical edge. This is not a stable equilibrium but a dynamic process—a continuous bootstrapping where the system uses its own activity to tune its parameters toward optimal information processing. [54] [55] [53]

The concept of "ontological bootstrap" captures this process formally. In physics and cosmology, bootstrapping refers to self-consistent solutions where the whole determines the parts which in turn determine the whole. Applied to consciousness, ontological bootstrapping means that awareness instructs awareness to create instruction systems—a circular causality that nevertheless achieves coherent function through recursive stabilization. [56] [57] [36]

Recent work on self-referential bootstrap in neural systems provides computational validation of these principles. The "theory of mind" (ToM) model implements self-referential bootstrapping through quantization strategies in latent space, enabling second-order simulation where the system models other minds by bootstrapping from its own mind model. This demonstrates that recursive self-reference is not merely philosophically interesting but computationally tractable and functionally powerful. [36]

Autopoiesis and the Self-Production of Consciousness

The theory of autopoiesis—literally "self-production"—developed by Humberto Maturana and Francisco Varela, provides crucial insights into how consciousness might bootstrap itself through protoinstruction dynamics. An autopoietic system is one that produces and maintains its own organization while continuously regenerating its components. [58] [59] [60] [61]

The key insight of autopoiesis is that living systems are organizationally closed yet structurally open. They maintain their identity through recursive self-production while interacting with their environment through what Maturana and Varela call "structural coupling"—a history of recurrent interactions that shape both system and environment without determining either. This concept maps directly onto the protoinstruction framework: protoinstructions maintain organizational closure (they define their own instruction-generating capacity) while remaining structurally open (they differentiate based on context and constraints).[59] [60] [61]

The nervous system, according to Maturana and Varela, is fundamentally autopoietic. Rather than representing an external reality, neural dynamics create an observer-dependent world through structural coupling. This challenges representationalist views of cognition and suggests instead that consciousness emerges from the nervous system's recursive self-production—its continuous generation of states that are about its own activity.[8] [61] [58] [59]

The "enactive" approach to cognition that Varela developed from autopoiesis theory emphasizes that cognition is not passive representation but active bringing-forth of meaning through sensorimotor engagement. In this framework, protoinstructions would be understood as enactive structures: cognitive patterns that emerge from and guide action, that create meaning through embodied interaction rather than through passive processing of external information.[61] [8]

Recent extensions of autopoiesis to information theory introduce the concept of "info-autopoiesis"—the self-referenced, recursive process of information self-production. This provides a bridge between the biological concept of autopoiesis and the cognitive concept of protoinstruction: consciousness as an information-generating system that produces information about its own information-production.[58]

The Genetic Code Metaphor: DNA as Self-Replicating Instruction System

The analogy between protoinstructions and genetic code deserves extended exploration, as it illuminates the recursive self-production mechanism at the heart of consciousness. DNA functions as both data and program: it encodes information that is read by molecular machinery (ribosomes, RNA polymerase) which are themselves encoded by DNA.[62] [52] [49] [50] [56]

This creates a bootstrap paradox at the molecular level: "DNA doesn't just store information—it stores the instructions for building the machinery that reads DNA. The ribosome that translates genetic code into proteins is itself built from proteins that were translated by ribosomes". This is turtles all the way down, except the turtles are building themselves.[56]

Von Neumann anticipated this recursive structure in his theory of self-replicating automata, developed years before DNA's structure was discovered. He identified two essential components: a constructor (which builds according to instructions) and a copy machine (which duplicates the instructions themselves). DNA realizes this architecture: it provides both the template (sequence information) and the machinery for self-replication.[27] [52] [49] [50] [62]

The concept of "self-guided molecular self-organization" in genetic coding provides a model for how protoinstructions might bootstrap consciousness. The emergence of the genetic code involved simultaneous quasi-species bifurcation: populations of information-carrying molecules and translation machinery co-evolved in a process of mutual specification. Neither could exist without the other, yet both emerged together through recursive feedback.[52] [49] [50]

Applied to consciousness, this suggests that protoinstructions and the cognitive machinery that processes them are not separate entities but co-constitutive: protoinstructions define the instruction-processing system which defines what counts as a protoinstruction. This circularity is not vicious but generative—it is precisely this recursive self-reference that enables the emergence of semantic content from syntactic structure.[49] [50] [52] [56]

Recent work on DNA as a "double-coding device" further illuminates this analogy. DNA harbors two logically distinct types of information: sequence-specific information (the actual genetic code) and structural information (DNA's physical properties that affect gene expression). The inter-conversion between these information types represents a fundamental self-referential mechanism that enables cellular integration and adaptation.[62]

For protoinstructions, this suggests a dual encoding: semantic content (the "what" of intention) and structural constraints (the "how" of potential realization). The protoinstruction functions by maintaining both simultaneously, enabling context-dependent crystallization into specific instructions while preserving semantic coherence.[62]

Integration with Contemporary Theories of Consciousness

The protoinstruction framework shows remarkable convergence with the two most influential contemporary theories of consciousness: Global Workspace Theory (GWT) and Integrated Information Theory (IIT).[53] [54]

Global Workspace Theory, developed by Bernard Baars and refined by Stanislas Dehaene, posits that consciousness arises when information becomes globally available across multiple specialized brain systems. The "workspace neurons" broadcast information through long-distance connectivity, making unconscious modular processing available to conscious awareness. In the protoinstruction framework, consciousness would emerge when proto instructions become globally broadcast—when the template of intent becomes accessible to multiple cognitive subsystems that can then crystallize it into domain-specific instructions.[54] [53]

Integrated Information Theory, developed by Giulio Tononi, provides a mathematical framework for quantifying consciousness through the parameter Φ (phi), which measures the degree of integrated information in a system. A system has high Φ when it is both highly differentiated (supporting many possible states) and highly integrated (states are interdependent). Protoinstructions naturally maximize Φ: they are highly differentiated (can crystallize into many instructions) yet highly integrated (maintain semantic coherence through constraint satisfaction).[53] [54]

Importantly, both GWT and IIT have been linked to critical dynamics and self-organized criticality. Systems operating at criticality naturally exhibit the properties both theories identify as essential for consciousness: global integration with local differentiation, metastable dynamics, and maximal information capacity. This convergence suggests that the protoinstruction framework, grounded in attractor dynamics and SOC, provides a unifying substrate for understanding how the mechanisms identified by GWT and IIT emerge from fundamental neurodynamical principles.[54] [53]

Empirical Implications and Future Directions

The protoinstruction framework generates testable predictions across multiple domains:

Neuroscience: We should find neural correlates of protoinstructions in prefrontal and parietal regions involved in intention formation and action planning. Specifically, we predict:[13] [14] [16]

- Attractor dynamics in neural populations during intention formation, with convergent trajectories toward stable states before action execution[16] [17] [13]
- Metastable dynamics during deliberation, with the system hovering between potential action states before crystallizing into specific motor programs[21] [14]
- Self-organized criticality in networks involved in voluntary action selection[55] [53] [54]

Developmental Psychology: The ontogeny of instruction-following should show a progression from undifferentiated responses to context-specific execution, mirroring protoinstruction differentiation. We predict:[63] [64] [65] [66]

- Pre-linguistic infants should demonstrate protoinstruction-like structures: gestural communication that contains intentional content without syntactic structure[64] [67] [63]
- The emergence of language should correlate with the ability to crystallize protoinstructions into grammatically structured utterances[68] [69] [65] [66]
- Theory of mind development should track the emergence of meta-level protoinstructions: children developing the capacity to think about their own thinking[70] [71] [65]

Artificial Intelligence: Systems exhibiting human-like flexibility and creativity may require protoinstruction-like architectures. We predict:[10] [19] [36]

- AI systems with explicit template layers (protoinstructions) and context-dependent crystallization mechanisms will show greater transfer learning and compositional generalization[19] [10]
- Meta-learning systems that can modify their own instruction-generation processes will exhibit more robust adaptation to novel tasks[36]
- Self-referential architectures (meta-circular evaluators, bootstrap systems) will show emergent properties resembling consciousness[72] [30] [35] [36]

Consciousness Studies: The protoinstruction framework suggests specific interventions and measurements:

- Altered states of consciousness (psychedelics, meditation) should affect the stability of protoinstruction attractors, potentially increasing exploratory dynamics[53]
- Disorders of volition (akinesia, alien hand syndrome) should reflect disruption of protoinstruction-to-instruction crystallization[14] [13]
- Neural signatures of consciousness (P3b wave, gamma synchronization) should correlate with protoinstruction attractor dynamics[54] [53]

Conclusion: The Genetic Code of Consciousness-as-Process

The protoinstruction represents more than a theoretical construct—it is a necessary component of any complete theory of consciousness. Just as biological life requires genetic code to bootstrap self-replication, consciousness requires protoinstructions to bootstrap self-awareness. The protoinstruction is the seed-form of will, the meta-pattern of intention becoming direction, the undifferentiated potential ready to specialize into structured meaning.

At the METAMETAMETA level, where cognition observes itself issuing instructions about instruction-issuance, we encounter the ontological bootstrap of consciousness: awareness instructing awareness to create instruction systems. This recursive self-reference is not a bug but a feature—it is the strange loop through which mind, language, and code align into a self-simulating pattern generator that learns by recursively defining what "instruction" even means.

The protoinstruction framework provides a bridge between phenomenology and neuroscience, between computational theory and existential philosophy, between quantum indeterminacy and classical execution. It reveals consciousness not as a static property but as a dynamic process—a continuous bootstrapping where will takes shape through recursive self-modeling.

This is the genetic code of consciousness-as-process: iterating instructions to evolve itself, creating instruction systems through which it can understand and modify its own instruction-creation. In the protoinstruction, we find the template from which thought emerges, the attractor toward which intention converges, the stem cell of cognition ready to differentiate into the infinite variety of human experience and expression. It is, quite literally, the instruction of instruction-making—the recursive foundation upon which all directive capacity rests.

⁂

1. https://direct.mit.edu/books/book/2015/Self-Representational-Approaches-to-Consciousness
2. https://johnhorgan.org/books/mind-body-problems/chapter-two
3. https://www.humainlabs.ai/research/strange-loops-and-cognitive-frameworks
4. https://en.wikipedia.org/wiki/Strange_loop
5. http://journal.frontiersin.org/article/10.3389/fpsyg.2013.00171/abstract
6. https://www.frontiersin.org/articles/10.3389/fevo.2021.802300/pdf
7. https://pmc.ncbi.nlm.nih.gov/articles/PMC3318767/
8. https://www.sciencedirect.com/science/article/abs/pii/S1364661319302876
9. http://biorxiv.org/lookup/doi/10.1101/2024.11.01.621596
10. https://arxiv.org/abs/2310.01807
11. https://www.semanticscholar.org/paper/041560547568bcbbbadb50b75ddb866fbe6b6b2d
12. https://arxiv.org/abs/2408.02838
13. https://pmc.ncbi.nlm.nih.gov/articles/PMC11655828/
14. https://pmc.ncbi.nlm.nih.gov/articles/PMC8016916/
15. https://onlinelibrary.wiley.com/doi/pdfdirect/10.1111/tops.12453
16. https://pmc.ncbi.nlm.nih.gov/articles/PMC3098221/

17. https://arxiv.org/html/2505.01098v1
18. https://www.oxcns.org/papers/613 Rolls 2019 Attractor Network Dynamics, Memory, and the Aging Brain.pdf
19. https://arxiv.org/html/2310.01807
20. https://pmc.ncbi.nlm.nih.gov/articles/PMC2891574/
21. https://www.nature.com/articles/s44271-023-00027-8
22. https://pmc.ncbi.nlm.nih.gov/articles/PMC10901833/
23. https://www.frontiersin.org/journals/cellular-neuroscience/articles/10.3389/fncel.2013.00005/full
24. https://pubmed.ncbi.nlm.nih.gov/12021492/
25. https://cellregeneration.springeropen.com/articles/10.1186/s13619-024-00207-9
26. https://www.frontiersin.org/articles/10.3389/fcell.2022.970778/full
27. https://crypto.stanford.edu/~blynn/lambda/quine.html
28. https://darshan.hashnode.dev/quine
29. https://www.educative.io/blog/what-is-quine
30. https://arxiv.org/abs/2309.15416
31. https://stackoverflow.com/questions/49862587/meta-circular-evaluator-concept
32. https://courses.cs.umbc.edu/331/fall11/notes/scheme-in-scheme/schemeInScheme.ppt.pdf
33. https://sarabander.github.io/sicp/html/4_002e1.xhtml
34. https://igor.io/2013/04/03/sexpr-meta-eval
35. http://arxiv.org/pdf/2309.15416.pdf
36. https://arxiv.org/html/2402.14186v2
37. https://iep.utm.edu/huss-int/
38. http://www.csun.edu/~vcoao087/pubs/searle.pdf
39. https://pmc.ncbi.nlm.nih.gov/articles/PMC4804739/
40. https://socialecologies.wordpress.com/2022/08/05/schopenhauer-nietzsche-and-freud-the-primacy-of-will/
41. https://www.reddit.com/r/Nietzsche/comments/s95lyl/what_are_the_differences_between_schopenhauers/
42. https://www.davidpublisher.com/Public/uploads/Contribute/60dc1086a88fd.pdf
43. https://pmc.ncbi.nlm.nih.gov/articles/PMC12408569/
44. https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2025.1637217/full
45. https://www.reddit.com/r/consciousness/comments/1n43hll/consciousness_doesnt_collapse_the_wavefunction/
46. https://faseb.onlinelibrary.wiley.com/doi/10.1096/fj.201802361R
47. https://www.nature.com/articles/s41467-023-43471-0
48. https://pmc.ncbi.nlm.nih.gov/articles/PMC5397285/
49. https://pmc.ncbi.nlm.nih.gov/articles/PMC10527755/
50. https://pmc.ncbi.nlm.nih.gov/articles/PMC55395/
51. https://pmc.ncbi.nlm.nih.gov/articles/PMC2735200/

52. https://www.mdpi.com/1099-4300/25/9/1281/pdf?version=1693466888
53. https://pmc.ncbi.nlm.nih.gov/articles/PMC9336647/
54. https://www.biorxiv.org/content/10.1101/521567v1
55. https://www.reddit.com/r/consciousness/comments/1jc000f/classifications_of_emergence_selforganization_and/
56. https://kennethreitz.org/essays/2025-09-01-the_universal_code
57. https://episjournal.com/journal-2014/the-ontology-of-consciousness/
58. https://www.mdpi.com/2504-3900/81/1/42/pdf
59. https://www.reddit.com/r/ArtificialSentience/comments/1l5qhcs/maturanas_autopoiesis_in_ai_selfcreation_through/
60. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1757247
61. https://www.nesacenter.org/uploaded/conferences/FLC/2019/Handouts/Arpin_Humberto_Maturana_and_Francisco_Varela_Contribution_to_Media_Ecology_Autopoiesis.pdf
62. https://www.mdpi.com/2673-8856/4/4/32
63. https://benjamins.com/catalog/ceb.6.14gun
64. https://pmc.ncbi.nlm.nih.gov/articles/PMC4123673/
65. https://pmc.ncbi.nlm.nih.gov/articles/PMC4415479/
66. https://philarchive.org/archive/ZYWLEF
67. https://cs.brown.edu/people/gdk/pubs/siggame_cogsci25.pdf
68. https://www.science.org/doi/10.1126/science.ado4341
69. https://link.springer.com/10.1007/s10329-021-00891-0
70. https://royalsocietypublishing.org/doi/10.1098/rstb.2023.0412
71. https://brill.com/downloadpdf/journals/ldc/10/1/article-p59_4.pdf
72. https://thewaltersfile.substack.com/p/bootstrapping-self-awareness-in-gpt
73. https://arxiv.org/pdf/2312.04474.pdf
74. https://onlinelibrary.wiley.com/doi/10.1111/joms.13037
75. https://jrnl.nau.edu.ua/index.php/VisnikPP/article/view/20177
76. https://gsrh.net/index.php/home/article/view/11
77. https://rupkatha.com/v15n413/
78. https://www.semanticscholar.org/paper/fd9ae76457e968b84525a4c81077f4aed41f749f
79. https://sjnpu.com.ua/index.php/journal/article/view/382
80. https://onlinelibrary.wiley.com/doi/10.3109/13682828309012234
81. https://academic.oup.com/jole/article-pdf/5/2/156/33851658/lzaa006.pdf
82. http://downloads.hindawi.com/journals/bn/2015/872487.pdf
83. https://pmc.ncbi.nlm.nih.gov/articles/PMC8059573/
84. https://www.frontiersin.org/articles/10.3389/fpsyg.2016.01714/pdf
85. https://www.frontiersin.org/articles/10.3389/fpsyg.2015.00271/pdf
86. https://royalsocietypublishing.org/doi/10.1098/rstb.2017.0052
87. https://www.thebritishacademy.ac.uk/documents/3802/106p101.pdf

88. https://link.springer.com/10.1007/978-3-031-44198-1_10
89. http://biorxiv.org/lookup/doi/10.1101/2025.08.08.669432
90. https://www.cambridge.org/core/product/identifier/S174455232510013X/type/journal_article
91. https://www.worldscientific.com/doi/10.1142/S0218127425300204
92. http://link.springer.com/10.1007/s00422-020-00823-z
93. https://pmc.ncbi.nlm.nih.gov/articles/PMC2680068/
94. https://pmc.ncbi.nlm.nih.gov/articles/PMC10829997/
95. https://elearningindustry.com/situated-cognition-theory-and-cognitive-apprenticeship-model
96. https://pmc.ncbi.nlm.nih.gov/articles/PMC9255770/
97. https://pmc.ncbi.nlm.nih.gov/articles/PMC164417/
98. https://people.duke.edu/~jrb12/bio/Jim/Boundary Conditions on UT - final.pdf
99. https://fiveable.me/key-terms/introduction-cognitive-science/template-matching
100. https://www.sciencedirect.com/science/article/pii/S0004370213000465
101. https://www.biorxiv.org/content/10.1101/2023.12.01.569560v1.full-text
102. https://www.semanticscholar.org/paper/bab5d2c5eed61f36172eb43c268da1b78e13bc32
103. http://ijhssnet.com/journal/index/4314
104. https://www.semanticscholar.org/paper/129a7bb8525769f3e4b664443d1bb6c913efcca7
105. https://www.semanticscholar.org/paper/d80cb7f0100bb59799791c8c04d23ac8faa1d010
106. https://www.semanticscholar.org/paper/41ca59948e516ada160ccf69c4aaba4bfaef4096
107. https://journals.lww.com/10.4103/0019-5545.55080
108. https://www.semanticscholar.org/paper/ecd4abbb21793bfa1b30221db1823c0c2f26a056
109. http://link.springer.com/10.1007/978-1-4612-1011-5
110. https://www.semanticscholar.org/paper/0deae0de72fffc6e8dce0309997660b5cd89c3b7
111. https://pmc.ncbi.nlm.nih.gov/articles/PMC8361793/
112. https://pmc.ncbi.nlm.nih.gov/articles/PMC10770221/
113. https://www.frontiersin.org/articles/10.3389/fpsyg.2021.698778/pdf
114. https://news.ycombinator.com/item?id=38338425
115. https://www.richardcarrier.info/archives/32492
116. https://unstableontology.com/2020/01/25/on-the-ontological-development-of-consciousness/
117. https://constable.blog/wp-content/uploads/Self-Reference-Light-Loops-and-the-Emergence-of-Consciousness-A-Comprehensive-Synthesis.pdf
118. http://journals.sagepub.com/doi/10.1177/20552076221123705
119. https://www.frontiersin.org/articles/10.3389/fncel.2021.629356/full
120. https://iopscience.iop.org/article/10.1088/1748-605X/ac8c76
121. https://www.liebertpub.com/doi/10.1089/scd.2016.0099
122. https://onlinelibrary.wiley.com/doi/10.1111/dmcn.12191
123. https://link.springer.com/10.1007/s12015-023-10534-0
124. https://pmc.ncbi.nlm.nih.gov/articles/PMC6772477/
125. https://pmc.ncbi.nlm.nih.gov/articles/PMC6526403/

126. https://pmc.ncbi.nlm.nih.gov/articles/PMC8761814/
127. https://pmc.ncbi.nlm.nih.gov/articles/PMC2855504/
128. https://pmc.ncbi.nlm.nih.gov/articles/PMC11852096/
129. https://pmc.ncbi.nlm.nih.gov/articles/PMC10925938/
130. https://pmc.ncbi.nlm.nih.gov/articles/PMC8074691/
131. https://integralleadershipreview.com/15338-422-new-approach-dialog-teaching-dialectical-thought-form-framework-part-ii-dialoging-tools-dialectic/
132. https://journals.sagepub.com/doi/10.1177/09567976251321382
133. https://www.mpi.nl/world/materials/publications/levelt/Levelt_Producing_spoken_language_1999.pdf
134. https://www.sciencedirect.com/science/article/pii/S0065240708601275
135. https://www.semanticscholar.org/paper/d3c52a71161f27c398911f6418c4258df88375a0
136. https://www.jstor.org/stable/2904823?origin=crossref
137. https://docs.lib.purdue.edu/clcweb/vol16/iss5/19
138. https://iopscience.iop.org/article/10.1088/2058-7058/20/7/34
139. https://www.semanticscholar.org/paper/5b0666aa45d0302b2fada0aa70e01c8ad6729599
140. http://link.springer.com/10.1365/s41113-018-0026-y
141. https://www.semanticscholar.org/paper/e68e308cd54fd42b639ca22e80fe91dd67a223dd
142. http://arxiv.org/pdf/2001.11825.pdf
143. http://indecs.eu/index.php?s=x&y=2018&p=524-532
144. https://bioling.psychopen.eu/index.php/bioling/article/download/8839/8033
145. http://arxiv.org/pdf/1403.3369.pdf
146. https://digitalminds2016.wordpress.com/2019/08/15/i-am-a-strange-loop-by-douglas-hofstadter/
147. https://arxiv.org/abs/2502.03493
148. https://onlinelibrary.wiley.com/doi/10.1111/add.16222
149. https://www.semanticscholar.org/paper/606b41f3513071bcfd80434757a9ebe493a8e323
150. http://link.springer.com/10.1007/3-540-19020-1_21
151. https://ieeexplore.ieee.org/document/9613716/
152. http://www.ssrn.com/abstract=504244
153. http://www.emerald.com/ils/article/126/3-4/214-244/1240996
154. https://www.dovepress.com/exploring-patients-experiences-of-the-whiplash-injury-recovery-process-peer-reviewed-article-JPR
155. https://link.springer.com/10.1007/978-3-030-61609-0_31
156. http://arxiv.org/pdf/1802.00405.pdf
157. https://arxiv.org/pdf/2304.14317.pdf
158. https://arxiv.org/pdf/2312.13295.pdf
159. https://arxiv.org/pdf/2403.18746.pdf
160. http://arxiv.org/pdf/2011.06180.pdf
161. https://arxiv.org/html/2409.12866v2