Consciousness Is Evolution in Real Time: A Deterministic Accessibility Account

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Article

Consciousness Is Evolution in Real Time: A Deterministic Accessibility Account

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Abstract

This paper argues that the moment-to-moment content of phenomenal consciousness is identical to whichever neural or mnemonic representation is, at any instant, transiently the most accessible given the system's causal history and current embedding context. Building on Tulving's distinction between availability and accessibility and on empirical findings about working-memory limits, the attentional blink, priming, and neuromodulation, we propose that James's "stream of consciousness" is a serial, determined sequence of state transitions governed by relative accessibility. Further, the stream of consciousness is not an accidental by-product of slower adaptive processes but the real-time continuation of the same abstract dynamics that operate across evolutionary, developmental, and cultural timescales, here unfolding at psychological speed. The account is deterministic (or near-deterministic) at the psychological level, reframes the hard problem of consciousness as a tractable question about accessibility mechanisms, and remains neutral on low-level physical indeterminism. It is compatible with major neuroscientific findings and yields testable predictions concerning priming effects, mind-wandering sequences, conscious transitions under neuromodulation, and clinical disruptions of conscious seriality.

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Introduction

> "Consciousness is not a chain, but a stream. It flows, bends, and merges — always changing, never still."
>
> — William James

More than a century ago, William James described conscious experience as a stream, always changing, no state recurs identically, and it is continuous from moment to moment, composed of senses, impressions, and mental phenomena in constant flux (James, 1890).

Despite enormous progress in cognitive neuroscience, the mechanisms that determine why one content rather than another occupies the stream at any given moment remain underexplored. Leading neuroscientific theories, the Global Neuronal Workspace (Baars, 1993; Dehaene, 2014) Integrated Information Theory (Tononi et al., 2016) And Higher-Order Thought accounts (Lau & Rosenthal, 2011) Successfully explain how contents are broadcast, integrated, or meta-represented. Yet, they typically treat the specific identity of the currently conscious representation as a downstream consequence rather than a core explanandum.

We propose that the moment-to-moment content of consciousness just is whichever neural/mnemonic representation is, at that instant, the most accessible state, given the system's history and embedding context. The accessibility term for the transient ease with which a stored representation can be retrieved becomes the central construct. On this view, the stream is not a mysterious addition to physical process; it is the serial, trajectory of a system undergoing relativistic state transitions.

The resulting framework is near-deterministic at the psychological level: every transition is fully shaped by prior causes acting through the accessibility mechanism, rendering libertarian free will

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impossible at the level of conscious choice, while remaining neutral on whether low-level physical indeterminism ultimately contributes noise to the perturbation phase.

An Evolutionary Account of Consciousness

Biological evolution is standardly described in terms of variation, selection, and inheritance operating across generations (Darwin, 1859). Over the last half-century, the framework has been repeatedly generalized as "Universal Darwinism" by Dawkins, who applies the same abstract logic, generates variants, selects some subset, and retains the selected features. The concept evolved and contributed to cultural evolution (Mesoudi et al., 2006), immune-system dynamics (Edelman, 1987), neural development (Calvin, 1988) and even cosmology (Smolin, 1997). In each case, a population of entities undergoes differential persistence according to context-sensitive criteria.

Thus, remarkably general abstract dynamic recurs across vastly different domains of nature. Systems that adapt and maintain coherence do so through repeated cycles in which (1) the current state is perturbed in multiple ways, (2) only certain resulting configurations transiently persist according to context-sensitive constraints, and (3) the persisting configuration becomes the starting point for the next cycle (Stoelhorst, 2005).

The central thesis of this paper is that the same abstract dynamic, varying only in timescale and substrate, operates on the millisecond-to-second level we directly experience as the stream of phenomenal consciousness. At this level, the competing entities are not organisms, antibodies, or cultural items, but fleeting neural and mnemonic patterns. Within conscious processing, the three phases take the following domain-specific forms:

Perturbation: the current dominant state is continuously modified by sensory input, spontaneous activity, and internal noise, modifications that are never ontologically random and originate from specific physical and biochemical imbalances produced by the system's current relations and antecedent causes.

Accessible momentary evaluation: selection becomes a relativistic evaluation via momentary accessibility. Evaluation is the process by which a system's perturbed state is assessed relative to its context, determining which changes stabilize and which configurations gain persistence or influence relative to alternatives.

Just as there is no absolute, environment-independent fitness in any adaptive system, there is no absolute "conscious-worthiness" at time t; dominance is strictly relative to the system's immediate relational context.

Relative stabilization: Retention as transient relative stabilization, where a system's new state, shaped by perturbation and relative evaluation, persists as the conscious content and becomes the basis for subsequent relevant future processes. In biology, selected traits are copied to the next generation. In conscious processing, the accessed representation is briefly sustained in a dominant processing pathway, thereby reshaping the accessibility landscape for future cycles.

The resulting perturbation, accessibility-governed evaluation, and transient relative stabilization are substrate-neutral and timescale-neutral. It is the same formal iterative process that operates across evolutionary, developmental, cultural, and perceptual timescales, here running so rapidly that its successive dominant states are experienced from the inside as the continuous flow of subjective awareness.

Phenomenal consciousness is not an accidental by-product of evolution; it is this same abstract persistence dynamic operating at psychological speed, whose rapid succession of dominant states is lived from the first-person perspective as continuous subjective experience. The remainder of the paper shows how the accessibility factors implement the crucial context-sensitive persistence stage and why the transiently dominant state feels, from the first-person perspective, like "what it is like" to be the system at that moment.

Computation as Sequential State Transformation

Contemporary philosophy of mind and cognitive science overwhelmingly treat the brain as a computational system (Rescorla, 2015). Even critics of strong computationalism accept the weaker

 doi:10.20944/preprints202512.0535.v1

claim that neural activity consists of systematic, rule-governed state transitions whose successor states are lawfully determined by prior states and contextual inputs (Piccinini, 2015).

A sufficiently broad yet non-trivial definition of computation captures exactly this idea: a physical system computes when its internal states evolve according to transition rules that map current state plus contextual input onto a unique (or narrowly constrained) successor state. The mapping may be discrete or continuous, serial or massively parallel; the essential feature is a deterministic (or near-deterministic) sequential transformation governed by the system's organization and embedding conditions (Eliasmith, 2010; Fresco & Miłkowski, 2021).

The abstract three-phase iterative dynamic introduced earlier (perturbation, accessibility-governed evaluation, and relative stabilization) maps closely onto this computational picture: Perturbation corresponds to the arrival of new exogenous and endogenous inputs. Accessibility driven selection corresponds to the application of context-sensitive transition rules that determine which candidate state achieves transient dominance. And transient stabilization corresponds to the brief sustaining of the resulting successor state and its future application. The result is an iterative, self-modifying computational process.

The computational perspective and the iterative evolutionary dynamical framework, therefore, describe the same underlying process from complementary angles. What remains to be specified is the concrete mechanism that determines which of the many representations wins the serial competition at each cycle and thereby enters phenomenal awareness. We propose that the decisive factor is relative accessibility, the transient ease with which a given representation can be retrieved and sustained, given the system's immediate history and current relational context.

Consciousness as Serial Accessibility

Consciousness, many meanings and definitions are attributed to the term; here, I adopt the most commonly used one: consciousness is awareness of a state or object, whether internal (within oneself) or external. Definitions of consciousness commonly include cognition, experience, feeling, perception, and thought. In simple terms, consciousness can be described as our state of being, a state characterized by sensation, emotion, volition, or thought.

The term "qualia" denotes the qualitative properties of experience, the subjective ways things appear to an individual (Chalmers, 2010). This issue is central to the so-called "hard problem" of consciousness. Although modulation of neural responses and patterns of information processing correlate with qualia, the neural basis of consciousness remains contested (Seth & Bayne, 2022).

One influential psychological account of consciousness was offered by William James, who characterized it as a stream of thought. James proposed that consciousness flows like a stream: it is always changing, no state recurs identically, and it is continuous from moment to moment, composed of senses, impressions, and mental phenomena in constant flux. According to him, consciousness is not static but dynamic and continually evolving.

Framing consciousness as a stream of thoughts and states, with one following another, raises further questions: how the stream is derived, and what its drivers are? Can we become conscious of something without any internal or external causes? For example, can I intentionally recall the capital of France without any external prompt or preceding internal states or cues? Do antecedent causes fully determine the stream? If not, do the randomness in our thoughts and states have any meaning, and do they exclude causal antecedents?

Declarative memories, both episodic and semantic, require external cues or internal related spreading activation to enter consciousness. Treating them as inherently intentional or freely accessible neglects the causal role of external cues, context, and current network state.

Crucially, conscious experience exhibits a pronounced serial bottleneck. Despite massive parallel processing in early sensory pathways, higher-order awareness typically accommodates only one coherent content stream at a time (King & Dehaene, 2014). Empirical signatures of this bottleneck include limited working-memory capacity (Cowan, 2001), the attentional blink (Dux & Marois, 2009) and the psychological refractory period (Klapp et al., 2019). These findings imply that, at the level relevant to phenomenology, neural computation is effectively winner-take-all, temporally discrete,

 doi:10.20944/preprints202512.0535.v1

and typically one dominant processing pathway achieves subjective prominence at any given moment.

The central claim of this paper is that phenomenal consciousness, at any instant, is identical to whichever neural/mnemonic representation is, at that instant, the most accessible, given the system's causal history and current relational context. In other words, the stream of consciousness described by William James is the real-time manifestation of the evolutionary dynamic introduced, a serial, selection process in which the candidate state is determined by relative accessibility.

Tulving's distinction between availability (whether a representation exists in storage) and accessibility (the transient ease with which it can be retrieved into active processing) provides the crucial construct (Tulving & Pearlstone, 1966). A memory or percept may be available without being accessible; conversely, the representation that enters awareness is the one that, given current constraints, is momentarily the most accessible.

Consciousness moves through successive mental states. Transitions from the current representation to the next depend on how accessible each candidate state is given the ongoing stream, which mental-state configuration becomes the next dominant processing pathway relative to the current state and the embedding context.

Although the stream can also be transited *to* several possible next states, like a branching river, one processing stream typically predominates. This dominant stream, the main river of processing produced by relatively stronger activation and/or inhibition of alternatives, largely constitutes the current phenomenal experience and qualia. Consciousness is therefore a serial selection and integration of the most accessible state, producing a dominant stream at any given time.

Although other potential branches can exist and be processed, they remain unconscious. The dominant current captures subjective awareness and masks alternatives (Ansorge et al., 2008). These unconscious processes, however, can modify accessibility and local scaffolding, thereby influencing subsequent related states.

Transitions to candidate states depend on the current state, the proximity, associativity, and history of the next relative states. The candidate with the highest relative accessibility becomes the next conscious content and shapes the trajectory of subsequent processing. In the following, I summarize the parameters that jointly influence relative accessibility:

Short-term and working-memory dynamics

Recently activated representations are sustained by transient recurrent activity and are therefore highly accessible (Jonides et al., 2008). Working-memory manipulations, mental arithmetic, verbal rehearsal, and visuospatial planning are paradigmatic conscious processes precisely because they rely on keeping a small number of items in a highly accessible state.

Although WM is often classified as a distinct memory system, it consists of STM representations plus serial manipulation, which correspond closely to our ongoing conscious processes (Aben et al., 2012). Although manipulation often seems intentional, it assumes knowledge of the relevant processes. If an agent doesn't know how to perform addition, the activation flow cannot carry out the addition step-by-step. The choice of strategy also depends on accessibility; when multiple solution methods are available, the one with higher accessibility in the current context is selected first.

As noted above, some branched, unconscious states can also be partially processed or manipulated depending on their accessibility, given the activation flow. Such manipulations may occur without accompanying subjective awareness. Thus, WM processes may not always be accompanied by conscious awareness (Trübutschek et al., 2017).

Activation history

The recent history of neural activation, both conscious and unconscious, modulates the accessibility of cognitive representations, biases related processing. Recent engagement of a representation facilitates (or occasionally suppresses) its subsequent reactivation (Schacter et al., 2007). Repetition priming, semantic priming, and negative priming all illustrate how the immediate past sculpts the accessibility landscape for the next processing cycle. Adjustments of neuronal

 doi:10.20944/preprints202512.0535.v1

baseline firing after recent activity, either suppressing (habituation) or enhancing (sensitization), also affect the accessibility of those states (Cevik, 2014).

Spatial contiguity and reachability constraints

Spatial contiguity influences perceptual grouping and association, aids in the grasping of relations, learning, and constructing cognitive maps for navigation (Ginns, 2006).

Beyond grouping and associative effects, spatial contiguity implies a local constraint on neural state transitions. Neural activity tends to flow through nearby, reachable, accessible paths rather than jump arbitrarily to distant, inaccessible states. Suppose accessibility is not immediately altered by environmental or contextual perturbations (for example, an abrupt sound). In that case, the next neural state is most likely to be one of the nearby, highly accessible states. The proximity of the current state to potential next states, modulated by situational context, affects subsequent transitions.

Temporal order and proximity

Temporal proximity refers to the closeness between encoding cues, events, or states, which aids in learning (Hintzman, 2016). Synaptic strength changes depend on the precise timing of pre- and postsynaptic spikes (Kennedy, 2013). Beyond facilitating associations and learning, the temporal order and proximity of states can influence which states follow and bias ongoing processing and the formation of conclusions (Crano, 1977).

Short-term synaptic/neuronal dynamics, facilitation/depression, and persistent neural activity create temporal windows during which prior activity influences the encoding of subsequent inputs, and if related, exerts bias on the processing of incoming states and subsequent transitions.

Associative strength and network topology

Pathways with stronger connections and richer associations are more accessible and therefore more likely to be traversed by ongoing neural dynamics. Such structural connectivity and network topology thus favor particular transitions between representations and guide the flow of activation (Luppi et al., 2024).

Modulatory factors

Neuromodulators (for example, dopamine, noradrenaline, acetylcholine) alter neural gain, plasticity, and threshold dynamics, thereby modulating accessibility either globally or locally, influencing both the main processing stream and branching behavior (Bazzari & Parri, 2019). Emotions and internal states bias processing toward congruent representations, increasing accessibility of mood-congruent information, and thereby steering the flow of thought toward emotionally relevant states (Faul & LaBar, 2023).

Attentional orienting amplifies the accessibility of task-relevant representations while suppressing competitors, providing top-down guidance that aligns the activation trajectory with current goals and environmental demands (Gazzaley & Nobre, 2012). Although attention feels voluntary, the set of representations available for attentional selection is itself constrained by the factors listed above.

Environmental entanglement

Ongoing sensory input continuously perturbs the accessibility landscape. External cues can dramatically redirect the dominant processing stream, as illustrated by the cocktail-party effect or sudden unexpected stimuli.

These factors do not operate independently; they interact dynamically. The resulting accessibility ranking is context-relative in exactly the sense required by the evolutionary framework: there is no absolute, environment-independent measure of which representation deserves to become conscious. The winner is whichever candidate achieves the highest transient activation given the total relational configuration at that moment.

The extent to which incoming sensory and contextual information drives neural processing determines how the external environment shapes the main activation flow. Thus, alongside internal state, external state, and environmental context influence accessibility and direction of processing.

 doi:10.20944/preprints202512.0535.v1

Predictive-processing and free-energy accounts are largely compatible with this picture, but typically treat prediction-error minimization as the primary driver (Friston, 2010; Sprevak & Smith, 2023). We propose the reverse priority: prediction and signaling errors are themselves subservient to accessibility dynamics. A representation is predicted, attended to, or treated as surprising only if it is already sufficiently accessible to enter the dominant processing pathway. Accessibility is the more fundamental principle; predictive coding is one of the mechanisms by which it is implemented.

Ordinary thinking further illustrates the same accessibility principle. Thoughts are not conjured ex nihilo; they are assembled from representations that are currently accessible (memory traces, perceptual fragments, concepts) and combined according to the operations the current dominant pathway can sustain (Smallwood & Schooler, 2015). Even apparently creative or spontaneous ideas are a recombination of existing elements whose joint accessibility is momentarily elevated (Beaty et al., 2016).

Mind-wandering episodes occur when internally generated representations achieve higher activation than task-related material, typically when external demands are low or when unresolved personal concerns are strongly primed (Christoff et al., 2016). The content of mind-wandering is therefore not random; it reliably tracks recent concerns, future goals, and autobiographically significant material, precisely the representations that enjoy elevated baseline accessibility (ER, 2010).

During sleep or anesthesia, the intensity and structure of activation flows change but do not disappear completely. Deep sleep and some anesthetic states may lack the coherent activation patterns typical of wakeful cognition, yet localized and smaller-scale activations persist. In other words, although no single dominant stream achieves the degree of integration and accessibility required for subjective experience, neural dynamics continue (Massimini et al., 2005).

In sum, phenomenal consciousness is the serial, accessibility-governed selection of the momentarily dominant representation within an ongoing iterative persistence process occurring at psychological speed.

Implications for Free Will, Agency, and the Hard Problem

The present account describes conscious transitions as the outcome of a deterministic competition governed by relative accessibility. Although the framework is fully compatible with physical determinism at the psychological level, it remains neutral on whether low-level physical indeterminism (e.g., quantum effects) ultimately contributes to the perturbation of accessibility rankings. What the theory does rule out is any form of libertarian free will that requires the agent to stand outside the causal stream and select among genuinely open possibilities with identical pasts.

On this view, the experience of deliberation and choice corresponds to a sequence of accessibility flow; the subjective sense that "I am the author of the decision" arises after the accessed winning representation has already achieved dominance (Soon et al., 2008). Compatibilist notions of freedom, acting in accordance with one's reasons without external coercion, remain intact because reasons, goals, and values are themselves potent modulators of accessibility (Shadlen & Roskies, 2012). The strong intuition that we could have done otherwise, given the same past, is explained as a post-hoc confabulation enabled by our capacity to verbally simulate counterfactual trajectories.

Predictive-processing and active-inference frameworks are highly compatible with the present account, as both emphasize serial, iterative updating of a single dominant model of the world. However, the two approaches differ in explanatory priority (Parr & Friston, 2019).

Predictive-processing theories typically treat the minimization of precision-weighted prediction error as the primary driver of perceptual and cognitive inference. The accessibility framework instead proposes the reverse: a representation can only register as a high-precision prediction, generate reportable surprise, or become the target of attentional selection if it has already achieved sufficient transient accessibility to enter the dominant processing pathway in the first place. Predictive coding and precision optimization are therefore best understood as important subsidiary mechanisms that operate within the broader constraints set by accessibility dynamics.

Regarding the hard problem of consciousness, the present account offers a radical reframing that borders on dissolution: phenomenal consciousness does not supervene on some special

 doi:10.20944/preprints202512.0535.v1

consciousness module or on global broadcasting per se; it is nothing over and above the first-person perspective of the brain's ongoing, real-time selection dynamic, the subjective side of serially selecting and transiently stabilizing whichever representation is momentarily most accessible.

In other words, what it feels like to be a conscious creature at any instant just is what it feels like, from the inside, when a neural system is iteratively perturbing, evaluating, and transiently stabilising representations according to the accessibility principle described**.** Asking "why does this accessibility-governed evolutionary process feel like anything?" is therefore transformed into the empirical question of how the specific factors we enumerated (priming, neuromodulation, associative strength, etc.) shape the qualitative character of the stream.

Whether this move fully dissolves the hard problem (Frankish, 2016) or merely relocates it to a more tractable set of mechanistic questions is left as an open interpretive issue, but the framework at least removes the mystery of an extra consciousness ingredient added to physical processing. In short, the stream of consciousness is not a by-product of evolution; it is evolution continued in real time, at psychological speed.

Despite the complexity of interacting accessibility factors, the theory generates several sharp, contrasting predictions that distinguish it from leading competitors such as Global Neuronal Workspace Theory (GNW), Higher-Order Thought theories, and pure predictive-processing accounts:

Priming or target manipulations that increase accessibility without producing strong global ignition (P3b) or higher-order meta-representation should nevertheless reliably insert content into phenomenal consciousness if the current state is relatively close.

During mind-wandering or low external load, the sequential structure and thematic content of conscious experience should be better predicted by pre-measured individual differences in long-term semantic/autobiographical accessibility gradients than by momentary prediction-error magnitude or global workspace measures alone.

Transient experimental reductions of accessibility of the current dominant content (e.g., via continuous flash suppression, backward masking, or TMS) should produce reportable microscopic gaps or rapid transitions in the conscious stream even when global integration metrics (P3b amplitude, perturbational complexity index) remain intact.

Neuromodulatory interventions that globally increase neural gain (e.g., moderate doses of psychedelics or noradrenergic agonists) should broaden the range of representations that can achieve transient dominance, producing measurable increases in the rate and thematic diversity of conscious transitions that exceed what precision-weighting accounts would predict.

In clinical populations with disrupted conscious seriality (e.g., schizophrenia patients with formal thought disorder or patients recovering from minimally conscious state), deficits should correlate more strongly with abnormalities in the specific accessibility factors enumerated (priming efficacy, working-memory maintenance, emotional biasing) than with global measures of integration or complexity alone.

Existing results already provide preliminary support for several of these predictions (Aru et al., 2019; Luppi et al., 2024) Direct experimental contrasts are still needed. The accessibility framework offers a unified, mechanistically grounded picture of the stream of consciousness. It makes strong, testable claims about the determinants of moment-to-moment phenomenal content and the serial structure of awareness, while remaining appropriately modest about deeper metaphysical questions of indeterminism and the ultimate nature of experience.

Conclusion

This paper has argued that phenomenal consciousness is neither a mysterious emergent property nor a mere computational epiphenomenon. It is, instead, the real-time expression, at psychological speed, of the same dynamics that operate across evolutionary, developmental, and cultural scales.

At every moment, typically one dominant processing pathway achieves subjective prominence; its content is whichever neural/mnemonic representation is, given the total causal history and current

 doi:10.20944/preprints202512.0535.v1

relational context, the momentarily most accessible. Accessibility, shaped by short-term and working-memory constraints, activation history, associative strength, neuromodulation, attention, and environmental entanglement, functions as the relativistic evaluation criterion in an unbroken, deterministic chain of perturbation, evaluation, and stabilization.

The resulting picture unifies three domains that are usually treated separately: biological evolution, neural computation, and the stream of conscious experience under a single substrate-neutral, timescale-flexible principle.

The account is near-deterministic at the psychological level (ruling out libertarian free will), reframes the hard problem as a tractable empirical question about accessibility mechanisms, and generates sharp, contrasting predictions that distinguish it from Global Workspace, Higher-Order Thought, Integrated Information, and pure predictive-processing theories. Future work should formalize the quantitative interaction of the enumerated accessibility factors, derive precise computational models, and test the framework's predictions in both healthy participants and clinical populations with disrupted conscious seriality.

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