

A Four-Track Human Memory Model: A Layered Signal-Fidelity Framework for Understanding Memory, Emotional Replay, and Late-Life Cognitive Vulnerability

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Abstract

This preprint proposes a Four-Track Human Memory Model that frames human memory as a multi-channel recording-studio environment rather than a unitary storage system. Four functional layers are delineated: (1) immediate awareness (fragile, short-horizon capture), (2) long-term narrative memory (durable biography and identity continuity), (3) embodied body-state memory (autonomic tone, interoceptive carryover, affective readiness, and channel noise), and (4) deeper biological persistence (cumulative allostatic and life-course vulnerability).

The model's central hypothesis centers on Track 3 as the primary operational carrier for emotional replay and cognitive readback. Emotionally salient events simultaneously deepen inscription and perturb the embodied channel, creating self-sustaining loops of recursive replay that increase noise while strengthening memory traces. In late life, reduced physiological reserve amplifies this noise, contributing to day-to-day variability, apparent acceleration of decline, and inconsistent access to existing content—even when structural pathology is moderate.

Proxy measures such as heart-rate variability (HRV), pulse-rate complexity, sleep quality, and autonomic flexibility offer indirect windows into Track-3 fidelity. The Recursive Emotional Load Index (RELI) is introduced as a practical clinical threshold to assess whether old emotional material remains biologically active and disruptive in the

present. When RELI is moderate to high, a two-phase approach—tracking active stems followed by therapeutic remixing (reducing maladaptive replay, improving carrier stability, increasing buffering, and overdubbing cleaner material)—offers a humane, signal-shaping path to support late-life function.

This framework holds potential applicability to caregiving practices, grief and trauma therapy, autonomic-focused interventions, and improved risk stratification for late-life cognitive decline including dementia.

The framework is conceptual and investigatory, integrating reconsolidation, allostasis, interoception, autonomic dysregulation, and life-course stress literatures into a layered fidelity interpretation. It aims to widen inquiry from “what was lost?” toward “on which track was it written, what noise entered the chain, and what can still quiet the channel or rebalance the mix?”

Keywords: Memory layering, embodied cognition, autonomic regulation, cognitive decline, grief, trauma, allostatic load, recursive emotional load index, heart rate variability, dementia vulnerability. JEL Classification: I12, J14

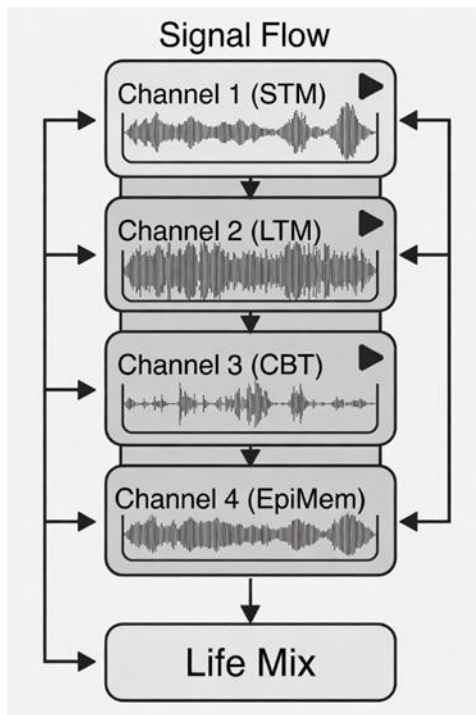
1. Introduction

Conventional models often treat memory as a monophonic archive: events are stored, retrieved, or lost. Yet lived experience suggests otherwise—some impressions vanish quickly, others become durable stories, some persist as bodily tone or vigilance without conscious narration, and some exert slow, cumulative influence across the life span.

This paper offers a heuristic alternative: memory as a multi-track recording studio. Separate functional layers (tracks) allow different elements of experience to be captured, preserved, replayed, distorted, or

stabilized independently yet interactively. The analogy is not literal neuroscience but explanatory clarity: not all experience is written the same way, at the same depth, or with the same long-term consequences.

2. The Four Tracks Defined



Track 1: Immediate Awareness Fast front-end registration, working memory, moment-to-moment handling. Fragile, overload-prone; explains transient lapses without implying global failure.

Track 2: Long-Term Narrative Memory Durable biography, conscious recall, identity continuity. Repeatedly reinterpreted; supports reflection, regret, wisdom. Failures here threaten personal story coherence.

Track 3: Embodied Body-State Memory (Core Focus) Autonomic expectation, affective tone, vigilance, readiness, dread, somatic background. Operates via interoception and regulation; persists as lived state rather than explicit recall.

Key hypothesis: Track 3 functions as the carrier medium for emotional replay and cognitive readback. Strong events deepen writes here while perturbing the carrier (\downarrow HRV, flattened variability, sleep disruption), creating circular loops: replay \rightarrow dysregulation \rightarrow noisier replay.

Track 4: Deeper Biological Persistence Slow substrate of allostatic embedding, developmental wear, long-run predisposition. Faintest but amplifies vulnerability when reserve declines.

Tracks interact: a single event may cascade across layers; aging narrows headroom, making background noise more dominant.

3. The Emotional-Heart-Memory Triangle and Track-3 Noise

Emotionally salient experiences affect the system in two ways simultaneously:

- Increased consolidation and replay probability
- Carrier disturbance (autonomic, inflammatory, sleep, metabolic shifts)

Recursive replay under disturbed conditions strengthens memory while raising the noise floor → self-amplifying loop. Late-life reduced reserve (less parasympathetic flexibility, vascular compliance, sleep resilience) lets moderate noise become functionally dominant, producing variability, fog, agitation, and inconsistent access that feels like accelerated decline.

Recent evidence (HRV-cognition links, bereavement cardiovascular risk, allostatic-interoceptive reviews) supports viewing HRV, pulse complexity, and related metrics as proxies for Track-3 fidelity.

4. Life-Course Burden as Weighted Open Loops

Burden is not event count but recursive emotional load: severity, replay density, embodied carryover, suppression cost, and resulting compression of human range (narrowed curiosity, trust, play, resilience).

Open loops remain biologically active—reactivating easily, disturbing regulation, narrowing adaptive bandwidth. Track-2 suppression does not guarantee Track-3 quiet. Late-life vulnerability emerges when compressed range meets low reserve: old stems bleed through proportionally louder.

5. The Recursive Emotional Load Index (RELI)

RELI serves as the clinical pivot: estimates whether old emotional material is still recursively active and disruptive enough to degrade the current mix.

Five-domain pattern matrix:

1. Event load (intensity, inescapability, repetition, lack of buffering)
2. Recursive replay (frequency, heat, intrusions)
3. Embodied carryover (sleep/autonomic/next-day effects)
4. Functional compression (narrowed range)
5. Buffering & recovery (what quiets the system)

RELI levels guide action: low → standard care; moderate → track; high/severe → remix.

6. Tracking vs. Remixing

Tracking: Identify active stems, triggers (loneliness, fatigue), quieting factors (company, routine, music, purpose), and variability patterns (good/bad day predictors).

Remixing (when RELI justifies):

- Reduce maladaptive replay gain (grief/trauma/sleep-first work)
- Improve carrier fidelity (sleep rhythm, gentle autonomic support, movement)
- Increase buffering (safe connection, low-drama belonging)

- Overdub cleaner material (well-pitched, absorbing local activity/role/mastery to override old bleed-through)

Goal: cleaner late-life mixdown—less hiss, less old-stem dominance, more stable playback, more usable present life. Not erasure, but rebalancing.

7. Conclusion

The Four Track model is a conceptual scaffold that reframes memory as layered and fidelity-dependent rather than monophonic and binary. By centering Track 3 as carrier, introducing RELI as threshold, and distinguishing tracking from remixing, it generates practical questions: What still plays in the background? What quiets or roughens the channel? What can still be overdubbed before headroom is exhausted?

It does not replace neuropathology or conventional diagnosis but widens the lens to include embodied regulation, recursive load, and supportive rebalancing—potentially useful for research, caregiving, and late-life support.

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