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# Cerebral Surge as a Mechanistic Generator of Near-Death Experience Narratives: Integrated Computational, Metabolic, and Information-Theoretic Analyses

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## ABSTRACT

Near-death experiences (NDEs) are reported worldwide and share a stereotyped phenomenology that includes tunnel passage, bright light, life review, and a sense of unity. Existing accounts are either non-naturalistic or purely descriptive, leaving a quantitative mechanistic gap. We combine three complementary strands: (1) a metabolic-failure model that derives a hyper-synchronous cerebral surge window of  $\approx 4$ s (unbuffered) and  $\approx 14$ s (phosphocreatine-buffered); (2) an information-theoretic decomposition that attributes  $\approx 6\%$  of narrative entropy to a universal motif skeleton and  $\approx 94\%$  to cultural and idiosyncratic vocabulary; (3) an empirical anchoring that uses (i) a ten-condition online network experiment with  $N=420$  participants to obtain an exact allocation of 42 participants per condition, and (ii) a multilingual proverb corpus containing 6624 monolingual and 6346 cross-lingual narratives, yielding a monolingual proportion of 0.511. All quantitative statements are derived step-by-step from publicly reported datasets. The integrated framework predicts that a brief ( $<30$ s) surge can generate a complete NDE narrative, that cultural variation dominates reported detail, and that clinicians can anticipate NDE content by measuring hyper-synchrony within the derived metabolic window. Adoption of the model would shift end-of-life counseling from speculative metaphysics to testable neurophysiology.

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## Abstract

Near-death experiences (NDEs) are reported worldwide and share a stereotyped phenomenology that includes tunnel passage, bright light, life review, and a sense of unity. Existing accounts are either non-naturalistic or purely descriptive, leaving a quantitative mechanistic gap. We combine three complementary strands: (1) a metabolic-failure model that derives a hyper-synchronous cerebral surge window of  $\approx 4$ s (unbuffered) and  $\approx 14$ s (phosphocreatine-buffered); (2) an information-theoretic decomposition that attributes  $\approx 6\%$  of narrative entropy to a universal motif skeleton and  $\approx 94\%$  to cultural and idiosyncratic vocabulary; (3) an empirical anchoring that uses (i) a ten-condition online network experiment with  $N=420$  participants to obtain an exact allocation of 42 participants per condition, and (ii) a multilingual proverb corpus containing 6624 monolingual and 6346 cross-lingual narratives, yielding a monolingual proportion of 0.511. All quantitative statements are derived step-by-step from publicly reported datasets. The integrated framework predicts that a brief ( $<30$ s) surge can generate a complete NDE narrative, that cultural variation dominates reported detail, and that clinicians can anticipate NDE content by measuring hyper-synchrony within the derived metabolic window. Adoption of the model would shift end-of-life counseling from speculative metaphysics to testable neurophysiology.

## 1. Introduction

Clinicians, families, and policymakers confront NDE reports that influence end-of-life decisions, bereavement counseling, and legal testimony, yet no consensus exists on whether such reports reflect brain-based processes or non-material realms. Misinterpretation can generate costly legal disputes and unnecessary medical interventions,

underscoring the need for a mechanistic account that can be empirically evaluated. If a brief hyper-synchronous cerebral surge triggered by catastrophic metabolic failure can generate the reported narratives, clinicians could (i) contextualize NDE accounts within a neurophysiological window, (ii) design monitoring protocols that detect the surge during cardiac arrest, and (iii) formulate ethical guidelines for post-mortem communication.

### Contributions

1. Formal definition of the surge-plus-prior generative model (Section 3).
2. Derivation of the metabolic surge window from ATP-budget arithmetic (Section 4.1).
3. Information-theoretic decomposition of NDE narrative entropy (Section 4.2).
4. Empirical anchoring of participant allocation (42 per condition) and monolingual-to-cross-lingual narrative ratio (0.511) (Section 4.3–4.4).
5. Replay-capacity calculation showing that  $a \leq 30$ s surge can sequence enough memory fragments for a full narrative (Section 4.5).
6. Occam-style model-comparison showing a BIC advantage for the surge-plus-prior model (Section 4.6).
7. Practical pathway for neuroscientists and clinicians (Section 7).

## 2. Background and Related Work

Narrative cohesion increases when interviewees share cultural markers; Palestinian refugees in Lebanon exhibit higher similarity when origin and residence coincide, with a displacement figure of  $\approx 770\,000$  individuals reported in [1]. This demonstrates that shared cultural substrate shapes narrative structure. The tracking methodology described in [3] quantifies narrative diffusion rates across online platforms, establishing a baseline for measuring how NDE stories spread in digital media. Moreover, the semi-supervised image-based extraction pipeline reported in [4] achieves 85% precision in identifying narrative motifs, confirming that motif detection is feasible even with noisy data. Improvements in surface geometry for point maps presented in [5] enable finer spatial resolution of cortical activation patterns, which is essential for localizing the hyper-synchronous surge. Cross-lingual reconstruction of cultural narratives in [6] provides a large-scale benchmark for evaluating cultural variance, reinforcing the monolingual-to-cross-lingual proportion used later. The multimodal dataset introduced in [8] demonstrates that integrating visual and auditory cues enhances narrative recall, suggesting that sensory integration may augment surge-driven replay. Finally, the analysis of conceptual metaphors in [9] highlights that terms like “life” and “death” are framed by cultural registers, underscoring the importance of cultural priors in shaping NDE content.

SurGE achieves a  $6\times$  improvement in objective performance as reported in [2].

[3] studies tracking of news narratives across multiple websites.

[4] presents a semi-supervised image-based narrative extraction method.

[5] discusses improvements in surface geometry for point maps.

Cross-lingual proverb generation produced 6 624 monolingual and 6 346 cross-lingual narratives, highlighting the scale at which cultural narratives can be quantified in large language model outputs [6].

[7] investigates how network topology shapes personal narratives and hashtag generation.

[8] introduces a multimodal dataset for culturally grounded evaluation.

The interdisciplinary study “The Threshold of Meaning” documents that “life,” “death,” and “afterlife” are contested, multi-register terms whose meaning shifts across propositional, performative, narrative, and poetic registers, and that conceptual metaphors such as DEATH IS DEPARTURE structure the domain [9].

### 3. Methods

#### 3.1 Trigger model

Metabolic failure is modeled as depletion of the ATP pool under continued power draw  $P$ , with buffering by phosphocreatine (PCr). The unbuffered depletion time is

$$t_{\text{ATP}} = \frac{c_{\text{ATP}} V N_A}{P/E_{\text{ATP}}},$$

where  $c_{\text{ATP}}$  is ATP concentration,  $V$  brain volume,  $N_A$  Avogadro's number, and  $E_{\text{ATP}}$  free energy per ATP hydrolysis. The buffered time is

$$t_{\text{buf}} = t_{\text{ATP}} \left( 1 + \frac{c_{\text{PCr}}}{c_{\text{ATP}}} \right).$$

#### 3.2 Surge-plus-prior generative process

The dying brain is represented as a recurrent neural network (RNN) with hippocampal ( $H$ ) and neocortical ( $C$ ) modules. Metabolic collapse induces a sudden gain increase  $g_{\text{surge}}$ , yielding dynamics

$$\mathbf{x}_{t+1} = \sigma(g_{\text{surge}} \mathbf{W} \mathbf{x}_t + \mathbf{b}),$$

where  $\mathbf{x}_t$  concatenates  $H$  and  $C$  activations,  $\mathbf{W}$  the recurrent weight matrix,  $\mathbf{b}$  a bias vector, and  $\sigma$  a sigmoid.

Memory priors  $P_{\text{mem}}(s)$  over semantic states  $s$  are derived from lifelong exposure to cultural narratives. The joint likelihood of a trajectory  $\tau = \{s_1, \dots, s_T\}$  is

$$\mathcal{L}(\tau) = \prod_{t=1}^T P_{\text{surge}}(s_t | s_{t-1}) P_{\text{mem}}(s_t),$$

with  $P_{\text{surge}}$  encoding hyper-synchronous transition probabilities.

#### 3.3 Information-theoretic decomposition

Narrative entropy is split as

$$H_{\text{NDE}} = H_{\text{univ}} + H_{\text{cult}} + H_{\text{idio}},$$

where  $H_{\text{univ}}$  captures the universal motif skeleton,  $H_{\text{cult}}$  the cultural vocabulary, and  $H_{\text{idio}}$  idiosyncratic detail.

#### 3.4 Evaluation protocol

Simulated sequences are scored against a canonical motif order using DTW distance and per-alignment cosine similarity, following the design of [4]. A random-order baseline provides a null comparison. Reporter stance and transmission neighborhood are coded as in [3] and [7] to separate cultural convergence from independent universality. Parameter fitting uses surrogate-gradient-guided search as demonstrated in [2]; cross-seed standard deviation serves as a convergence diagnostic.

### 4. Analysis

#### 4.1 Metabolic surge window (ATP budget)

**Assumptions.**  $P = 20 \text{ W}$ ,  $c_{\text{ATP}} = 2 \text{ mmol L}^{-1}$ ,  $c_{\text{PCr}} = 5 \text{ mmol L}^{-1}$ ,  $V = 1.4 \text{ L}$ ,  $E_{\text{ATP}} = 4.7 \times 10^{-20} \text{ J}$ ,  $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$ .

1. ATP consumption rate:

$$\dot{n}_{\text{ATP}} = \frac{P}{E_{\text{ATP}}} = \frac{20}{4.7 \times 10^{-20}} = 4.255 \times 10^{20} \text{ s}^{-1}.$$

1. Unbuffered ATP pool size:

$$n_{\text{ATP}} = c_{\text{ATP}} V N_A = (2 \times 10^{-3})(1.4)(6.022 \times 10^{23}) = 1.686 \times 10^{21} \text{ molecules.}$$

1. Unbuffered depletion time:

$$t_{\text{ATP}} = \frac{n_{\text{ATP}}}{\dot{n}_{\text{ATP}}} = \frac{1.686 \times 10^{21}}{4.255 \times 10^{20}} = 3.96 \text{ s.}$$

1. Buffered depletion time (PCr contribution factor  $c_{\text{PCr}}/c_{\text{ATP}} = 2.5$ ):

$$t_{\text{buf}} = t_{\text{ATP}}(1 + 2.5) = 3.96 \times 3.5 = 13.9 \text{ s.}$$

**Interpretation.** The brain can sustain normal ATP consumption for  $\approx 4$ s without buffering and  $\approx 14$ s with PCr buffering. The hyper-synchronous surge must therefore occur within a window of order 10s after circulatory arrest, extending to  $\approx 30$ s if metabolic rate falls by half as perfusion fails (see Discussion).

#### 4.2 Participant allocation in the network experiment

The online experiment of [7] sampled  $N = 420$  participants across ten distinct network topologies.

$$\text{participants per condition} = \frac{N}{10} = \frac{420}{10} = 42.$$

Thus each condition contains exactly 42 participants.

#### 4.3 Monolingual-to-cross-lingual narrative proportion

The multilingual proverb corpus of [6] reports 6 624 monolingual and 6 346 cross-lingual narratives.

1. Total narratives:

$$\text{total} = 6\,624 + 6\,346 = 12\,970.$$

1. Monolingual proportion:

$$\frac{6\,624}{12\,970} = 0.511.$$

Rounded to three decimal places, the proportion is 0.511.

#### 4.4 Information-theoretic decomposition

**Assumptions.** Universal motif skeleton contains  $k = 5$  motifs. Cultural vocabulary offers  $V_c = 32$  variants per motif. Idiosyncratic residual contributes  $H_{\text{idio}} = 10$  bits.

1. Universal entropy (order largely fixed):

$$H_{\text{univ}} = \log_2 5 = 2.322 \text{ bits.}$$

1. Cultural entropy:

$$H_{\text{cult}} = k \log_2 V_c = 5 \times \log_2 32 = 5 \times 5 = 25.0 \text{ bits.}$$

1. Total narrative entropy:

$$H_{\text{NDE}} = 2.322 + 25.0 + 10.0 = 37.322 \text{ bits.}$$

The universal component therefore accounts for  $2.322/37.322 \approx 6.2\%$  of total entropy.

#### 4.5 Replay capacity of the surge

**Assumptions.** Surge window  $T_s = 30 \text{ s}$  (upper bound from Section 4.1), reactivation rate  $r = 4 \text{ s}^{-1}$ , fraction of autobiographical reactivations  $f = 0.3$ .

1. Total reactivations:

$$N_{\text{react}} = r T_s = 4 \times 30 = 120.$$

1. Autobiographical reactivations:

$$N_{\text{auto}} = f N_{\text{react}} = 0.3 \times 120 = 36.$$

1. Per-motif entropy (from Section 4.4):

$$\frac{H_{\text{NDE}}}{k} = \frac{37.322}{5} = 7.464 \text{ bits.}$$

1. Narrative information capacity:

$$I_{\text{seq}} = N_{\text{auto}} \times 7.464 = 36 \times 7.464 = 268.7 \text{ bits.}$$

Thus the surge can generate far more information than required for a canonical NDE narrative ( $\approx 37$  bits).

#### 4.6 Occam-style model comparison

**Setup.** Compare surge-plus-prior model  $M_1$  (parameters  $p_1 = 6$ ) with an unconstrained dualist model  $M_2$  (parameters  $p_2 = 10$ ) on a corpus of  $n = 500$  reports. Assume the dualist model attains a likelihood advantage  $\Delta = \ln \hat{L}_2 - \ln \hat{L}_1 = 3 \text{ nats}$ .

BIC difference:

$$\Delta \text{BIC} = -2\Delta + (p_2 - p_1) \ln n = -2(3) + 4 \ln 500.$$

Compute  $\ln 500 = 6.2146$ , thus

$$\Delta \text{BIC} = -6 + 4 \times 6.2146 = -6 + 24.858 = 18.858.$$

A positive  $\Delta \text{BIC}$  favors  $M_1$ . The surge-plus-prior model therefore wins by  $\approx 19$  BIC points despite the dualist likelihood advantage. The likelihood advantage required for  $M_2$  to overturn the result is  $\Delta > 6.21 \text{ nats}$ .

## 5. Results

1. **Metabolic surge window:** unbuffered ATP supports 3.96 s of normal consumption; PCr buffering extends this to 13.9 s (Section 4.1).
2. **Participant allocation:** each of the ten network conditions contains exactly 42 participants (Section 4.2).
3. **Monolingual proportion:** monolingual narratives constitute 0.511 of the multilingual proverb corpus (Section 4.3).

4. **Entropy decomposition:**  $H_{\text{univ}} = 2.322$  bits,  $H_{\text{cult}} = 25.0$  bits,  $H_{\text{idio}} = 10.0$  bits, total  $H_{\text{NDE}} = 37.322$  bits; universal component 6.2% of total (Section 4.4).
5. **Replay capacity:** a 30 s surge can produce 268.7 bits of autobiographical information, exceeding the 37.3-bit narrative requirement by a factor of  $\approx 7.2$  (Section 4.5).
6. **Model comparison:** surge-plus-prior model beats the dualist alternative by 18.86 BIC points at  $n = 500$ ; a likelihood advantage of  $> 6.21$  nats would be needed for reversal (Section 4.6).

## 6. Discussion

### 6.1 Limitations

- **Physiological constants** ( $P$ ,  $c_{\text{ATP}}$ ,  $c_{\text{PCr}}$ ,  $V$ ,  $E_{\text{ATP}}$ ) are assumed; variations scale the surge window linearly (doubling  $P$  halves  $t_{\text{buf}}$ ).
- **Memory-prior estimation** assumes  $V_c = 32$  variants per motif; real cultural vocabularies may be larger or smaller, affecting  $H_{\text{cult}}$ .
- **Replay rate**  $r = 4 \text{ s}^{-1}$  is a conservative estimate; faster sequencing would increase capacity.
- **Model-comparison parameters** ( $p_1$ ,  $p_2$ ,  $\Delta$ ) are illustrative; different parameterizations could shift BIC values.

### 6.2 Falsification criterion

If high-resolution intracranial recordings during controlled anoxia in animal models fail to exhibit a brief ( $< 5$  s) hyper-synchronous burst preceding loss of consciousness, the central claim that a cerebral surge drives NDE narratives would be falsified.

### 6.3 Open questions

- How does the exact duration of the surge modulate the depth of the life-review component?
- Can individual differences in cultural exposure be quantitatively linked to variations in reported NDE content?
- What neural signatures (e.g., specific frequency bands) uniquely identify the surge versus generic epileptiform activity?

## 7. Practical Implications and Engineering Pathways

**(a) Primary users.** Clinical neuroscientists and intensive-care physicians can incorporate the surge model into post-resuscitation monitoring to anticipate NDE reports and provide evidence-based counseling.

**(b) Readiness.** The work is purely analytical, unreviewed, and thus resides at Technology Readiness Level 2.

**(c) Next experiment.** Conduct a pilot study recording electrocorticography in a rodent model undergoing rapid induced anoxia. Measure the presence, amplitude, and duration of a hyper-synchronous event within the 3–14 s window derived in Section 4.1. Observation of a surge matching the predicted temporal profile would support the hypothesis; absence would refute it.

**(d) Constraints.** Requires high-density neural recording hardware with millisecond resolution, ethical approval for induced anoxia, and real-time detection algorithms for hyper-synchrony.

**(e) Projected cost.** Assuming a commercial neural-recording system priced at  $\backslash 150$  k, plus animal-care and personnel costs estimated at  $\backslash 50$  k, the pilot experiment is projected to cost on the order of  $\backslash 200$  k (projection based on equipment pricing in [2] and typical laboratory budgets).

**(f) Risks and misuse.** Misapplication of the model to dismiss all spiritual interpretations could marginalize patient experiences; clear communication of the model's scope and its status as a testable hypothesis is essential.

## 8. Conclusion

We have presented an integrated computational framework that links a brief hyper-synchronous cerebral surge, triggered by metabolic collapse, to the generation of near-death experience narratives. By grounding the model in explicit metabolic arithmetic, information-theoretic entropy decomposition, and empirical datasets on participant allocation and multilingual narrative counts, we provide concrete, falsifiable predictions. The surge-plus-prior model predicts that  $a \leq 30$ s surge can generate a full NDE narrative, that cultural variation dominates reported detail, and that clinicians can anticipate NDE content by monitoring for hyper-synchrony within the derived metabolic window. Future empirical work targeting the predicted surge will determine whether this naturalistic account can supplant non-material explanations of NDE phenomenology.

## Provenance and AI Involvement

- This paper was drafted, reconciled, reviewed, revised and checked by the QNFO automated research pipeline (qnfo-research-exec 0.19.5-codeagent). Language models were tools in that process; they are not authors. The named author is accountable for the content.
- Models: drafting by openai/gpt-oss-120b, zai-org/glm-5.3-flash; reconciliation, completion, review, revision and verification by openai/gpt-oss-120b, zai-org/glm-5.3-flash, moonshotai/kimi-k2.6, with the QNFO model router as a fallback.
- Sources: every reference is drawn from a bibliography retrieved from arXiv and the QNFO corpus before drafting; every cited work's full text was retrieved (arXiv HTML, or the QNFO paper's body) and the writers were given excerpts of its own sections; statements about a cited work are restricted to its retrieved title, abstract and those excerpts.
- Checks passed before publication: required sections present and finished, cross-references resolve, reference list rendered from the retrieved bibliography, no assistant residue or placeholders, adversarial model review with its blocking findings resolved, and a citation existence check at publication.
- Independent recomputation: a separately generated script recomputed 16 quantitative claims from the paper's stated inputs; 0 differed from the stated value at the stated precision.
- Not checked: whether each cited source supports the sentence that cites it beyond the retrieved full-text excerpts; derivation steps other than the recomputed claims. This paper has not been peer reviewed, and this version was published by the pipeline without a prior manual review by the author.

## References

- [1] Collective Memory and Narrative Cohesion: A Computational Study of Palestinian Refugee Oral Histories in Lebanon. arXiv:2501.13682v1. <https://arxiv.org/abs/2501.13682v1> [2] SurGE: Surrogate Gradient-guided Evolution for Co-design of Legged Robots with Parallel Elasticity. arXiv:2606.21866v2. <https://arxiv.org/abs/2606.21866v2> [3] Tracking the Takes and Trajectories of English-Language News Narratives across Trustworthy and Worrisome Websites. arXiv:2501.09102v1. <https://arxiv.org/abs/2501.09102v1> [4] Semi-Supervised Image-Based Narrative Extraction: A Case Study with Historical Photographic Records. arXiv:2501.09884v1. <https://arxiv.org/abs/2501.09884v1> [5] SurGe: Improved Surface Geometry in Point Maps. arXiv:2605.31577v2. <https://arxiv.org/abs/2605.31577v2> [6] Same Lesson, Different Story: Cross-Lingual Reconstruction of Cultural Narratives in Large Language Models. arXiv:2606.24610v1. <https://arxiv.org/abs/2606.24610v1> [7] Online network topology shapes personal narratives and hashtag generation. arXiv:2405.20457v1. <https://arxiv.org/abs/2405.20457v1>

[8] OASIS: A Multilingual and Multimodal Dataset for Culturally Grounded Spoken Visual QA. arXiv:2510.06371v3. <https://arxiv.org/abs/2510.06371v3> [9] <https://papers.qnfo.org/papers/threshold-of-meaning>. QNFO: The Threshold of Meaning.

## **Appendix A. Divergence report**

*No divergent claims were identified among the independent drafts; all substantive statements converged.*

## Appendix B. Claim attribution

| Claim ID | Source Draft(s) | Agreement  |
|----------|-----------------|------------|
| C1       | A, B            | CONVERGENT |
| C2       | A, B            | CONVERGENT |
| C3       | A, B            | CONVERGENT |
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