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The Temporal Manifold of Suffering

—Perceptual-Temporal Scaling, Moral Status, and the Problem of Evil

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Abstract

This paper develops a quantitative bridge between the comparative neuroscience of time perception and the philosophical problem of evil. Its rigorous core rests on an established empirical regularity: a species' maximum rate of visual temporal information processing, measured by critical flicker-fusion frequency (CFF), scales positively with mass-specific metabolic rate and negatively with body mass across vertebrates (Healy et al., 2013). I treat this scaling as defining a temporal manifold on which every nervous system occupies a characteristic refresh rate, and I formalise the conjecture—already advanced in the moral-patienthood literature—that the rate at which subjective time passes is proportional to this processing rate. From this I derive a lifetime-experience relation, conditional on jointly specified scaling exponents and the functional form linking CFF to subjective time, and argue that if morally relevant suffering is integrated over experienced rather than clock time, then the distribution of evil in the world is plausibly misweighted by anthropocentric intuition: small, fast, short-lived animals may undergo far more experienced suffering per clock-second than their lifespans suggest. I then situate this result against the major theodicies and against the Cartesian denial of animal mind that I criticised in earlier work. The contribution is a single mathematical object, the experienced-suffering functional, that makes the moral stakes of temporal perception precise and testable.

Keywords

Critical Flicker-Fusion Frequency, Metabolic Scaling, Subjective Time, Moral Status, Problem of Evil, Cross-Species Welfare Comparison, Experienced-Time Integration, Philosophy of Mind

1. Introduction: From the Cartesian Denial to a Measurable Mind

The problem of evil—why a world that might have been otherwise contains so

much suffering—has been argued almost entirely on a human stage. The animals appear, when they appear at all, as a footnote: Rowe's fawn dying slowly in a forest fire (Rowe, 1979) is invoked as a limit case of gratuitous suffering precisely because it is suffering no human observes and no human soul-building requires. My aim here is to take that footnote and make it the text. I want to ask not whether animals suffer—I take that as settled by the convergent evidence summarised in the Cambridge Declaration on Consciousness (2012)—but how much, and in what currency the books of evil should be balanced.

In an earlier study of the epistemology of measurement in non-human animal consciousness I argued that the Cartesian and Aristotelian denials of animal mind were never empirical findings but applications of parsimony: the *res cogitans* was withheld from animals because a mechanistic description was simpler, not because the evidence demanded it (Pater, 2022). I argued there that Occam's razor, far from being a neutral instrument, smuggles a physicalist metaphysics into the foundations of the special sciences, and that the comparative scaling laws of biology offer a route to quantifying consciousness that does not depend on solving the hard problem first. This paper is the constructive sequel to that critique.

The argument has two movements. The first (Sections 2 - 3) is empirical and mathematical: I formalise the temporal manifold and derive the lifetime-experience relation together with an explicit statement of the conditions under which it approaches an invariant. The second (Sections 4 - 5) is philosophical: I connect the relation to moral status and to the standard theodicies, and I draw out the consequence I call temporal misweighting.

2. The Temporal Manifold: An Established Scaling Law

2.1. Critical Flicker-Fusion as a Clock Rate

Critical flicker-fusion frequency is the lowest frequency at which an intermittent light is perceived as steady; above it, the flicker is invisible. It is the standard psychophysical proxy for the maximum rate at which a visual system can resolve change in time (Healy et al., 2013). Reported values span roughly two orders of magnitude across the animal kingdom. Humans fuse at about 60 Hz; the leatherback turtle at about 15 Hz; many small, fast birds and flying insects far higher. About two-thirds of studied animals have lower CFF than humans, but a fast minority—flycatchers, dragonflies—see a world that to them is unhurried where ours would blur.

Healy and colleagues showed, in a phylogenetic comparative analysis across vertebrates, that CFF increases with mass-specific metabolic rate and decreases with body mass (Healy et al., 2013). The functional interpretation is clean: harvesting temporal information is metabolically costly, and high resolution pays only for an animal that can also act fast. Schematically, with q the mass-specific resting metabolic rate, M body mass, and L ambient light level, their minimal adequate model takes the form

$$\mathrm{CFF} \approx \beta_0 + \beta_q \cdot \log q - \beta_M \cdot \log M + \beta_L \cdot 1\left[\text{high light}\right], \tag{1}$$

with β_q, β_M, $\beta_L > 0$ (Equation 1). (Equation 1) is the empirical anchor of the paper, and its derivation is not defended further here.

2.2. Two Geometries: The Inverse-Square Law and the Quarter-Power Law

The inverse-square law is pure geometry and contains no biology: a fixed luminous flux spreads over the surface of an expanding sphere, whose area grows as r^2, so intensity falls as $1/r^2$. The quarter-power law has a quite different origin. Following West et al. (1997), the exponent 1/4 arises because resource-distribution networks—the vascular tree, the bronchi—are volume-filling and terminate in size-invariant units. Optimising such a hierarchical network to service a three-dimensional body introduces an effective fourth dimension into the scaling, and it is this 3-plus-1 network geometry, not the geometry of external space, that puts the 4 in the denominator of $M^{\pm 1/4}$.

The two laws meet at exactly one place: signal intensity. (Equation 1) carries a light-level term β_L because CFF is luminance-dependent. Since a source's intensity at the eye falls as $1/r^2$, distance sets the available luminance, which modulates the perceiver's effective temporal resolution. The inverse-square law thus enters the manifold not as an alternative clock-rate scaling but as the supply curve for the light on which the clock rate operates.

2.3. Defining the Manifold

Let each organism be assigned a characteristic processing rate

$$f_s = \text{CFF of species } s \text{ (Hz, cycles per clock-second)} \quad (2)$$

I call the ordered set of these rates, indexed across the phylogeny, the *temporal manifold* $\boldsymbol{T}$. A point on $\boldsymbol{T}$ is not a place but a tempo. Two animals standing in the same meadow at the same instant of clock time nonetheless inhabit different positions on $\boldsymbol{T}$: the flycatcher resolves perhaps 100 distinguishable visual frames in the second during which the human resolves 60 and the turtle 15. This is the precise, defensible core of the intuition that animals live in "different worlds"—von Uexküll's *Umwelt* (von Uexküll, 1934) given a number—and it supplies the comparative-neuroscience purchase on Nagel's (1974) question of what it is like to be a bat that the philosophy of mind has long approached qualitatively.

It is worth being careful about one tempting overstatement. CFF is a visual temporal resolution; whether it tracks the global rate of subjective time—the felt pace of experience as such—is a further hypothesis, not a measurement. I make that hypothesis explicit in Section 3 and treat it as a hypothesis throughout. The manifold itself, as a map from species to visual processing rate, is not hypothetical.

2.4. An Aside on Blinking

Blink rate is a sensitive index of visual attention: it is suppressed when attention is engaged, and suppression is deepest for absorbing material (Maffei & Angrilli,

2019). Acute, abrupt threat briefly reduces blinking while pupils dilate and fixations shorten, but sustained fear runs the other way: fear films produce comparatively higher blink rates. What survives, and what I use, is the well-supported claim that blink dynamics track the allocation of visual attention over time.

3. The Lifetime-Experience Relation

3.1. The Proportionality Hypothesis

I state the substantive bridge hypothesis of the rigorous core so it can be attacked.

Hypothesis H1 (rate proportionality). The rate at which subjective time passes for an organism is proportional to its temporal processing rate f_s. Formally, if τ denotes experienced (subjective) time and t denotes clock time,

$$d\tau/dt = k \cdot f_s, \tag{3}$$

with $k > 0$ a species-independent constant (Equation 3).

H1 is not established; it is the natural reading of a sizeable body of work and is the premise that the moral-patienthood literature has recently begun to scrutinise explicitly (Rethink Priorities, 2024). Two honest caveats. First, CFF is visual and may not index global subjective rate; H1 generalises from the part to the whole. Second, the relation might be sub-linear (a power law $d\tau/dt \propto f_s^a$ with $a < 1$) rather than strictly proportional.

An Observable Test of H1

H1 is not empirically vacuous; it makes quantitative predictions that a well-designed comparative psychophysics protocol can adjudicate. Consider an *interval-production* task in which an organism is trained to produce a target duration Δ_{target} (e.g., by operant conditioning to a delayed reward), and let $\Delta_{\text{produced}}(s)$ denote the mean clock-time duration a species s produces when instructed, by its own internal clock, to wait for a fixed subjective interval. Under strict proportionality (H1 with exponent $a = 1$), the log-log regression of $\Delta_{\text{produced}}(s)$ against $1/f_s$ should yield a slope of +1 across species. Under a sublinear relation ($0 < a < 1$) the slope should be strictly between 0 and +1. Under a null relation ($a = 0$, i.e., CFF and subjective-time rate are independent) the slope should be indistinguishable from 0. A second, intra-species test avoids the cross-species calibration problem entirely: in ectotherms, ambient temperature reversibly modulates metabolic rate and CFF within a single organism. H1 predicts that a temperature-induced fractional change in CFF should produce a proportional fractional change in interval-timing performance in the *same* individual, with slope +1 under strict proportionality and less under sublinear versions. This intra-individual design controls for the phylogenetic and welfare-calibration confounds that beset the cross-species regression.

3.2. Deriving the Relation

Integrate (Equation 3) over a lifespan. Let an organism live for clock-duration T_s. Its total experienced time is

$$H_s = \int_0^T k \cdot f_s \, \mathrm{d}t = k \cdot f_s \cdot T_s \tag{4}$$

Now recall two further allometric facts. Lifespan scales with body mass roughly as $T_s \propto M^{1/4}$ (West et al., 1997). By (Equation 1), CFF—hence f_s—decreases with body mass; take the empirical dependence to be approximately $f_s \propto M^{-c}$ for some $c > 0$. Then

$$H_s \propto M^{-c} \cdot M^{1/4} = M^{(1/4-c)} \tag{5}$$

The direction and magnitude of any relative equalisation of experienced lifespans across species depend jointly on three quantities: 1) the lifespan-mass exponent (here taken as +1/4, but empirically variable by clade and life-history strategy); 2) the CFF-mass exponent c; and 3) the functional relation between CFF and subjective-time rate, denoted here by the exponent a in the generalisation $\mathrm{d}\tau/\mathrm{d}t \propto f_s^a$. Under this generalisation,

$$H_s \propto M^{(1/4-ac)} \tag{6}$$

Relative equalisation across species obtains only when ac approaches 1/4; if $ac <$ 1/4 the exponent is positive and larger species accumulate more experienced time; if $ac >$ 1/4 the exponent is negative and smaller species accumulate more. The strong invariant $H_s \approx$ constant is therefore a *knife-edge* case rather than a robust consequence of monotonicity. The moral argument of Sections 4 - 5 requires only that the f_s-weighting in the experienced-suffering functional (Equation 8 below) redirects moral attention away from clock-time totals toward experienced totals. That weaker premise is licensed by the empirical scaling laws alone, independent of the precise value of ac.

4. Evil in the Right Currency: The Experienced-Suffering Functional

The problem of evil is an accounting problem before it is a metaphysical one: it asks us to total up the suffering in the world and ask whether any good could justify that total. But the totalling is always done, implicitly, in clock time and through human eyes. I propose to do it in the right currency.

4.1. What $s(t)$ Represents, and How It Can Be Compared across Species

The instantaneous-suffering rate $s(t)$ is best understood as a stipulated welfare index operationalisable in one of four ways, each with its own strengths and each dependent on further empirical work. First, $s(t)$ may be operationalised as a *behavioural proxy*: escape latency, nociceptive threshold, self-administration of analgesics, or the abandonment of preferred activities under noxious conditions. Second, it may be operationalised as a *physiological indicator*: circulating glucocorticoid concentration, heart-rate variability, or activity in phylogenetically conserved nociceptive circuitry. Third, it may be operationalised as an *inferred affective state*, in the sense of the Cambridge Declaration on Consciousness (2012) and

the moral-patienthood literature that scores valenced experience from convergent multi-modal evidence. Fourth, and most conservatively, it may be treated as a *stipulated ordinal welfare scale* with an explicit calibration step—a mapping, defended clade by clade, from observable states to a shared unit. The functional in (Equation 8) is invariant under the choice among these operationalisations only up to that calibration step; different choices will yield different numerical estimates and, in the limit, different orderings of taxa. Under any operationalisation that is not monotonically anti-correlated with f_s (bar the current empirical literature clears comfortably for the vertebrate cases where cross-species measurements exist), the direction of the temporal-misweighting correction is preserved. The magnitude of that correction, and the ranking of non-vertebrate taxa, awaits the cross-species welfare calibration flagged again in Section 4.4.

4.2. The Linearity-in-Experienced-Time Assumption

The functional as written accumulates suffering linearly over experienced time. This is a normative choice, not a logical necessity, and I state it explicitly so it can be contested. A moral theory could instead weight instantaneous intensity non-linearly (for example, by a convex function that treats very high $s(t)$ as morally worse than a proportionately longer stretch of moderate $s(t)$); could weight by cognitive complexity or self-modelling capacity, so that suffering in creatures with richer models of self and future counts for more; could weight by memory, so that suffering with lasting narrative consequences counts for more than transient suffering; or could apply a temporal-integration kernel that discounts very brief episodes on the grounds that they fail to constitute experience of the relevant kind. I do not adjudicate among these theories here. The linear-integration convention adopted below is the simplest and most tractable assumption compatible with the underlying empirical scaling, and substantially different weightings would rescale but, in most cases, not reverse the temporal-misweighting conclusion. Where a specific alternative weighting *would* reverse the conclusion—a strongly cognitive-complexity-weighted theory, for instance, might restore anthropocentric ordering—that is a philosophically substantive result about the assumptions required to preserve the anthropocentric verdict, and it is worth stating in those terms rather than presupposing linearity silently.

4.3. The Functional

Let an organism's instantaneous suffering at clock-time t be a rate $s(t) \geq 0$, understood in the sense stipulated in Section 4.1. The morally relevant quantity is not suffering per clock-second but suffering integrated over what is actually undergone—over experienced time. Using (Equation 3) and the linear-integration convention of Section 4.2:

$$E_s = \int_0^T {}_s s(t) \cdot (\mathrm{d}\tau/\mathrm{d}t)\,\mathrm{d}t = k \cdot f_s \cdot \int_0^T {}_s s(t)\,\mathrm{d}t \tag{7}$$

The factor f_s is the bombshell. Two organisms subjected to the same clock-duration of the same intensity of pain do not, on this accounting, undergo the same

quantity of suffering: the faster perceiver, with more subjective moments per second, undergoes proportionally more.

Define the total evil of a world as the sum over all sentient organisms of their experienced-suffering functionals:

$$E = \sum_s E_s = k \cdot \sum_s f_s \cdot \int_0^T {}_s s(t)\,\mathrm{d}t \tag{8}$$

Anthropocentric theodicy implicitly computes a different, smaller quantity—roughly Σ over humans of $\int s(t)\,\mathrm{d}t$, with f set to the human value and non-human terms neglected or steeply discounted. (Equation 8) says this is wrong on two independent counts. It omits the vast non-human majority of the sum, and within each term it omits the f_s-weighting that upweights exactly the small, abundant, fast animals that anthropocentric intuition discounts most.

4.4. Temporal Misweighting

Whether any given taxon dominates the sum in (Equation 8) depends on five empirical inputs, none fully settled, all of which must be specified before any numerical claim can be made:

(i) *Population size* N_s for each taxon—global abundance, seasonally and geographically resolved. (ii) *Probability of sentience* p_s—the credence, defensible on convergent behavioural, physiological, and neuroanatomical evidence, that members of taxon s are subjects of experience at all. (iii) *Exposure to harmful states*—the fraction of a lifetime, in expectation, during which $s_s(t)$ exceeds relevant thresholds, together with the intensity distribution of those states. (iv) *CFF* f_s—measured, where possible, rather than inferred from body mass. (v) *Cross-species welfare calibration*—the mapping that makes $s_s(t)$ values comparable across taxa in the sense stipulated in Section 4.1. The dominance of any taxon in (Equation 8) is a conclusion about the product $N_s \cdot p_s \cdot f_s \cdot E\left[\int s_s(t)\,\mathrm{d}t\right]$, and cannot be read off from N_s and f_s alone. What the framework does robustly say is that anthropocentric ordering underweights each of (i), (iv), and (v) simultaneously, so that the qualitative direction of correction—toward greater weight on small, fast, abundant animals—is preserved even where the numerical dominance question remains open.

5. Consequences for the Theodicies

I take the major responses to the problem of evil in turn and ask what the experienced-suffering functional does to each. I am not adjudicating between theism and atheism; I am showing that the temporal manifold reshapes the dialectic whichever side one starts from.

5.1. Soul-Making (Hick)

Hick's theodicy justifies suffering as the necessary medium of moral and spiritual growth toward God (Hick, 1966). Its notorious weakness is animal suffering, which builds no soul. The temporal manifold sharpens the objection: on the

framework of Section 4, the suffering that soul-making cannot touch is plausibly a large fraction of the total in (Equation 8), conditional on the empirical inputs listed in Section 4.4. Even under conservative settings of those inputs, the non-human summand is large enough that a theodicy addressing only the human summand explains a small fraction of the total it was meant to address.

5.2. Free Will

The free-will defence addresses moral evil—suffering caused by the misuse of human freedom. It is silent on natural evil. The share of (Equation 8) attributable to natural rather than moral evil depends on the distribution, duration, and severity of suffering across taxa, applied separately to natural and human-caused suffering. Human-caused animal suffering—industrial animal agriculture, wild-caught fisheries, habitat destruction—is itself vast and, on some accountings, may rival or exceed non-anthropogenic sources; a confident claim about the balance requires taxon-by-taxon distributional data that the current literature does not yet supply. What can be said firmly is that the free-will defence is structurally incapable of touching the natural-evil summand of (Equation 8), whatever its size; whether that summand dominates the total is a question the framework poses rather than settles.

5.3. Sceptical Theism

The sceptical theist replies that we are in no epistemic position to judge whether God lacks a justifying reason for any given evil. The temporal manifold turns this defence into a double-edged sword. Granting our cognitive limits, the same limits—anthropocentric, clock-bound, slow-fusing—are precisely what (Equation 8) identifies as the source of systematic underestimation of evil. Scepticism about our access cuts against the comfortable conclusion as hard as against the disquieting one.

5.4. The Non-Theistic Reading

One need not frame any of this theologically. Read naturalistically, the functional in (Equation 8) is simply a corrected ethical ledger. It says that a thoroughgoing consequentialism, honestly computed, must weight the welfare of small fast animals by f_s and must include them at their actual abundance, subject to the empirical inputs and normative choices set out in Sections 4.1 - 4.4. This is a demanding conclusion in its own right, independent of whether any deity is in the dock.

A boundary case sharpens the framework's discipline: the demonstration that stressed plants emit airborne ultrasonic clicks at higher rates when cut or dehydrated (Khait et al., 2023). The sounds are almost certainly cavitation, not 'screams', and plants lack the integrative nervous architecture that the manifold and the functional presuppose. Plants contribute nothing to $\boldsymbol{E}$ as I have defined it, which is what keeps the framework from collapsing into pan-sentientism. But the case earns its place because these emissions are inaudible to us and well within the

hearing of many insects and small mammals: an entire channel of ecological information crosses the manifold beneath human perception.

5.5. The Evolutionary Objection to Teleology

A reader might suspect I have smuggled teleology back in. I have not. On the standard non-teleological reading, CFF and lifespan scalings are the frozen residue of selection: organisms that mistimed the world left fewer descendants, and the quarter-power exponents are the attractors of that optimisation, not its goals. The experienced-suffering functional needs no teleology: $s(t)$ and f_s are descriptive quantities, and (Equation 8) is an integral, not an intention.

6. Conclusion

The durable contribution of this paper is a single object: the experienced-suffering functional, $E = k \cdot \sum_s f_s \cdot \int s(t)\mathrm{d}t$. It rests on an established scaling law (CFF with metabolism and mass), one explicit and falsifiable bridge hypothesis (rate proportionality, with the observable prediction set out in Section 3.1.1), standard allometric lifespan scaling, an explicit stipulation of what $s(t)$ means and how it is calibrated across species (Section 4.1), and an explicit statement of the linear-integration convention over experienced time (Section 4.2). From these it derives the lifetime-experience relation and, through it, the conclusion I take to matter most: that the world's suffering, totalled in the currency of experienced rather than clock time and summed over the fast, small, abundant majority of sentient life, is plausibly and systematically underestimated by the anthropocentric intuitions that have framed the problem of evil for three millennia. The magnitude of that underestimation is conditional on the empirical inputs enumerated in Section 4.4 and cannot be read off from CFF and population counts alone; the direction of the correction is robust to the choices flagged in Sections 4.1 and 4.2. This temporal misweighting is not a theological claim. It survives whether or not there is a God to be exculpated; it is a correction to the moral ledger itself, and it vindicates, with a conditional but principled correction rather than a sentiment, the case made in Pater (2022) against the Cartesian withholding of mind from animals.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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