

Sensorial Performance Score: A Property-Resolution Framework for Measuring How Built and Ecological Environments Shape Human Performance

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Status note. This is a *framework and position* paper. It proposes a measurement instrument and its evidence basis, and it pre-specifies a validation program. It does **not** report validated outcomes, and the Sensorial Performance Score is **not** a medical or diagnostic device. Environmental health relationships cited here are, with few exceptions, *associations* from observational and short-term experimental studies; they are described as such throughout.

Abstract

Environmental epidemiology has established that features of the places people live — greenness, light, noise, air, temperature, biodiversity — are associated with measurable differences in sleep, cardiovascular function, cognition, stress physiology, and mortality. Yet a structural asymmetry limits the field: human biology is increasingly measured at individual resolution (wearables, biobanks), while environmental *exposure* is typically assigned at neighborhood-to-metropolitan scale, introducing substantial misclassification. We propose the **Sensorial Performance Score**, a framework that characterizes a single property's environment across six channels — five evidence-mapped (**Air, Light, Noise, Thermal, Nature**) plus a candidate **Microbiome** channel under investigation — at the resolution of the dwelling itself, and that is designed to be paired longitudinally with the same occupants' biological markers. Critically, the environmental half of the instrument is already operating: a live property-resolution reading system and a design-build practice that generates dated, field-measured interventions. The contribution here is the method for pairing that operating environmental record with human biology, and a pre-registered test. We describe the channel definitions and their supporting literature, a source-agnostic scoring method that does not require in-dwelling sensors for every property, and a pre-registered within-person (aggregated n-of-1) validation program in which dated environmental interventions are tested against continuously measured human outcomes. Sensorial Performance is offered as an open

instrument: a structured way to ask, for a given property and a given person, whether improving the environment measurably improves the body that lives in it.

Keywords: exposome; environmental health; greenspace; circadian; soundscape; built environment; sensory ecology; n-of-1; property-resolution exposure.

1. Introduction: the exposure-resolution problem

The case that environment shapes human function is, in its broad strokes, well supported. Residential greenness is associated with lower all-cause mortality in pooled longitudinal data (Rojas-Rueda et al., 2019). Evening light exposure suppresses melatonin and degrades sleep and next-morning alertness under controlled conditions (Chang et al., 2015; Cajochen et al., 2022), while morning bright light advances circadian phase and improves mood (Crowley & Eastman, 2015). Road-traffic noise is associated with ischemic heart disease in WHO-grade systematic review (WHO, 2018; Münzel et al., 2018). Elevated indoor CO₂ and particulate matter measurably slow cognitive performance, and reducing indoor PM_{2.5} via filtration lowers blood pressure in a randomized crossover trial (Allen et al., 2016; Brugge et al., 2025). Natural soundscapes reduce stress and improve affect in meta-analysis (Buxton et al., 2021). Time in nature is associated with self-reported health and well-being above a threshold dose (White et al., 2019), and acute nature exposure reduces rumination with corresponding changes in prefrontal activity (Bratman et al., 2015) — building on the founding observation that a natural hospital-window view accompanied faster surgical recovery (Ulrich, 1984).

What the field lacks is not evidence that environment matters, but *resolution*. The exposome literature explicitly identifies an asymmetry: internal biological state is measured at high individual resolution, while external environmental exposure is assigned coarsely and inferred rather than measured (the asymmetry framed across exposome reviews; Snyder-lab personal-exposome work shows two people in the same neighborhood carry sharply different real exposures — Jiang et al., 2018). Greenspace exposure assigned from satellite indices at the neighborhood scale carries documented misclassification on the order of tens of percent (Jimenez et al., 2022). The strongest "before-and-after" intervention evidence — greening of vacant urban lots improving residents' mental health (South et al., 2018) — is neighborhood-clustered and self-reported.

Sensorial Performance is a response to this resolution problem. It characterizes the environment at the scale at which people actually live — the **property and the dwelling** — and it is built to be joined to the *same person's* continuously measured biology over time. The unit of analysis is not a census tract but a parcel and an occupant.

1.1 An operating instrument, not a proposal

Sensorial Performance is not introduced here in the abstract; its environmental half already runs. Two existing systems supply it:

1. **A live property-resolution reading instrument.** Any U.S. address resolves, on the spot, to a parcel-scale environmental reading drawn from public datasets — soil survey (USDA), terrain and hydrography (USGS), climate (NOAA / Open-Meteo), flood exposure (FEMA), and observed biodiversity (iNaturalist) — and renders per-channel values immediately. This is the "estimated, no-hardware" path of §3, operating today across thousands of properties.

1. **A design-build practice that changes properties.** The author's firm does not merely observe sites; it alters them, and records the alteration. Each project — a residential bioswale retrofit (Alamo Heights, 2024), a hand-cast 28-foot concrete water feature, fountains and biochar soil work at a transitional-housing village — is a **dated environmental intervention with field measurement** (infiltration, soil organic matter, shade temperature, captured volume, plant survival). This is the scarce ingredient most environmental-health programs lack and cannot cheaply manufacture: a continuous stream of real, dated, property-level natural experiments.

The contribution of this paper is therefore not to argue that the environment should be measured — that half is operating — but to specify how the operating environmental record is paired with the same occupants' biology, and to pre-register the test that turns association into within-person evidence.

2. The framework: six evidence-mapped channels

Sensorial Performance decomposes a property's sensory environment into six channels, each selected because it maps to a distinct, documented human-outcome literature and to a distinct measurement path.

Channel	Representative metrics	Associated human outcome	Evidence strength
Air	CO ₂ , PM _{2.5}	cognitive performance; blood pressure	strong
Light	daytime illuminance/spectrum; nighttime light	circadian phase; sleep; mood	strong
Noise	day/night sound level (Lden)	blood pressure; sleep quality	strong

Channel	Representative metrics	Associated human outcome	Evidence strength
Thermal	temperature, humidity (esp. sleeping environment)	sleep efficiency	moderate
Nature	vegetation index, canopy, visible greenery, access	stress; well-being; recovery	moderate
Microbiome (candidate)	environmental biodiversity; soil/vegetation contact	immune and mental-health pathways	emerging — not yet co-equal

"Strength" is reported honestly: *Air, Light, and Noise* rest on controlled human trials and WHO-grade reviews; *Thermal* and *Nature* on consistent but largely observational or short-term experimental evidence; *Microbiome* on a mechanistically plausible but still-maturing literature (the "old friends" / biodiversity hypothesis; Hanski et al., 2012; Rook, 2013) — it is included as a **candidate channel under investigation, not a co-equal measurement target**, named to be explicit about intended scope rather than to claim parity with the established channels. The framework does not weight channels equally or treat all evidence as equivalent; it makes the evidentiary status of each channel explicit so that downstream use can be appropriately cautious.

This channel set is deliberately *not* a list of landscape features. It is a list of the pathways through which a place reaches a nervous system. A property's soil, hydrology, planting, and shade are inputs to these channels (chiefly Nature, Microbiome, and Thermal), not the channels themselves.

2.1 Relation to existing frameworks

Sensorial Performance is not the first attempt to score the health quality of a place, and it does not replace the existing ones. Building-certification systems (WELL, LEED) and biophilic-design rubrics assess a *structure* against design checklists; the restorative-environments literature (Attention Restoration Theory, Stress Recovery Theory) supplies much of the mechanistic basis cited above. Sensorial Performance differs on the three axes that the exposure-resolution problem of §1 demands: (1) **resolution** — it measures a specific occupied property and dwelling, not a building's design intent or a neighborhood index; (2) **temporality** — it is a re-measured longitudinal time series tied to dated interventions, not a one-time certification; and (3) **pairing** — it is built from the outset to be joined to the same occupants' biology, where certification schemes stop at the building. A WELL-certified building still has an occupant whose measured biology is unknown — which is precisely the gap Sensorial Performance exists to close.

3. Scoring methodology

Sensorial Performance is, first, a set of **per-channel raw measurements** in physical units, with timestamps and source — the scientific content lives there. A composite 0–100 is offered only as a

provisional, illustrative communication device for non-technical use; it is explicitly **not** a validated index and **not** the unit of analysis. Three design commitments govern the method.

3.1 Source-agnostic measurement (sensors optional). Each channel value carries an explicit *source* and *fidelity*. A channel may be populated by (a) **estimated** values derived from public data (e.g., vegetation indices, modeled traffic-noise surfaces, climate normals, land-cover); (b) **self-reported** occupant assessment; or (c) **sensor** measurement (e.g., a CO₂/PM_{2.5} monitor, a light or sound meter). Most properties are scored from estimated values requiring no hardware; sensor nodes exist primarily to *calibrate* the public-data estimate so that the hardware-free score becomes trustworthy at scale. This makes the instrument deployable to many properties while reserving direct measurement for the calibration set.

3.2 Raw values are retained. The composite 0–100 score is a communication device; the underlying per-channel raw values (in physical units, with timestamps and source) are retained, because validation and any causal analysis must operate on raw channel values, not on a lossy composite.

3.3 Honesty about the composite. The composite weighting is, at this stage, a *proposed* aggregation, not an empirically validated index. We make no claim that a given composite score corresponds to a specific quantitative health outcome. The composite's role is triage and communication; the scientific content lives in the per-channel values and their longitudinal relationship to biology.

4. Validation program (pre-specified)

The framework is only as good as the test it invites. We pre-specify a within-person design rather than a cross-sectional one, because the central threat to environment-health inference is not measurement but *causal identification* — self-selection (healthier or wealthier people occupy greener, quieter homes) and reverse causation (Besser et al., 2021).

4.1 Design. Aggregated **n-of-1** (single-subject / one-person-trial) design (Schork, 2015). For one consenting occupant of one property, a single environmental channel is altered in a dated, controlled intervention (e.g., an ABA introduction of HEPA air filtration on the Air channel), while all other channels are held constant. The primary outcomes are objective, wearable-derived markers validated against reference instruments: nocturnal heart-rate variability and resting heart rate (research-grade in consumer wearables; Dial et al., 2025) and sleep/wake-derived sleep efficiency (actigraphy-class; sleep *staging* is explicitly excluded as not validated). Each block's primary metric and expected direction are **pre-registered** before data collection.

4.2 The paired record. The unit produced is a *paired land–human record*: a property's per-channel environmental time series and the same occupant's biological time series on a shared clock, with dated intervention markers. This pairing — multi-domain environment at property resolution

joined to the same individual's continuous biology across real interventions — is, to our knowledge, not held by any existing dataset, precisely because of the resolution asymmetry described in §1.

4.3 Scaling. The first node is the author (a single subject, a single property), which collapses identity, consent, and multi-tenant complexity to a tractable case and exercises the full instrument. Generalization to additional subjects proceeds under a consented residency model with research-ethics oversight (a commercial IRB) and privacy protections consistent with contemporary consumer-health-data standards.

5. Limitations and claim discipline

- The environmental instrument **operates**, but the **human pairing is not yet validated**; this paper

reports no paired outcome data.

- Much of the supporting literature is **observational**; associations are not causal claims, and residual confounding is plausible throughout the environmental-health evidence base.

- The composite score is an **un-validated aggregation**; only per-channel raw values are treated as

data.

- Sensorial Performance is **not diagnostic or therapeutic**. It describes conditions *associated with* better sleep,

cognition, or cardiovascular markers in published literature; it does not treat, cure, or prevent any condition, and it operates within a general-wellness, non-medical frame.

- Channel evidence is **uneven** (Air/Light/Noise strong; Thermal/Nature moderate; Microbiome a

candidate), and the framework is written to keep that unevenness visible rather than to flatten it.

6. Conclusion

The Sensorial Performance Score is an attempt to give a well-supported but coarsely-measured idea — that the environment shapes the body — the resolution it has been missing: the property, the dwelling, the individual, over time. It is offered openly, with its evidence basis itemized and its validation pre-specified, in the hope that property-resolution environment data and continuous human-biology data can finally be measured *together*, on the same person, across real change.

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All citations verified against source (June 2026); DOIs included.

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