AURA

Autonomic Universal Responsive Architecture

Exploring Conscious Autonomic Control Through Bioelectrical Signal Acquisition

RESEARCH CONCEPT WHITE PAPER | October 2026

Research focus: Voluntary piloerection; repeated and combined initiation; DC electrodermal conductance; complementary AC skin impedance/admittance; synchronized physiological characterization; potential intentional interfaces.

Evidence status: Concept and proposed experimental program. The originating observations are self-reported; no prototype, verified individual bioelectrical signature, or functioning closed-loop system is claimed.

Publication scope: Public scientific rationale and feasibility framework, not a construction manual or disclosure of detailed implementation parameters.

Unlocking the Nervous System.

01 Executive concept and significance

AURA proposes a research and engineering program investigating whether intentionally initiated autonomic events can be measured as structured physiological information and, if reliable, interpreted as inputs to adaptive technology. Its initial experimental entry point is **voluntary piloerection (VGP)**: a documented human capacity to produce goosebumps intentionally. Its immediate engineering priority is **bioelectrical signal acquisition**, with independent pilomotor verification and appropriate controls. These priorities are complementary, not interchangeable.

The originating participant reports more than a single voluntary event: two initiation approaches, rapid successive attempts, perceived changes in intensity, apparent left/right differences, and a stronger subjective effect when methods are combined. AURA asks whether these reports correspond to measurable physiological events, whether associated electrodermal signals are detectable, and whether repetition or combination produces a distinctive response history. No specific autonomic electrical outcome is presumed.

The broader architecture described in the underlying patent specification encompasses distributed sensing, electrical and mechanical measurement, multimodal fusion, event classification, and feedback. The present paper deliberately distinguishes that **long-range architecture** from the **first achievable feasibility experiment**. The first milestone is not a wearable suit or an emotion-reading algorithm. It is an interpretable, reproducible physiological recording with adequate controls.

Why this question matters

- **Scientific:** voluntary initiation provides an opportunity to study autonomic timing and the relationship between pilomotor and sudomotor responses without relying exclusively on external eliciting stimuli.
- **Instrumentation:** the same reported event can be observed using independent measurement classes, allowing electrical findings to be compared with direct piloerection evidence.
- **Human-computer interaction:** if a distinguishable physiological event can be produced reliably and recognized on unseen trials, it could become an additional intentional control channel.

Central proposition: investigate whether repeated and combined VGP attempts are associated with reproducible, temporally structured electrodermal changes beyond what matched breathing, movement, and environmental controls explain.

02 Scientific foundation: what is established and what is not

Piloerection involves contraction of arrector pili muscles attached to hair follicles. Voluntary piloerection has been described in historical and contemporary research, including self-report and objective measurement studies. It is not equivalent to generalized voluntary control of the entire sympathetic nervous system. Nor does a visible goosebump event prove a simultaneous change in sweating, cardiac activity, or other autonomic outputs.

Electrodermal activity (EDA) refers to changes in skin electrical properties primarily associated with sympathetic control of eccrine sweat glands. Conventional EDA distinguishes slower **skin conductance level (SCL)** from faster **skin conductance responses (SCRs)**. An SCR can rise and recover over seconds; nearby events may therefore produce overlapping measured responses. Such overlap is already understood in EDA research. AURA does not claim to have discovered overlapping EDA responses.

The unknown is narrower and more interesting: whether the originating participant's repeated or combined VGP attempts elicit EDA changes at all, whether any temporal summation or history dependence is reproducible, and whether patterns survive controls. The pilomotor and sudomotor systems are distinct effectors, even though both can participate in sympathetic physiology. Their temporal relationship must be established experimentally.

03 Originating observations and testable hypotheses

Reported initiation modes

The originating participant describes a localized shoulder-associated somatic maneuver and a brief respiratory maneuver as two ways of initiating a subjective piloerection response. The participant also reports the ability to attempt repeated initiations in rapid succession, to combine both approaches (informally described as "stacking"), and to perceive differences in intensity and laterality. The underlying specification additionally describes informal series of approximately 20–30 successive initiation attempts and subjective changes after repetition. These are **informal self-observations**, not independently confirmed event counts, physiological measurements, or demonstrated neural pathways.

A hierarchy of hypotheses

- **H1 — event confirmation:** intended VGP trials produce objectively identifiable piloerection more often than matched non-VGP control trials.
- **H2 — electrical accompaniment:** at least a subset of verified VGP events is accompanied by time-locked DC EDA changes exceeding baseline variability and control-condition responses.
- **H3 — repetition and history:** rapid successive attempts alter response latency, amplitude, overlap, recovery, or event-to-event dependence compared with isolated attempts.
- **H4 — combined initiation:** combined somatic and respiratory attempts yield patterns distinguishable from either method alone and from equivalent breathing/movement without VGP intent.
- **H5 — complementary measurement:** AC-derived impedance, admittance, or phase measurements offer incremental discriminatory information beyond DC conductance under comparable recording conditions.
- **H6 — usable control:** if repeatable features exist, a model trained on earlier sessions can identify intentionally generated events on previously unseen trials or sessions.

Possible outcomes are not restricted to success

The study may find no reproducible EDA correlate, an electrical correlate entirely attributable to respiration or movement, a correlation that cannot be decoded reliably, or a robust signature associated with verified events. A null result would still clarify the limits of the proposed sensing strategy. A strong finding in one participant would be a feasibility observation requiring replication, not proof of a population-wide capability or a new sympathetic pathway.

04 Bioelectrical measurement: DC and AC have different jobs

DC-based skin conductance: primary reference channel

A DC-based EDA channel can characterize tonic skin conductance and phasic skin conductance responses. It is a sensible first reference because it is established, interpretable, and directly aligned with the proposed question about overlapping or successive electrodermal responses. The principal outcomes are changes relative to baseline, event timing, peak magnitude, slope, recovery, and response overlap. DC conductance measurements do not directly measure nerve action potentials or the electrical activity of arrector pili muscles.

AC-based skin impedance and admittance: complementary channel

AC excitation permits characterization of frequency-dependent impedance and admittance, potentially including phase-related information. These properties are affected by the skin-electrode interface and tissue electrical behavior; they may not track DC conductance identically. AC measurement could offer complementary information, but its value for VGP-associated changes has not been demonstrated here. A technically valid comparison would establish whether AC features improve repeatability, specificity, or held-out classification beyond a DC-only baseline, rather than treating AC as automatically superior.

Terminology that matters

Bioelectrical sensing is the overarching engineering description. **EDA** is a specific physiological measurement domain. **Conductance** is the inverse of resistance; **impedance** generalizes opposition to alternating current and may depend on frequency; **admittance** is the inverse of impedance. AC and DC describe excitation/measurement approaches, not separate kinds of autonomic impulses. The patent specification uses "AC-coupled" and "DC-coupled" language; the experimental discussion here refers more directly to the intended electrical measurements.

05 Independent piloerection confirmation and multimodal context

AURA must avoid a circular inference: an EDA transient cannot by itself be counted as evidence that piloerection occurred. Independent pilomotor observation is therefore necessary. Appropriate optical or image-based recording can document visible skin texture and hair elevation in accessible regions. The underlying specification also describes capacitive and other direct piloerection sensing approaches as longer-term options. The first study can use established observation methods before attempting custom wearable fabrication.

Synchronized context measurements help interpret what an electrical change means. Respiratory recording is particularly important because one reported initiation mode involves a breathing maneuver. Motion or muscle activity monitoring helps distinguish genuine skin electrical changes from electrode contact or movement artifacts. Cardiovascular, thermal, or vascular channels may be included when they address specific questions, but the first experiment should not become an unfocused collection of every possible biosignal.

Spatial questions from the broader AURA architecture

The patent specification discusses cervical, upper-arm, forearm, and palmar/fingertip measurement regions and proposes comparing regional onset, bilateral asymmetry, and apparent propagation. These are **research questions**, not an established cervical initiation mechanism or verified signal propagation path. A future multi-region study could ask whether a consistent temporal ordering exists and whether it changes with initiation method. A first-stage study should select regions according to measurable signal quality and physiological rationale, without committing publicly to detailed electrode layouts or custom array designs.

The palm and fingertips are scientifically interesting because they are electrodermally responsive but do not exhibit the same visible pilomotor response as hair-bearing skin. A signal recorded there would therefore be a possible associated autonomic correlate, not direct evidence of palm piloerection. This separation can help clarify the relationship between subjective sensation, visible goosebumps, and sudomotor physiology.

06 Proposed feasibility study

Study structure

Begin with a carefully documented within-participant feasibility study, developed with an autonomic physiology collaborator. Establish resting baselines and independently confirm whether VGP occurs. Then compare isolated shoulder-associated initiation, isolated brief-respiratory initiation, repeated attempts at more than one interval, and combined initiation. Include matched shoulder-movement and breathing conditions in which VGP is not intentionally initiated. Repeat sessions to test stability across days and minimize interpretation based on a single favorable recording.

Trial integrity and safeguards

- Define an event marker and timing convention before data collection; distinguish the intention to initiate from the observed onset of piloerection.
- Randomize or counterbalance conditions where feasible, allow recovery periods, and retain unsuccessful trials rather than discarding them.

- Use validated, electrically safe human-contact instruments and qualified supervision; do not construct or attach unreviewed excitation circuitry to the body.
- Record relevant conditions such as ambient temperature, electrode contact quality, posture, and recent movement; monitor respiration when testing breath-associated initiation.
- Preserve synchronized raw data and event annotations, and define quality exclusions before inspecting outcomes.

This is a **proposed design**, not a report that such sessions have already occurred. Sample size, acquisition settings, and any human-subject oversight requirements should be determined with appropriate research collaborators and institutions.

07 What would count as evidence?

Primary outcomes

First establish the rate of independently confirmed piloerection during intended attempts versus controls. Then assess the frequency and timing of associated EDA responses, their amplitude relative to baseline, latency distributions, recovery, and within-session and between-session reproducibility. A convincing result should survive matched controls and plausible alternative explanations.

How to evaluate "stacking" without overclaiming

The term "stacking" describes the participant's reported experience of combining methods or initiating events successively. It does **not** establish electrical summation. Measured responses could appear additive, larger than additive, smaller than additive, saturated, delayed, or absent. Overlap can arise from the known slow dynamics of EDA, and a larger signal could reflect breathing or movement rather than pilomotor recruitment. Comparisons should therefore distinguish response overlap, genuine event-associated change, and confounding.

Signal analysis and interpretation

An initial analysis should emphasize transparent plots and interpretable features: onset estimates, amplitude, slope, area, time-to-peak, recovery, and trial-to-trial variability. Where repeated responses overlap, a physiological response model may help estimate event-related components, but the model assumptions should be tested rather than accepted as proof. Cross-channel timing between optical piloerection, DC EDA, optional AC measurements, respiration, and movement can help identify competing explanations.

Only after signal quality and reproducibility are established should machine-learning classification become a central objective. Start with simple baselines and compare them with more complex methods if justified. Report held-out performance on unseen trials and, preferably, unseen sessions; include false-positive rates, calibration, and failure cases. A model that recognizes the breathing maneuver alone would not establish an independently useful autonomic control channel.

Criteria for progression

- **Feasibility:** objective confirmation of voluntary events and reliable synchronized acquisition.
- **Association:** statistically and physiologically interpretable electrical differences from matched controls.
- **Distinctiveness:** repeated/combined conditions offer reproducible information beyond simple movement or respiration.
- **Engineering utility:** practical recognition performance with acceptable false triggers and latency.

08 Architecture: from measurement to closed-loop interaction

The broader AURA concept organizes development into linked functions: **physiological sensing** → **acquisition and synchronization** → **signal conditioning and feature extraction** → **interpretation** → **adaptive output** → **renewed measurement**. This sequence reflects the underlying specification's multimodal architecture while remaining implementation-agnostic in this public paper.

A closed-loop autonomic interface (CLAI) is envisioned as a system that senses physiological activity, interprets it, delivers adaptive feedback, and measures subsequent responses. Feedback might be visual, auditory, tactile, or another modality appropriate to the use case. The initial prototype need only demonstrate trustworthy sensing and interpretation; closed-loop feedback is a subsequent milestone. An output triggered by a physiological event does not, by itself, prove that feedback altered autonomic state.

09 Research opportunities beyond the first experiment

Autonomic physiology and spatial mapping

If reliable events are established, AURA could investigate how regional piloerection, EDA, respiration, cardiovascular signals, and subjective experience covary. Questions include whether different initiation strategies yield different timing patterns, whether apparent left/right differences are measurable, whether rapid repetition produces habituation or facilitation, and whether any cervical-associated sensations precede observable peripheral changes. No anatomical initiation site or direct nerve pathway is assumed.

Voluntary versus externally elicited events

A longer-term comparison could examine voluntarily initiated piloerection against emotional frisson, cold-related piloerection, and ordinary movement artifacts. Distinctive patterns, if observed, would need to be tested against the possibility that differences arise from experimental context rather than fundamentally separate autonomic mechanisms.

Interactive systems and media

Validated physiological inputs could eventually support adaptive virtual environments, gaming, music and sound experiences, performance systems, and media-response research. A horror game might alter audiovisual intensity based on detected events; a music interface might map a recognized response to a parameter change; a research environment might use voluntary events as repeatable timing references. These are illustrative future applications, not functioning products or validated emotion-detection technologies.

Longer-term health-related possibilities

Biofeedback and physiological monitoring may be worth investigating after feasibility and replication. Clinical or therapeutic claims would require separate studies, safety review, and applicable regulatory analysis. This concept paper makes no diagnosis, treatment, or efficacy claims.

10 Collaboration program and near-term milestones

The most valuable first collaboration combines **autonomic physiology** with **electrical/biosignal instrumentation**. The physiology partner can refine event definitions, controls, and interpretation; an electrical or biomedical engineer can advise on safe EDA acquisition, optional AC measurements, synchronization, and artifact management. Signal-processing expertise becomes increasingly important after a reliable dataset exists.

- **Milestone A:** agree on operational definitions, objective VGP verification, and a controlled feasibility protocol.
- **Milestone B:** collect synchronized DC EDA, piloerection evidence, and movement/respiratory controls across repeated sessions.
- **Milestone C:** determine whether the proposed electrical correlates and repetition/combination effects survive controls.
- **Milestone D:** evaluate incremental value of AC impedance/admittance and, only if warranted, prototype a robust recognition pipeline.
- **Milestone E:** explore a constrained closed-loop demonstration using validated signal features.

Collaboration should address data stewardship, publication expectations, contribution credit, safety, and intellectual-property boundaries before unpublished technical work is exchanged. The research concept is intentionally open to falsification and revision based on measured results.

11 Limitations, boundaries, and publication status

No measurements are claimed. The originating participant's experience is not a substitute for optical confirmation, EDA recording, or independent replication. The proposal does not claim consciously generated electrical power, direct control of sweat glands, an established new neural pathway, or a novel electrical waveform already observed in the participant.

Scientific novelty remains to be established. Voluntary piloerection, EDA, overlapping SCRs, bioimpedance measurement, multimodal physiological sensing, and closed-loop biofeedback each have substantial prior art. AURA's specific empirical value would depend on demonstrating an informative association or usable intentional control pattern beyond known confounds. Its intellectual-property claims are a separate legal question from scientific novelty or feasibility.

Privacy and reproducibility matter. Future research should consider participant consent, raw-data retention, independent analysis, replication, and clear disclosure of negative outcomes. Technical demonstrations and visualizations should be labeled conceptual until validated.

Public disclosure boundary. This white paper deliberately omits detailed array geometry, component selections, circuit designs, excitation parameters, signal-processing implementation choices, and proprietary control mappings. These omissions reduce unnecessary technical disclosure but do not guarantee patent safety. The author should confirm alignment with the actually filed application and seek qualified patent advice before publication.

12 Selected Research Foundation and Source Notes

Maxwell, S. (1902). A Case of Voluntary Erection of the Human Hair and Production of Cutis Anserina. American Journal of Physiology, 7(4), 369–379. https://doi.org/10.1152/ajplegacy.1902.7.4.369

An early documented case of voluntary human piloerection establishes a historical basis for investigating intentional pilomotor control and its physiological characteristics.

Lindsley, D. B., & Sassaman, W. H. (1938). Autonomic Activity and Brain Potentials Associated with “Voluntary” Control of the Pilomotors (Mm. Arrectores Pilorum). Journal of Neurophysiology, 1(4), 342–349. https://doi.org/10.1152/jn.1938.1.4.342

Autonomic activity and brain potentials were examined alongside voluntary pilomotor control, providing an early physiological precedent for studying measurable correlates of the response.

Benedek, M., Wilfling, B., Lukas-Wolfbauer, R., Katzur, B. H., & Kaernbach, C. (2010). Objective and Continuous Measurement of Piloerection. Psychophysiology, 47(5), 989–993. https://doi.org/10.1111/j.1469-8986.2010.01003.x

Objective, continuous measurement of piloerection enabled investigation of its timing. Notably, the proof-of-principle experiment included a participant capable of voluntarily erecting body hair, making it especially relevant to quantitative VGP research.

Uchida, M., Akaho, R., Ogawa-Ochiai, K., & Tsumura, N. (2019). Image-Based Measurement of Changes to Skin Texture Using Piloerection for Emotion Estimation. Artificial Life and Robotics, 24(1), 12–18. https://doi.org/10.1007/s10015-018-0435-0

Using camera-based skin-texture analysis, the researchers detected piloerection without skin-attached sensors. This optical approach offers a measurement precedent complementary to AURA’s proposed distributed physiological sensing.

Heathers, J. A. J., Fayn, K., Silvia, P. J., Tiliopoulos, N., & Goodwin, M. S. (2018). The Voluntary Control of Piloerection. PeerJ, 6, e5292. https://doi.org/10.7717/peerj.5292

The modern characterization of voluntary piloerection covers reported sensations, actions, timing, and affective associations. Unresolved physiological questions help motivate AURA’s proposed multimodal investigations.

Katahira, K., Kawakami, A., Tomita, A., & Nagata, N. (2020). Volitional Control of Piloerection: Objective Evidence and Its Potential Utility in Neuroscience Research. Frontiers in Neuroscience, 14, 590. https://doi.org/10.3389/fnins.2020.00590

Across multiple participants, objective evidence of voluntary piloerection and observations at different body locations support its potential as an experimental model for spatial and physiological research.

Kim, J., Seo, D. G., & Cho, Y. H. (2014). A Flexible Skin Piloerection Monitoring Sensor. Applied Physics Letters, 104(25). https://doi.org/10.1063/1.4881888

Flexible capacitive sensing has been demonstrated for detecting skin deformation associated with piloerection, including measurements on the human forearm. This offers a direct engineering precedent for AURA’s proposed wearable sensing approach.

Fukushima, S., & Kajimoto, H. (2012). Facilitating a Surprised Feeling by Artificial Control of Piloerection on the Forearm. In Proceedings of the 3rd Augmented Human International Conference (AH ’12). https://doi.org/10.1145/2160125.2160133

Electrostatic manipulation of forearm hair was investigated for its possible influence on subjective experience. The findings inform AURA’s longer-term interest in somatosensory feedback while distinguishing externally induced effects from physiological piloerection.

Invitation to collaborate

AURA seeks researchers and engineers interested in evaluating whether intentionally generated autonomic events can be independently confirmed, characterized through safe bioelectrical measurements, and translated into meaningful, reproducible physiological data. The first question is deliberately concrete: **what can we actually measure?**

AURA — Unlocking the Nervous System.