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Data Article

# Human experience in regulated offices (HERO) dataset: Synchronized multimodal physiological, environmental, perceptual, and video-derived measurements across structured office activities in a controlled indoor setting

Puneet Tomar[a,*], Dianel Ago[b], Ilaria Pigliautile[a], Gloria Cosoli[b,*], Veronica Martins Gnecco[a,c], Sara Casaccia[d], Gianluca Sartini[d], Silvia Angela Mansi[b,e], Anna Laura Pisello[a,c], Marco Arnesano[b]

[a] EAPlab at CIRIAF Interuniversity Research Centre of Pollution and Environment Mauro Felli, University of Perugia, Italy
[b] Department of Theoretical and Applied Sciences, eCampus University, Italy
[c] Department of Engineering, University of Perugia, Italy
[d] Department of Industrial Engineering and Mathematical Sciences, Marche Polytechnic University, Italy
[e] Department of Brain and Behavioural Science, University of Pavia, Italy

A R T I C L E I N F O

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A B S T R A C T

The Human Experience in Regulated Offices (HERO) dataset is a synchronized, multimodal resource dataset designed to characterize human physiological and perceptual dynamics during realistic office activities in a controlled indoor setting. The dataset comprises data gathered on 24 voluntary healthy adults, each completing two laboratory sessions under distinct thermal regimens: Lower Temperature (LT; 22–24 °C) and Higher Temperature (HT; 30–32 °C), regulated within ±0.5 °C, conducted during the summer season in Köppen–Geiger Csa climate classification (temperate with dry and hot summer). In each session, participants followed a standardized nine-phase office-work protocol comprising

* Corresponding authors.
*E-mail addresses:* puneet.tomar@unipg.it (P. Tomar), dianel.ago@uniecampus.it (D. Ago), gloria.cosoli@uniecampus.it (G. Cosoli), veronica.martinsgnecco@unipg.it (V.M. Gnecco), s.casaccia@staff.univpm.it (S. Casaccia), gianluca.sartini@pm.univpm.it (G. Sartini), silviaangela.mansi@unipv.it (S.A. Mansi), anna.pisello@unipg.it (A.L. Pisello), marco.arnesano@uniecampus.it (M. Arnesano).

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*Keywords:*
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an acclimation baseline, activity blocks, and interleaved washout periods, enabling analyses that explicitly account for activity type, sequencing, and recovery. The release integrates four-channel electroencephalography (EEG) acquired with a Muse-2 headband, electrodermal activity (EDA), and peripheral skin temperature (ST) recorded using an EmotiBit wrist-worn wearable sensor, indoor multi-domain environmental measurements acquired via the NEXT.ROOM facility, and phase-aligned surveys capturing multi-domain perceptions of the indoor environment and task experience. Visual context, such as, derived video quality check (QC)/coverage features, was recorded using laptop webcams. All data are distributed as level-0 device exports, restricted to the experimental window and enriched with consistent session identifiers and phase labels, while intentionally avoiding downstream preprocessing choices. The dataset is archived on Zenodo (DOI: 10.5281/zenodo.17957768) with documentation and code in the associated project's GitHub repository.



Specifications Table

| | |
|---|---|
| Subject | Thermophysiology; Neurophysiology; Indoor environmental quality; Human-centered sensing; Building science; Personalized comfort; Office protocol |
| Specific subject area | Multimodal human response to controlled environmental conditions across realistic office-like activities. |
| Type of data | Table (.csv format), Survey text (.pdf format) |
| Data collection | Data was collected in the NEXT.ROOM climate chamber during a scripted ∼90-min session timelined in Table 4 (two simultaneous participants) within the framework of the WEPOP (WEarable Platform for OptImised Personal comfort) project. Surveys were administered digitally via the WEPOP platform. Physiologic signals were recorded with Muse-2 (EEG) and EmotiBit (EDA/ST) sensors. A calibrated lab station logged environmental parameters; derived video QC/coverage features were retained (no raw video to preserve privacy according to the EU-GDPR). |
| Data source location | NEXT.ROOM facility, CIRIAF, University of Perugia, Perugia, Italy.<br>Coordinates: 4995+Q2R |
| Data format | Raw/level-0 records (device-export streams restricted to experiment window; not feature-engineered), organized per session and modality; phase labels provided for each sample where applicable. |
| Data accessibility | Repository Name: Zenodo<br>Data identification number: v3.17957768<br>Direct URL to data: https://doi.org/10.5281/zenodo.17957768<br>Instructions for accessing these data:<br>The dataset repository is publicly accessible to overview dataset on Zenodo, while the underlying record files are available from the corresponding author upon request using Zenodo access request forum. |
| Related research article | P. Tomar, A.L. Pisello, Physiological-perceptual divergence (PPD) in human thermal adaptation: Multimodal evidence of decoupled body-mind responses during controlled indoor exposure, Building and Environment. (2026) 1–19, doi: https://doi.org/10.1016/j.buildenv.2026.114256 |

## 1. Value of the Data

- The dataset provides synchronized, phase-annotated recordings of EEG, EDA, and ST collected during a standardized office-activity protocol, enabling protocol-aligned analyses across base-

line, task, and washout periods. Adding to this, HERO fills a methodological gap between broad field-survey comfort databases and tightly controlled psychophysiology datasets by combining synchronized biosignals, indoor environmental measurements, repeated multi-domain perception surveys, and structured office-task phases within one reproducible backbone.
- Paired lower-temperature and higher-temperature sessions (LT/HT) are accompanied by time-stamped indoor environmental measurements and repeated perception surveys, supporting the development and evaluation of models that relate indoor exposures to subjective experience under controlled conditions.
- The protocol includes reading, writing, group discussion, and conference-call activities interleaved with washouts, enabling analyses of physiological and perceptual variation across different activity demands and recovery intervals within the same session structure. This gives the dataset utility as a middle-ground resource between fully naturalistic monitoring and highly artificial laboratory paradigms, supporting analyses that require both experimental control and activity-specific ecological relevance.
- Data are released as level-0 device exports with consistent identifiers and phase labels, allowing transparent comparison of preprocessing, temporal alignment, and feature-extraction strategies across heterogeneous sensing streams (EEG, EDA, ST, environment, surveys, and video-derived indicators).
- The dataset offers a testbed for multimodal methods under realistic sensing constraints, including missingness, variable signal quality over time, and participant-specific variability typical of wearable and in-situ monitoring.

## 2. Background

Open, well-documented datasets have been central to progress in indoor environmental quality (IEQ) and thermal comfort research because they allow the community to test models, compare assumptions, and reproduce findings across diverse climates and building contexts. The best-known example is the *ASHRAE Global Thermal Comfort Database II*, which aggregates tens of thousands of records from field studies and links indoor environmental measurements with “right-here-right-now” subjective thermal evaluations [1]. Christenko [2] proposes a task and knowledge based occupational mobility network with automation probability of occupations. While such resources could support different analyses initiatives for population-level comfort science and standards development, they are primarily *field-survey-centric* and typically lack high-resolution neurophysiological measurements and structured task contexts.

In parallel, several datasets support personalized multidomain comfort modeling using wearables, usually combining skin temperature and cardiovascular signals with environmental variables over long periods of daily life [3]. These datasets are well-suited for longitudinal personalization, but they often trade off experimental control and protocol structure: activities, cognitive demand, and social interaction vary naturally and are difficult to isolate. Other multimodal comfort datasets exist outside the building domain, such as thermal comfort data collected in vehicles (e.g., passenger comfort datasets combining physiological signals and self-report) [4], highlighting the value of multimodal sensing, but in a context that does not directly transfer to office IEQ and work-related activity patterns.

A separate but relevant line of research comes from affective computing and psychophysiology, where benchmark datasets such as WESAD provide synchronized wearable physiology for stress and affect detection under controlled protocols [5]. These datasets are methodologically mature for signal-processing and machine-learning benchmarking, yet they generally do not include the building microclimate variables and multi-domain IEQ perception that are necessary to connect physiological dynamics to indoor environmental exposures. Recent dataset-oriented work has also expanded toward longitudinal and continuous monitoring, combining environmental sensing, physiology, and subjective micro-surveys across cities, further demonstrating the value of multi-stream data for human-environment research [6]. However, there remains a need for datasets that jointly provide (i) controlled indoor exposures, (ii) structured office-like activities with recovery periods, and (iii) synchronized neurophysiology, physiology, environment, perception, and visual contexts within a single experimental backbone.

The HERO [7] dataset was created to address this gap by capturing human responses during a standardized office-work protocol under regulated indoor thermal regimens, while explicitly preserving the dataset as level-0 device exports so that downstream researchers can apply, compare, and report preprocessing choices transparently. By combining activities blocks with interleaved washouts and providing consistent phase annotation, HERO [7] supports analyses that treat physiology and perception as outcomes of contextual co-variation (activity, sequencing, recovery, and indoor conditions), rather than attributing changes to a single driver. This makes the dataset particularly suitable for research on neurophysiological dynamics, multidomain comfort and stress modeling, affective/cognitive responses under challenge, and multimodal machine learning in ecologically relevant office scenarios.

## 3. Data Description

### 3.1. Overview of the dataset

The HERO [7] dataset provides synchronized, time-stamped recordings of human physiology, indoor environmental context, subjective perception, and privacy-preserving visual context collected during realistic office activities in a controlled laboratory setting. The dataset contains the data gathered on $N = 24$ pseudonymized participants IDs (*P01–P26*, non-contiguous), each with up to two sessions under distinct thermal regimes: Lower Temperature (LT; 22–24 °C) and Higher Temperature (HT; 30–32 °C), regulated within ±0.5 °C (48 sessions total). All released time-series are level-0 device exports, restricted to the experimental window and enriched with consistent identifiers and phase labels to enable protocol-aligned analysis without imposing downstream preprocessing choices. All participant-specific recordings use a consistent session naming convention: PXX_LT and PXX_HT. Within each session, the protocol is represented by nine ordered phases: *baseline, activity_reading, first_washout, activity_writing, second_washout, activity_discussion, third_washout, activity_call (conference call), fourth_washout.* For the physiological and EEG modalities, phase membership is provided at the sample level via the columns phase_name, phase_label, and phase_order, enabling direct aggregation or modeling by protocol phase and supporting analyses that explicitly account for activity type, sequencing, and recovery dynamics. For usability, the dataset description is organized around the practical questions a secondary user needs to answer first: what files exist, at what level they are stored (participant/session, condition, or consolidated table), and which fields allow deterministic linkage across modalities.

### 3.2. Data files inventory

An inventory file (HERO_inventory.csv) is provided to support cohort construction of dataset files. For each file in the release, it summarizes relative path, modality, session identifier (when applicable), number of rows, start and end timestamps (UTC), recording duration, an approximate effective sampling frequency inferred from timestamps, a column preview, and phase coverage where available. Phase start/end timestamps for each session are stored in timeline.csv, which acts as the temporal backbone for phase annotation across modalities. This inventory is designed to be the primary entry point for automated pipelines (e.g., “select all sessions with complete nine-phase coverage across modalities” or “identify sessions with truncated recordings”). The dataset is organized by modality folders (e.g., eeg/, eda/, st/, env/, survey/, vid/), with participant/session-level files for physiology/EEG and consolidated files for environment, surveys, and video derived indicators. An overview of file organization within the dataset repository is reported in Section 3.3. Table 1 shows the file structure for each collected modality.

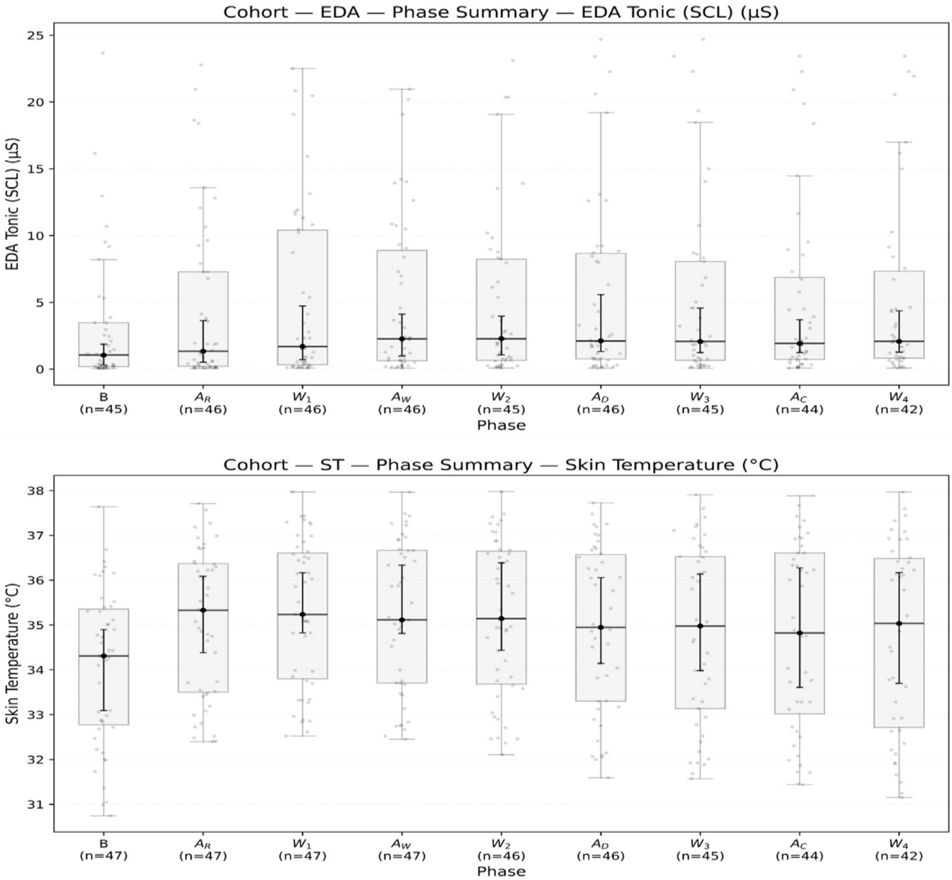



**Fig. 1.** Cohort phase distributions of electrodermal activity (EDA tonic level) and skin temperature. Boxplots summarize aggregated observations across sessions, with individual observations shown as jittered points. The value n indicates the number of valid observations contributing to each phase after preprocessing.

**Table 1**
Overview of data modalities and file structure.

| Modality | Files in release | Sampling Frequency | Key columns (preview) | Instrumentation Location/Position |
|---|---|---|---|---|
| **EEG** | 48 | ∼ 247 Hz | ID_Session, tp9, af7, af8, tp10, ts, ts_dt, phase_name, phase_label, phase_order | Muse-2 four channel; Headband |
| **EDA** | 48 | ∼ 15 Hz | datetime, ID_Session, eda, phase_name, phase_label, phase_order | EmotiBit; Non-dominant wrist |
| **ST** | 48 | ∼ 7.5 Hz | datetime, ID_Session, st, phase_name, phase_label, phase_order | EmotiBit; Non-dominant wrist |
| **ENV** | 2 | ∼ 2 Hz | datetime, AirTemp_C, RH_ %, AirVelocity, Net_Rad_1, RTD/Tpav,RTD/T60cm, RTD/T110cm, RTD/T130cm, RTD/Tglobe | National Instrumentation; NEXT.ROOM |
| **SURVEY** | 2 | As per protocol | ID_Session, thermal_comfort_typology, env_sensitivity; Multi-domain questionnaire (Perception survey). | WEPOP Platform; Application |
| **VID** | 7 | Exp window | column, unit, description, allowed_values | User laptop webcam |

### 3.3. Data records and modalities

{ **Modality | Directory | Instrument | Location}** The modality descriptions below are intended to clarify, for each data stream, the storage directory, acquisition device, storage granularity, and the minimum fields needed to align records across files.

**The outline below depicts the high- level folder hierarchy of the cohort dataset inventory:**

```
HERO_dataset/
│
├─ README.md
├─ inventory.csv            # cohort construction metadata
├─ timeline.csv             # Sessions and phases experimental timeline
│
├─ eeg/
│   ├─ PXX_LT_eeg.csv
│   ├─ PXX_HT_eeg.csv
│   ├─ ...
│   └─ eeg_summary.csv
│
├─ eda/
│   ├─ PXX/
│   │   ├─ PXX_LT_eda.csv
│   │   └─ PXX_HT_eda.csv
│   ├─ ...
│   └─ eda_summary.csv
│
├─ st/
│   ├─ PXX/
│   │   ├─ PXX_LT_st.csv
│   │   └─ PXX_HT_st.csv
│   ├─ ...
│   └─ st_summary.csv
│
├─ env/
│   ├─ HT_env.csv
│   └─ LT_env.csv
│
├─ survey/
│   ├─ initial_survey.csv
│   └─ perception_survey.csv
│
├─ vid/
│   ├─ metadata/
│   │   ├─ manifest_videos_public.csv
│   │   ├─ manifest_videos_public.parquet
│   │   ├─ data_dictionary.csv
│   │   ├─ processing_parameters.json
│   │   └─ manifest_summary.json
│   ├─ features/
│   │   ├─ video_features_summary.csv
│   │   ├─ video_features_summary.parquet
│   │   ├─ video_features_data_dictionary.csv
│   │   └─ video_features_processing_parameters.json
│   └─ release_pack/
│       ├─ video_qc.csv
│       ├─ video_qc_parameters.json
│       ├─ video_coverage.csv
│       ├─ video_paired_deltas.csv
│       └─ video_modality_summary.json
│
└── (END)
```

**Electroencephalography | eeg | Muse-2 | Forehead.** The recordings are provided as session–level CSV files that capture the four dry–electrode sensors of the Muse–2 headband [8]—TP9 (left temporal), AF7 (left frontal), AF8 (right frontal) and TP10 (right temporal)—which sit on the forehead region of the wearer. Each row includes a session identifier, a high–resolution timestamp, and a phase–label tag. The format is purpose–built to support a wide array of downstream pipelines (spectral decomposition, band–power tracking, event–related modeling of protocol phases) while keeping every preprocessing choice—filtering, re–referencing, artifact rejection—fully under the researcher's control.

**Electrodermal activity & skin temperature | eda; st | EmotiBit | wrist.** The EmotiBit wearable [9]—a single device that simultaneously records both EDA and ST—is placed on the user's non–dominant wrist. Session–level CSV files contain a datetime axis, a unique session identifier (ID_Session), the raw signal value (either *eda* or *st*), and a per–sample phase–label tag denoting the current experimental segment. This unified format supports flexible downstream work such as autonomic–state modeling, thermoregulatory dynamics, or combined EDA–temperature event–related analyses, while leaving all preprocessing choices (filtering, smoothing, artifact handling) entirely to the researcher's discretion.

**Indoor Climate | env | NEXT.ROOM | Climate chamber.** The collection supplies consolidated time–series CSV files for each thermal regime (e.g., LT_env.csv for lower–temperature conditions and HT_env.csv for higher–temperature conditions). Every file contains a datetime index and a suite of indoor–environment quality (IEQ) channels recorded by the NEXT.ROOM [10] sensor array positioned throughout the laboratory: air temperature, relative humidity, air velocity, globe temperature, and vertically distributed temperature probes (RTD/T10 cm, RTD/T60 cm, RTD/T110 cm, RTD/T130 cm). These logs capture the controlled ambient context in which each participant session took place. Because the environmental data are logged at the condition level, researchers can align them to individual participant streams by matching overlapping timestamps (or by using the protocol timeline), enabling integrated analyses of physiological responses within the precisely measured indoor environment.

**Questionnaire Feedback | survey | WEPOP platform | platform.** The repository includes two CSV–formatted questionnaire datasets. The first file holds the initial survey (48 rows) collected before the experiment timeline, capturing participant typology, sensory, sensitivity, and initial levels of the target constructs. The second file contains the multi-domain perception survey (228 rows), which records repeated self–report measures at each protocol–defined checkpoint throughout the experimental session. Both tables share a common participant/session identifier, allowing seamless linkage with the physiological streams and the indoor–environment logs. Conducted via the WEPOP online platform [11], this dual–survey structure supports comprehensive analyses that relate objective biosignals and contextual conditions to multi–domain subjective experiences and task–related outcomes, while leaving any scoring, scaling, or data–cleaning decisions entirely under the researcher's control.

**Visual Context | vid | Laptop Webcams | Working desk.** To satisfy ethical standards and EU data–protection regulations [12], the repository does not contain raw, identifiable video footage. Instead, the vid/ directory provides a curated set of non–identifying, video–derived indicators and accompanying metadata that support quality–control, coverage assessment, and missing–data modeling. Included are a public manifest listing all available video–derived features, QC summary reports that flag frame–rate drops or occlusions, paired–condition delta files that quantify visual differences across experimental states, and a detailed data dictionary describing each derived metric (e.g., face–presence probability, gaze–direction estimate, illumination level) and the overall metadata schema. This structure enables researchers to incorporate visual context into multimodal analyses while preserving participant anonymity.

## *3.4. Technical validation*

### *3.4.1. Data completeness and quality summaries*

To support transparent integrity checks without imposing analysis-specific preprocessing, modality-specific session summaries are provided, for instance *eda_summary.csv, st_summary.csv, eeg_summary.csv* (See dataset inventory in Section 3.2). These summaries report, for each session, the number of samples present in the raw export, the number retained after restriction to the experimental window, the number of protocol phases with available data, and status flags indicating potential data issues (e.g., ok, missing_raw).

For EEG recordings with nominal sampling rate $\approx$ 247 Hz (device default sampling rate $\approx$ 256 Hz), the summary file additionally allows users to assess signal completeness across experimental phases by reporting phase-aligned coverage of the recorded samples. Because the dataset is released as Level-0 raw recordings without artifact rejection, no fixed artifact removal or rejection procedure is applied prior to release. Instead, the EEG summaries provide the information necessary for users to evaluate data availability across phases (e.g., reading, discussion) and to determine appropriate preprocessing and artifact-handling strategies for their analyses.

Together, the inventory and modality summaries document the expected minor missingness typical of multimodal human studies (e.g., absent EDA/ST for a single session and absent EEG for a single session) and highlight sessions with truncated recordings (notably for EEG). These summaries enable researchers to define inclusion criteria and perform quality screening prior to applying modality-specific preprocessing pipelines.

### *3.4.2. Cohort-level signal validation*

To assess the consistency and plausibility of the measurements across participants and experimental phases, cohort-level phase summaries were computed for EDA, ST, ENV air temperature, and EEG alpha relative power. Phase-wise distributions for EDA and ST are shown in Fig. 1, while the corresponding summaries for EEG alpha power and environmental air temperature are presented in Fig. 2. For each modality, observations were aggregated across all sessions after preprocessing and quality control procedures, including artifact removal and signal validation.

For EDA and ST, each observation corresponds to a session-level phase mean derived from the cleaned time-series signals. Environmental variables were summarized at the session-phase level. In contrast, EEG features were computed using sliding-window spectral analysis to estimate alpha-band relative power within each phase. Consequently, the number of observations (n) contributing to EEG distributions is larger than for other modalities, as multiple valid spectral windows can occur within a single phase.

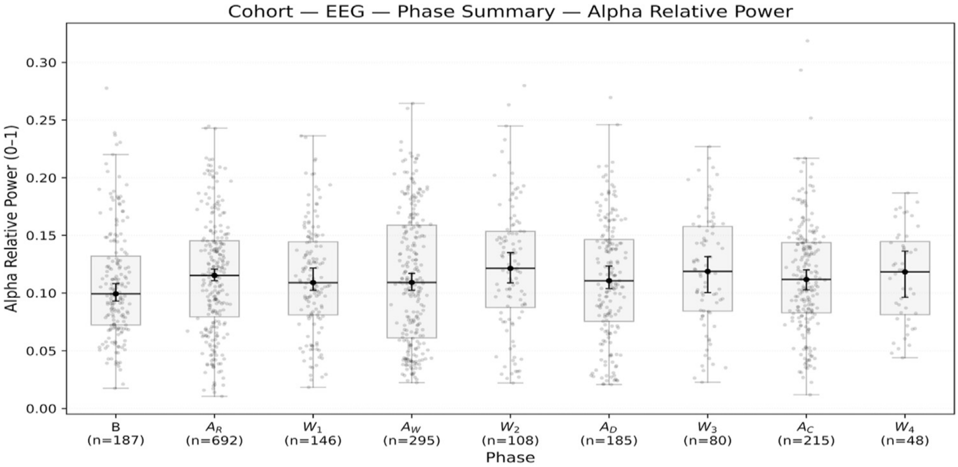
Across modalities, the cohort distributions fall within physiologically plausible ranges and exhibit variability patterns consistent with the experimental protocol. Peripheral physiological signals such as EDA and ST show phase-dependent variability, while environmental measurements remain comparatively stable, reflecting controlled chamber conditions. These descriptive summaries confirm that the dataset captures meaningful physiological variation across participants while maintaining signal integrity after preprocessing and quality control.

### *3.4.3. Intended usage notes*

HERO Tomar (2025) [7] is distributed as level-0 device exports with explicit identifiers and phase labels so that users can: (i) reproduce protocol-aligned analyses, (ii) benchmark preprocessing strategies across modalities, and (iii) develop multimodal models that treat physiology and perception as outcomes of contextual co-variation (activity, sequencing, recovery, and indoor conditions). Users are encouraged to apply modality-appropriate QC (e.g., checking per-session phase completeness and duration, inspecting timestamp regularity, and screening for truncated signals) prior to downstream inference. Table 1 describes the different data modalities and file structures.

### *3.4.4. Session coverage and completeness*

Session–level EEG/EDA/ST files are available for most LT/HT sessions, with minor missingness. Based on the inventory, EDA and ST are absent for session P10_HT, while EEG is absent for session P24_LT. One EEG session file is markedly short ($\sim$51 s), indicating export truncation; users should perform per–session QC before analysis (Table 2).



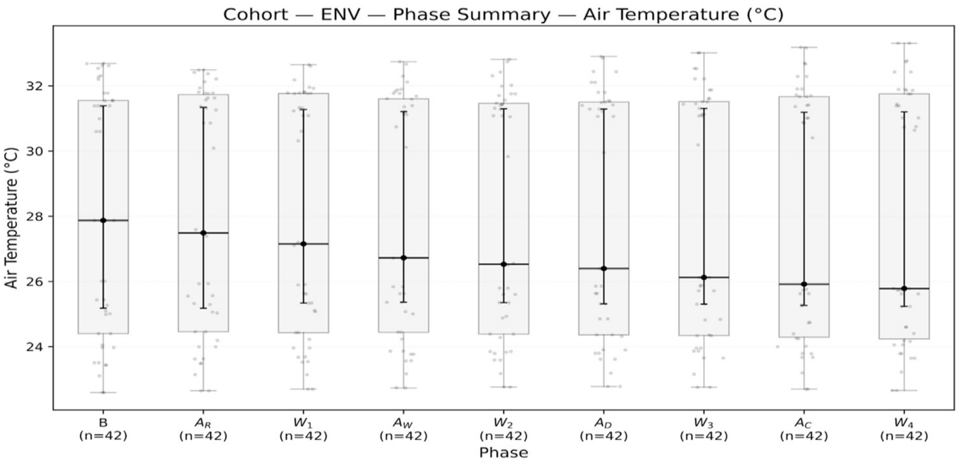




**Fig. 2.** Cohort phase distributions of EEG alpha relative power and environmental air temperature. Boxplots summarize observations across sessions. The value n denotes the number of observations per phase; for EEG, observations correspond to sliding-window spectral estimates within each phase.

**Table 2**
Duration distribution of session–level streams (IQR in hours).

| Modality | Q1 (h) | Median (h) | Q3 (h) |
|---|---|---|---|
| **EDA** | 0.94 | 1.03 | 1.24 |
| **ST** | 0.94 | 1.03 | 1.24 |
| **EEG** | 0.81 | 0.98 | 1.11 |

## 4. Experimental Design, Materials and Methods

### *4.1. Study design*

The study employed a controlled, repeated-measures laboratory design to capture synchronized physiological, environmental, perceptual, and visual-context data during realistic office activities. Data collection was conducted in Perugia, Italy, under summer mediterranean climatic

**Table 3**
Chronological timeline of experimental events and phases.

| Timeline | Minutes | Phase | Levels |
|---|---|---|---|
| $T_n$ | 00:00 | Acclimation | START |
| $T_1$ | 00:15 | Acclimation | Survey-Initial |
| $T_2$ | 00:20 | Baseline | Survey-Baseline |
| $T_3$ | 00:25 | Baseline | Signals |
| $T_4$ | 00:30 | Activity | Reading |
| $T_5$ | 00:40 | 1st Washout | Survey-Perception |
| $T_6$ | 00:45 | Activity | Writing |
| $T_7$ | 00:55 | 2nd Washout | Survey-Perception |
| $T_8$ | 00:60 | Activity | Discussion |
| $T_9$ | 00:70 | 3rd Washout | Survey-Perception |
| $T_{1n}$ | 00:75 | Activity | Call |

conditions, within the NEXT.ROOM [10] experimental facility. Sessions were run under two regulated indoor thermal regimes: Lower Temperature (LT; 22–24 °C) and Higher Temperature (HT; 30–32 °C), maintained within ±0.5 °C. Each participant completed two sessions (LT and HT), enabling within-participant comparisons while preserving ecological relevance through office-like tasks as depicted in the chronological timeline of the experiment (see Table 3).

A total of $N = 24$ participants (10 females, 14 males), with a mean (±standard deviation) estimated age of 25.67 ± 5.25 years based on age-group bins (range 18–45), took part in the study. Each participant was assigned a pseudonymous identifier (e.g., P01, P02, etc.) to preserve privacy. The eligibility criteria were designed to recruit individuals who were medically fit for controlled, laboratory–based indoor exposure protocols.

### *4.2. Experimental protocol*

Each experimental session involved two participants tested simultaneously within the same controlled laboratory chamber. Two fixed workstations were used: the door-side workstation was consistently assigned to *Subject A*, and the window-side workstation to *Subject B*. Participants accessed the WEPOP survey platform using a unique, anonymized identifier. Laptop 1 (door side) and Laptop 2 (window side) were permanently mapped to Subject A and Subject B, respectively, to ensure consistent synchronization between task execution, survey delivery, and physiological recordings. The overall experimental workflow and temporal structure are summarized in Fig. 3, which illustrates the synchronized multimodal data collection across nine sequential phases, including acclimation, baseline ($S_B$), and activity blocks ($A_R$, $A_W$, $A_D$, $A_C$).

The physical layout of the experimental setup, including the fixed seating arrangement (door-side vs. window-side) and the positioning of physiological and environmental sensors within the NEXT.ROOM climate chamber, is shown in Fig. 4. Upon arrival, participants underwent a 20-min [13] acclimation phase, during which they were seated and exposed to the target thermal condition. During this period, the experiment operator remained inside the chamber to assist with sensor placement, verify signal quality, and provide standardized task instructions. Importantly, no information regarding the thermal condition or experimental hypotheses was disclosed. Written informed consent was obtained, and an initial questionnaire (*initial_survey.csv*) capturing demographic information and baseline traits was administered via WEPOP platform.

Following acclimation, a seated resting baseline of 90 s was recorded, during which participants remained still and silent. This phase served as the physiological and perceptual reference for subsequent analyses.

Throughout the session, multi-domain perception self-reports (*perception_survey.csv*) were administered repeatedly at predefined checkpoints. Each survey was preceded by a brief on-screen instruction screen to standardize interpretation and response timing. Survey domains covered thermal, visual, acoustic, air-quality comfort, and perceived productivity. Task order, phase du-

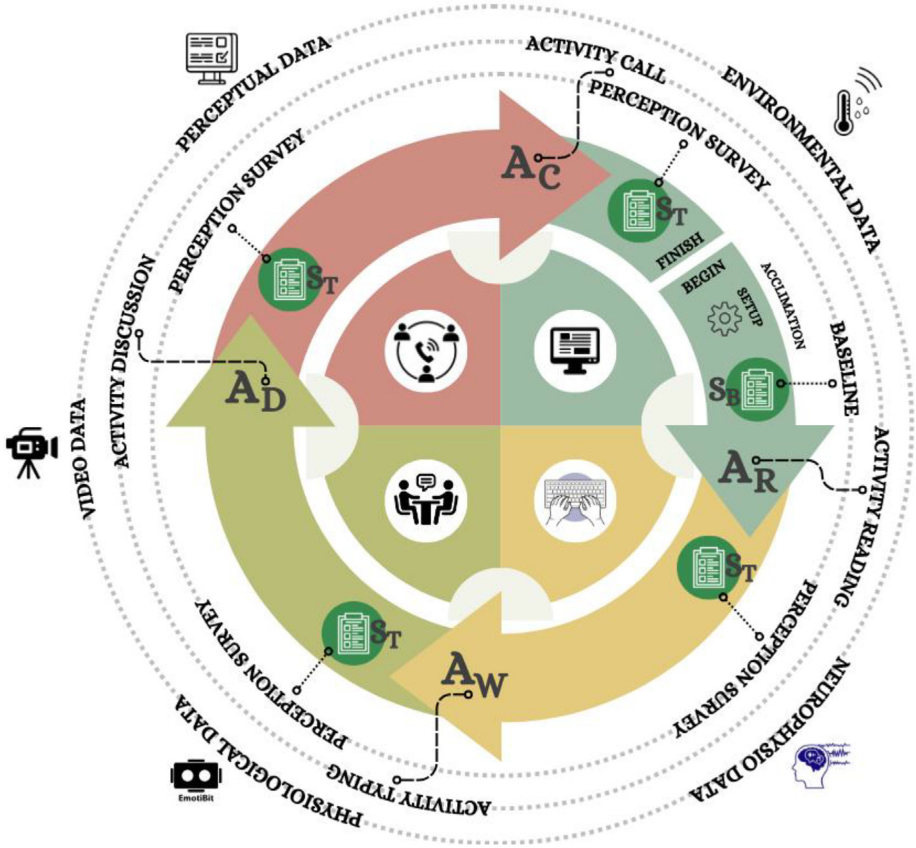



**Fig. 3.** The diagram provides a comprehensive view of the study's synchronized multimodal sensing dataset collection. It illustrates an overview of nine sequential phases—including the acclimation phase, baseline ($S_B$), activity blocks $A_x$ ($A_R$–Activity Reading; $A_W$–Activity Writing; $A_D$–Activity Discussion; $A_C$–Activity Call), and washout intervals ($S_T$).

rations, and survey checkpoints followed the fixed sequence depicted in Fig. 3, ensuring consistent temporal alignment between task execution, survey administration, and physiological signal acquisition across participants and sessions. The task sequence was fixed across sessions and participants:

**Reading task.** Participants first viewed a title and instruction screen for 30 s, followed by silent reading of an on-screen article for 150 s. Immediately after reading, a comprehension survey lasting 90 s was presented, consisting of five multiple-choice and five true/false questions. No cover or distraction screen was interposed between reading and comprehension; only a countdown timer transition indicated task progression.

**Transcription tasks.** Two consecutive transcription blocks of 300 s each were completed. In the first block, Subject A performed handwritten transcription while Subject B typed the same content using an on-screen text box; in the second block, modalities were swapped. To prevent copy–paste behavior in the typed condition, the source text was displayed as an image rather than selectable text. Handwritten and typed outputs were digitally captured and stored for subsequent performance and efficiency analyses.

After the transcription tasks, participants completed a standing resting baseline of 90 s, during which they stood quietly without interacting with the workstation. This phase enabled assessment of postural and activity-related physiological changes.

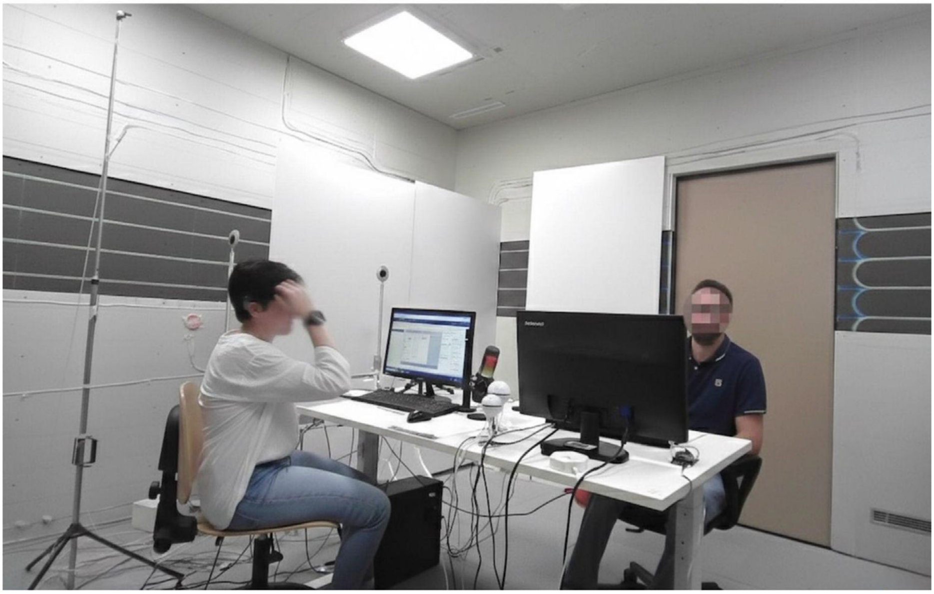


**Fig. 4.** Photomontage of the NEXT.ROOM climate chamber showing the seating arrangement and the positioning of physiological and environmental sensors.
(Image source [14]).

**Discussion task.** Participants then completed a guided discussion task. A 30-s instruction screen introduced the topic and bullet-point prompts, followed by a 300 s face-to-face discussion between the two participants. Prompts remained visible on the screen throughout the discussion to standardize content and cognitive load.

**Interference tasks.** Two interference blocks were implemented, each lasting 150 s, with explicit role alternation. In each block, one participant simulated a phone call by holding their personal phone to their ear and verbally presenting the other participant's viewpoint on the given topic. Simultaneously, the other participant typed a short report in a text box, also presenting the counterpart's viewpoint, guided by key points displayed on screen. Roles were swapped for the second block to ensure balanced exposure to verbal and written interference demands.

The full experimental session, including acclimation, baselines, tasks, surveys, and transitions, lasted approximately 64 min per session. All task onsets, offsets, survey submissions, and baseline periods were automatically time-stamped to allow deterministic alignment with physiological and environmental data streams. The detailed protocol used in this research study is available on protocols.io (Protocol Integer ID 235334 [15]).

### *4.3. Instrumentation and signals*

Physiological signals include electrodermal activity (EDA; skin conductance, µS) and peripheral skin temperature (ST; °C) recorded from EmotiBit [9] a wrist–worn wearable sensor on the non–dominant hand. The related study documentation reports nominal sampling rates of approximately 15 Hz for EDA and 7.5 Hz for ST, with manufacturer–reported accuracy ±0.01 µS and ±0.1 °C, respectively. Environmental parameters were collected using an integrated monitoring national instrumentation (NI) system installation in the NEXT.ROOM [10]; documented nominal rates are ~2 Hz for air temperature, relative humidity, air velocity, and globe temperature with typical accuracies ±0.1 °C, ±2 % RH, ±0.05 m/s, and ±0.2 °C. EEG, sample frequency ~256 Hz, is provided as four channels (TP9, AF7, AF8, TP10) from a headband wearable sensor

**Table 4**
Description of questionnaires' files.

| Survey | File(s) | Description |
|---|---|---|
| Initial Survey | initial_survey.csv | Demographic information, thermal and environmental topology. |
| Perception Survey | perception_survey.csv | Encompasses multi-domain sensation and comfort questionnaire: Thermal, Visual, Acoustic, Air-quality, and Productivity |

Muse-2 [8]; the session files include absolute timestamps. All sensing devices were operated according to the manufacturer's factory calibration specifications. The measurements represent direct device outputs collected during the experimental sessions, and no additional calibration procedures were applied prior to dataset release.

### *4.4. Surveys*

Perceptual responses were collected via the WEPOP platform [11], which was hosted on a local server and interfaced directly with each participant's laptop. Questionnaires were administered at pre–specified checkpoints within the experimental protocol, ensuring consistent temporal alignment across all sessions. Two primary questionnaire responses were generated as shown in Table 4.

All responses were recorded on ordinal Likert–type scales, and each entry is tagged with a unique session identifier to facilitate linkage between physiological measurements and perceptual outcomes. This structured approach enables rigorous multivariate analyses of how environmental variables influence occupants' comfort and performance across distinct thermal regimes.

### *4.5. Video modality (privacy–preserving release)*

To safeguard participants' privacy and support responsible data sharing under EU data-protection requirements, the dataset does not contain raw webcam video streams, individual video frames, or audio recordings. Instead, the release provides abstracted metrics together with a set of derived numerical descriptors that were extracted at a low sampling frequency. These descriptors include, for example, proxies for motion intensity, brightness, and image sharpness, as well as a face–presence ratio indicating the proportion of time a face was detected within a recording. The purpose of these aggregated features is twofold:

- Quality–Control: They enable researchers to assess the integrity and completeness of the video capture without exposing identifiable visual content.
- Coverage Assessment: They allow quantitative evaluation of participant engagement and the temporal distribution of facial visibility across experimental conditions.

By providing only these abstracted metrics, the dataset retains its utility for methodological validation and multimodal analysis while adhering to stringent ethical standards for participant confidentiality.

### *4.6. Reference preprocessing workflow*

To facilitate reproducible use of the dataset, a reference preprocessing workflow for the recorded timeseries signals is provided through the open-source HERODEV software package (available on GitHub [16]). The HERODEV pipeline demonstrates a standardized approach for transforming the raw recordings into analysis-ready signals and phase-level features.

The workflow includes modality-specific preprocessing steps commonly applied in physiological signal analysis. EDA signals are resampled and filtered, followed by decomposition into tonic and phasic components to estimate skin conductance level and event-related responses. ST signals undergo resampling and smoothing to reduce high-frequency noise. Environmental variables are temporally synchronized with the physiological measurements and aggregated to the same temporal resolution. EEG signals are processed using conventional spectral analysis procedures, including band-pass filtering, artifact rejection, and estimation of band-limited spectral power using sliding-window analysis.

The HERODEV pipeline further integrates synchronization of multimodal signals with the experimental timeline, enabling extraction of phase-level summary features across sessions and participants. By providing a transparent reference workflow alongside the Level-0 dataset, the resource supports reproducible signal preparation while allowing researchers to adapt preprocessing strategies according to their specific analytical objectives. Detailed usage instructions and implementation details are available in the GitHub repository [16].

## Limitations

The HERO dataset is released as level-0 data consisting of raw device exports annotated with session identifiers and experimental phase labels. No modality-specific preprocessing (e.g., EEG re-referencing or artifact correction, EDA tonic–phasic decomposition, or uniform resampling) has been applied. Consequently, analytical results depend on users' preprocessing choices, which should be documented and tailored to the characteristics of each modality.

Data were collected in a controlled climate-chamber environment using a standardized office-work protocol under a summer Mediterranean climate. While the experimental design enables controlled comparisons across thermal conditions, the laboratory setting does not capture the full diversity of real-world office environments, which may differ in building systems, ventilation strategies, occupancy patterns, lighting conditions, and acoustic environments. Future data collection could extend the dataset to larger and more diverse participant populations and include measurements from operational office environments with heterogeneous building systems and occupancy dynamics, complementing the controlled design presented here.

Each participant contributed two sessions (LT and HT), enabling within-subject comparisons but also introducing substantial inter-individual variability in baseline physiology, thermoregulatory capacity, and comfort perception. Analytical approaches should therefore account for participant-level structure, for example using mixed-effects or hierarchical models. For transparency on sample adequacy, the related research article associated with this dataset ([14], Section 3.1.1, Table 1) reports a formal G*Power post-hoc sensitivity analysis for the same cohort, indicating that $N = 24$ supports detection of medium within-subject effects, whereas subgroup analyses and small effects should be interpreted cautiously.

Multimodal sensing introduces practical challenges including missing data, variable signal quality, and device-specific artifacts (e.g., motion artifacts, sensor contact loss, device drop-outs, or truncated recordings). Dataset inventories and session summaries help identify potential data-quality issues; however, users must define appropriate inclusion criteria and conduct sensitivity analyses aligned with their analytical objectives.

To comply with ethical requirements and EU data-protection regulations, identifiable audiovisual recordings are not included in the public dataset. Instead, non-identifying video-derived metrics (e.g., motion, brightness, sharpness, and face-presence ratio) are provided for quality-control and coverage assessment, which limits analyses requiring raw visual content such as detailed behavioral coding or pose estimation.

## Dataset (level–0) availability

All physiological streams are released exactly as exported from the acquisition hardware and confined to the predefined experimental windows. Each record is annotated solely with a session identifier and hierarchical phase descriptors—phase_name, phase_label, and phase_order. No downstream processing (e.g., filtering, artifact correction, signal decomposition, re-referencing, or independent-component analysis) has been applied. When the acquisition or export pipeline introduces irregular sampling or buffering artifacts, users may apply resampling strategies appropriate for their analysis. To support quality control, the accompanying inventory provides an approximate effective sampling rate derived from the timestamps, enabling reconstruction of uniformly sampled time series using the researcher's preferred methodology.

The complete Level-0 raw recordings are archived on Zenodo [7]. These raw exports are distributed through an access-request procedure rather than unrestricted direct download. This access model allows tracking of dataset usage and ensures that users are informed about the dataset structure, preprocessing requirements, and appropriate citation practices before accessing the full raw recordings. The Zenodo dataset release therefore provides derived data information that enable suitability of the dataset, while the Level-0 recordings remain available through the Zenodo access form for researchers requiring the original device exports.

## Ethics Statement

This study was conducted within the project MuSIC—Multi-sensory Solutions for Enhancing Human–Building Resilience in the Face of Climate Change, received ethical approval for WE-POP project Nr. 369308 from 30/11/2023, approved on 15/01/2024 by the Comitato Universitario di Bioetica from the University of Perugia. All participants provided written informed consent prior to participation and were debriefed after completion, including clarification of the study objectives and intended data use. Participant confidentiality was protected in accordance with institutional standards for human-subject research and applicable European data-protection requirements, including the EU General Data Protection Regulation (GDPR). The dataset contains no direct personal identifiers and all records are pseudonymized. Because video data are inherently identifying, the release does not distribute raw audiovisual recordings; instead, it provides privacy-preserving, non-identifying derived video features intended for quality and coverage assessment.

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## CRediT Author Statement

**Puneet Tomar:** Conceptualization, Investigation, Methodology, Validation, Experimentation, Data Curation, Formal analysis, Visualization, Writing–Original Draft. **Dianel Ago:** Validation, Experimentation, Methodology, Software, Data Curation, Visualization, Writing-Review & Editing. **Ilaria Pigliautile:** Conceptualization, Methodology, Investigation, Validation, Writing-Review & Editing. **Gloria Cosoli:** Conceptualization, Methodology, Investigation**,** Writing – review & editing. **Veronica Martins Gnecco:** Conceptualization, Methodology, Writing – review & editing. **Sara**

**Casaccia:** Conceptualization, Validation. **Gianluca Sartini:** Conceptualization, Methodology. **Silvia Angela Mansi:** Conceptualization, Writing – review & editing. **Anna Laura Pisello:** Investigation, Resources, Supervision, Project Administration, Funding acquisition. **Marco Arnesano:** Investigation, Resources, Supervision, Project Administration, Funding acquisition.

## Data Availability

Human Experience in Regulated Offices (HERO) (Original data) (Zenodo).

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## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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