# The Human State Interface (HSI) 1.0

## A Canonical Contract for Interoperable Human-State Systems

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## Abstract

Modern computing systems increasingly attempt to model aspects of human state—such as affect, engagement, attention, or stress—using diverse signals, models, and devices. However, the absence of a shared interface contract has resulted in fragmented ecosystems, vendor-specific representations, and incompatible assumptions around time, confidence, and privacy.

The Human State Interface (HSI) 1.0 introduces a canonical, language-agnostic contract for representing human-state outputs in a way that is interoperable, privacy-first, and strictly validated. HSI does not prescribe how human states are inferred, which signals are used, or which models are applied. Instead, it defines a stable interface layer—analogous to HTTP for networking or JSON for data exchange—allowing independent systems to produce, consume, and combine human-state representations without tight coupling.

This whitepaper describes the motivation, design principles, and architecture of HSI 1.0, and explains how it enables scalable, privacy-preserving human-state ecosystems across devices, platforms, and organizations.

## 1 Introduction

Human-aware computing has become a core capability across domains including health, productivity, education, entertainment, and human–computer interaction. Systems now routinely estimate emotional states, engagement levels, behavioral patterns, or physiological proxies using machine learning, heuristics, or signal processing pipelines.

Despite rapid progress in inference methods, interoperability remains a fundamental bottleneck. Today:

- Each system defines its own schemas and semantics.
- Time windows are implicit or inconsistently defined.
- Confidence is often missing or incomparable.
- Privacy guarantees vary widely and are rarely explicit.
- Consumers must hard-code assumptions about producers.

As a result, combining human-state outputs across systems—or evolving internal implementations without breaking downstream consumers—is unnecessarily difficult.

HSI addresses this gap by defining a contract-only interface for human-state outputs. It separates what is communicated from how it is computed.

## 2 Design Philosophy

HSI is guided by several core principles:

### 2.1 Contract-Only by Design

HSI intentionally avoids specifying:

- inference algorithms
- sensor requirements
- model architectures
- SDK implementations
- storage or visualization strategies

This ensures that innovation in modeling and sensing can proceed independently, without breaking compatibility.

### 2.2 Time as a First-Class Concept

All human-state readings are explicitly scoped to named time windows. This eliminates ambiguity around:

- instantaneous vs. aggregated states
- overlapping observations
- alignment across producers

### 2.3 Confidence as a Required Signal

Every axis reading includes a normalized confidence score. This allows consumers to reason about uncertainty explicitly rather than relying on implicit heuristics.

### 2.4 Privacy-First Defaults

HSI forbids personally identifiable information (PII) and treats embeddings as sensitive by default. Privacy constraints are explicitly declared in every payload.

### 2.5 Strict Validation and Fail-Fast Semantics

HSI is defined by a normative JSON Schema. Consumers are expected to reject invalid payloads rather than silently accepting malformed data.

## 3 Conceptual Model

At a high level, an HSI payload represents:

- when a human state was observed
- over what time window it applies
- what dimensions (axes) were estimated
- how confident the producer is

- which sources contributed (without exposing devices or identities)
- what privacy guarantees apply

HSI is intentionally agnostic to whether states are derived from physiology, behavior, self-report, or hybrid approaches.

## 4 Canonical Payload Structure

An HSI payload is a single JSON object containing:

- Versioning metadata (`hsi_version`)
- Temporal metadata: `observed_at_utc` (event time) and `computed_at_utc` (processing time)
- Producer identity (non-PII)
- Named time windows
- Axis readings, grouped by domain
- Optional sources and embeddings
- Explicit privacy assertions

This structure allows multiple readings—across different domains and time scales—to coexist in a single, self-describing payload.

## 5 Time Windows

Rather than repeating timestamps for every reading, HSI uses named windows:

- Each window declares a start and end time.
- Axis readings reference windows by identifier.
- Multiple axes can share the same temporal scope.

This approach supports:

- short-term and long-term aggregation
- overlapping analyses
- consistent alignment across producers

Windows are treated as half-open intervals by default, enabling precise temporal reasoning.

## 6 Axes and Domains

HSI expresses human state using axis readings—normalized scores with confidence values—grouped into semantic domains:

### 6.1 Affect

Represents internal emotional or physiological state, such as arousal or calmness.

### 6.2 Behavior

Represents observable interaction patterns, such as activity intensity or attention proxies.

### 6.3 Engagement

Represents integrative or derived involvement states, often computed from affective and behavioral inputs.

HSI deliberately avoids a closed ontology. Producers may introduce new axes, and consumers are required to handle unknown axes gracefully.

## 7 Handling Uncertainty and Missing Data

HSI distinguishes between:

- **Omitted axes**: the producer does not emit that axis.
- **Explicitly null readings**: the axis exists but is unavailable due to access control, missing sources, or other constraints.

This distinction is critical for systems operating under consent, authorization, or degraded sensing conditions.

Null values are never interpreted as zero.

## 8 Sources and Evidence

HSI allows producers to describe input sources in an abstract, non-identifying manner. Sources are classified by type (e.g., sensor, app, derived) and include quality indicators.

Axis readings may reference the sources used as evidence, allowing consumers to understand why a reading exists without learning how it was computed.

## 9 Embeddings as Optional, Sensitive Artifacts

HSI supports optional embeddings for advanced use cases such as downstream modeling or clustering. However:

- Embeddings are treated as sensitive by default.
- Payloads may include hashes instead of raw vectors.
- Consumers must not assume embeddings are present or accessible.

This design balances extensibility with privacy and access control.

## 10 Privacy Model

Every HSI payload includes explicit privacy assertions, including:

- confirmation that no PII is present
- whether raw biosignals are included or allowed
- whether derived metrics and embeddings are permitted
- consent level and intended purposes (optional)

If a producer cannot guarantee these constraints, it must not emit HSI payloads.

## 11 Validation and Compliance

HSI defines two validation compliance levels:

- **Basic**: structural and range validation
- **Strict**: structural validation plus reference integrity

The canonical schema enables both, allowing systems to choose the appropriate level based on risk and capability.

## 12 Versioning and Evolution

HSI uses semantic versioning:

- Minor versions extend the contract in backward-compatible ways
- Major versions may introduce breaking changes

Consumers validate against the major version they support, ensuring long-term stability.

## 13 Positioning and Use Cases

HSI is not an application, SDK, or model. It is infrastructure.

Potential applications include:

- on-device affective computing
- cross-platform engagement analytics
- privacy-preserving human-state aggregation
- consent-aware adaptive interfaces
- research interoperability across datasets and tools

## 14 Conclusion

HSI 1.0 establishes a foundational interface for human-state systems—one that decouples representation from inference, enables interoperability without standardizing models, and treats privacy and uncertainty as first-class concerns.

By defining a stable, validated contract, HSI enables ecosystems where human-state intelligence can evolve rapidly without fragmenting the systems that depend on it.