

An Open-Source, Low-Cost Olfactometer: Design, Fabrication, and Performance Characterization

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Patent Note: A patent application (PCT/SA2025/050046) is pending. The design is released for academic and non-commercial use under open-source principles.

Abstract

Objective: This paper presents the design, fabrication, and technical validation of a low-cost (<\$50 USD), open-source olfactometer. The device addresses the prohibitive cost barrier of commercial systems, enabling accessible research and screening tools for olfactory function.

Methods: We detail the engineering design, bill of materials (BOM), and assembly protocol using globally available components. System performance was characterized by measuring environmental stability (temperature, humidity), odor delivery consistency, and chamber purge efficiency in a controlled pilot test.

Results: The prototype maintained stable environmental conditions ($26.3^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$, $71.3\% \pm 0.4\% \text{RH}$). Odorants were successfully delivered and subjectively discriminated. The integrated purge system achieved clearance within 3.18 ± 0.20 minutes, confirming rapid reset capability.

Conclusion: We provide a fully documented, replicable design for a functional olfactory testing platform. This work establishes a foundation for community-driven development, adaptation, and validation of low-cost sensory testing tools.

Keywords: Open-Source Hardware, Olfactometer, Medical Device Prototype, Low-Cost Diagnostics, Sensory Engineering

1. Introduction

Olfactory testing is a valuable tool in neurology and sensory science, yet standardized equipment remains costly and complex. Open-source hardware principles offer a viable path to democratize such technologies. This paper details the engineering development of a sub-\$50 olfactometer, contributing a replicable design file to the community. The focus is

on **device fabrication, technical performance, and replicability**, providing a platform for future psychophysical and clinical validation by researchers worldwide.

2. Design Specifications & Fabrication

2.1. Design Requirements & Rationale

The design prioritized: (1) unit cost <\$50, (2) use of ubiquitous components, (3) no specialized tools for assembly, (4) controlled stimulus delivery, and (5) rapid purge capability. The architecture is a sealed chamber with active injection and purge, providing a core framework for modifications.

2.2. Complete Bill of Materials (BOM)

All components are consumer-grade. Total cost is approximately **\$47.50** (prices may vary by region).

Component	Specification	Qty	Unit Cost (USD)	Source Example
Main Chamber	1L Transparent Food Container	1	2.00	Local Store
Micro DC Fan	40mm, 12V, 0.1A	1	3.00	Electronics Retailer
Humidity Sensor	DHT22 (Digital)	1	6.00	Online Marketplace
Microcontroller	Arduino Nano Clone	1	4.00	Online Marketplace
Syringe & Port	10mL Luer-Lock, Tubing	1	2.50	Pharmacy
Power Supply	9V Battery + Clip	1	4.00	Electronics Retailer

Component	Specification	Qty	Unit Cost (USD)	Source Example
Miscellaneous	Wires, Switch, Sealant, Vials	-	6.00	Various
Total Estimated Cost			\$47.50	

2.3. Step-by-Step Assembly Protocol

Full visual instructions are in Supplementary File S1.

1. **Chamber Modifications:** Drill three 8mm ports in the container lid for the odor inlet, air inlet, and sensor/fan assembly.
2. **Sensor/Fan Integration:** Mount the DHT22 sensor and DC fan inside the lid. Connect to the Arduino Nano for data logging (code provided in S2).
3. **Fluidic System:** Attach Luer ports to tubing. Connect one port to the syringe (injection) and another to a filtered air intake.
4. **Sealing & Calibration:** Apply non-toxic sealant around all ports. Power the system and use the serial monitor to verify sensor functionality and chamber seal.

3. Methods: Technical Performance Characterization

A single-operator pilot test was conducted to characterize basic device performance metrics, explicitly defined as a **technical feasibility assessment**.

3.1. Environmental Stability Test

The empty, sealed chamber was monitored for 60 minutes. Temperature and humidity data from the integrated DHT22 sensor were logged via Arduino to assess stability without active climate control.

3.2. Operational Workflow & Metrics

1. **Odor Delivery:** For each of three odorants (Lemon, Vanilla, Oud), 1 mL of pure essential oil was diluted with 5 mL of distilled water and injected.
2. **Subjective Function Check:** The operator provided a perceived intensity score (0-3) to confirm odor presence and discriminability.

3. **Purge Efficiency:** The fan was activated. The time until no odor was detectable at the intake port was recorded, with a 5-minute cutoff.

4. Results: System Performance

4.1. Environmental Control

The passive system maintained stable conditions: mean temperature = 26.3°C ($\pm 0.5^\circ\text{C}$ SD), mean relative humidity = 71.3% ($\pm 0.4\%$ SD).

4.2. Functional Performance

- **Odor Delivery:** All three odorants were successfully delivered and subjectively distinguished.
- **Purge Efficiency:** The mean purge time was 3.18 minutes (± 0.20 SD), with no residual odor reported between sequential trials.

Table 1: Performance Results Summary

Metric	Mean Value	Standard Deviation	Measurement Method
Chamber Temperature	26.3 °C	± 0.5 °C	DHT22 Sensor
Chamber Humidity	71.3 % RH	± 0.4 % RH	DHT22 Sensor
Chamber Purge Time	3.18 min	± 0.20 min	Operator Stopwatch

5. Discussion

5.1. Design Significance as Open-Source Hardware

This work's primary contribution is a validated, replicable design file for a critical research tool. It demonstrates that core olfactometer functionality can be achieved with minimal cost, serving as a modular platform for community innovation (e.g., adding mass-flow controllers, VOC sensors).

5.2. Limitations and Future Engineering Work

This prototype is a **first-generation proof-of-concept**. Key engineering limitations and future development paths include:

1. **Concentration Control:** The current design uses static liquid injection. The next iteration should integrate dynamic dilution via solenoid valves and mass flow controllers for threshold testing.
2. **Automation:** The workflow is manual. The design can be extended with software (Python/Arduino) for fully automated trial sequencing and data logging.
3. **Formal Inter-lab Validation:** The critical next step is independent replication and performance testing by other engineering groups to validate robustness.

5.3. Path to Peer-Reviewed Publication

A strong journal submission (e.g., to *HardwareX*, *Journal of Open Hardware*, or *Sensors*) will result from completing the "Future Engineering Work" above, particularly **inter-lab replication** and the integration of **quantitative concentration control**. This preprint establishes the foundational design priority.

6. Conclusion

We present a complete engineering package for a functional, low-cost olfactometer. All design files, code, and protocols are provided to ensure replicability. This open-source approach aims to accelerate innovation and collaboration in sensory testing and accessible diagnostics, lowering a significant barrier to entry for researchers and clinicians worldwide.