Mindfully: A Miniature BioMEMS Wearable for DHI(Discrete Habit Intervention)

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Motivation and Problem Statement

80% addiction relapse, 70% habit failure.

Wellness industry is $6.3 Trillion as of 2023 with a CAGR of 7.3%

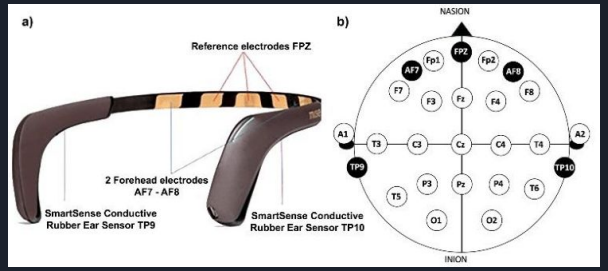
Lack of real-time, predictive, discreet intervention tools

Gaps in Existing Technology

Fitbit: Reactive Health and Fitness Tracking

Muse EEG: Intrusive Design, not Habit-Specific

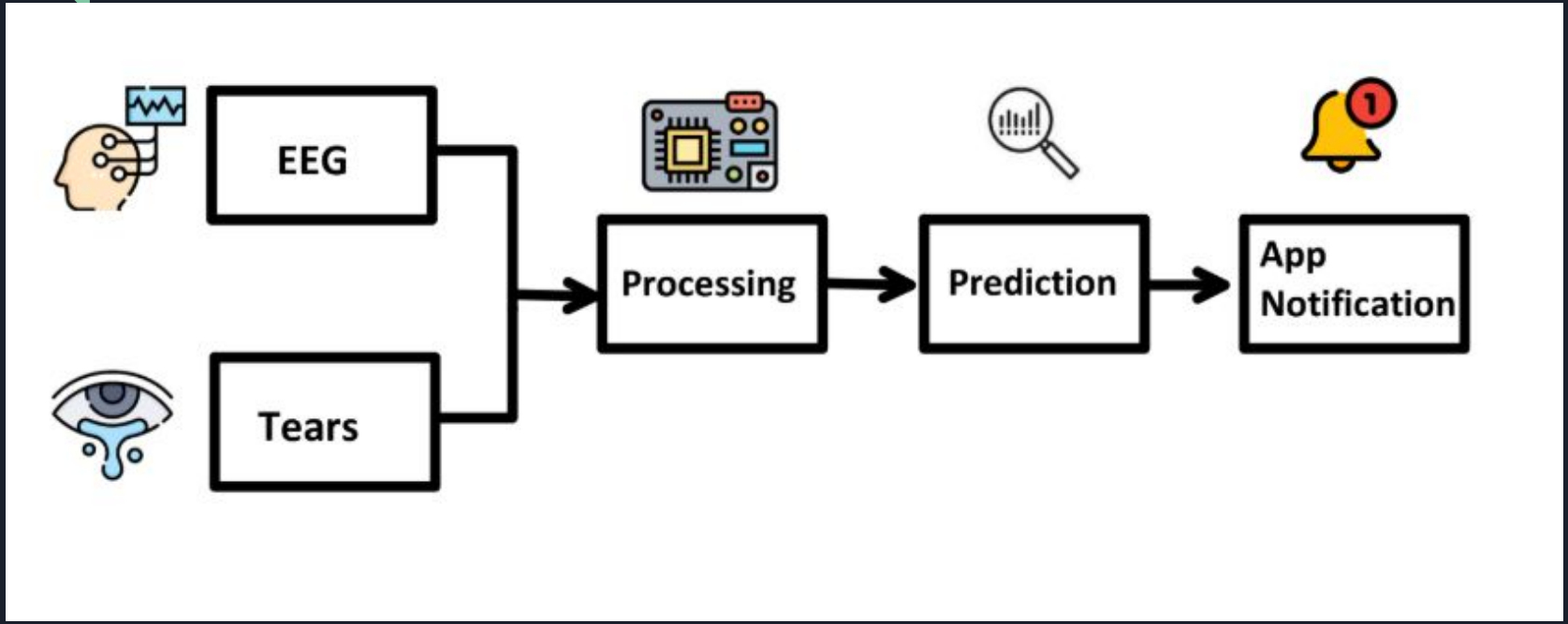
Lack of Miniaturization, Comfort, and Multi-Modal sensing



Project Objective

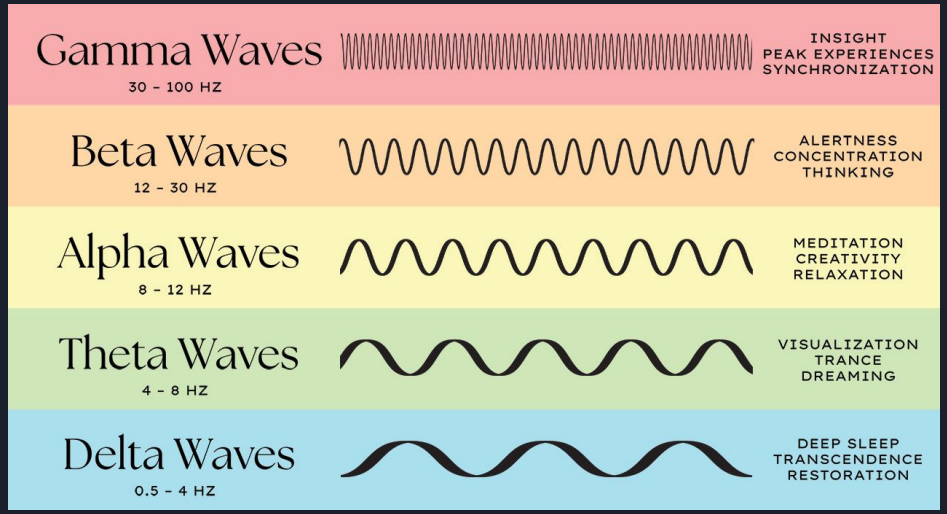
- Develop a Discreet, Predictive, Wearable BioMEMS device
- Combines EEG + Tear Analysis for Early Relapse Detection
- Seamlessly Integrate into Glasses as a Clip-on

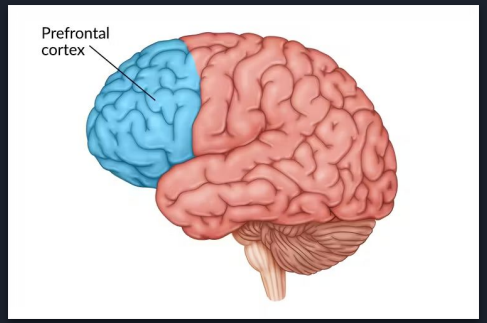
System Overview/Block Diagram



General Working Mechanism

1. EEG signal acquisition and processing
2. Prefrontal cortex monitoring for impulse control
3. Tear collection via microfluidic pad
4. Colorimetric analysis for stress hormones (cortisol, dopamine)





https://pmc.ncbi.nlm.nih.gov/articles/PMC3462342/

Applied Physics Analysis

EEG: Measures brain signals via biopotentials (Ag/AgCl electrodes)

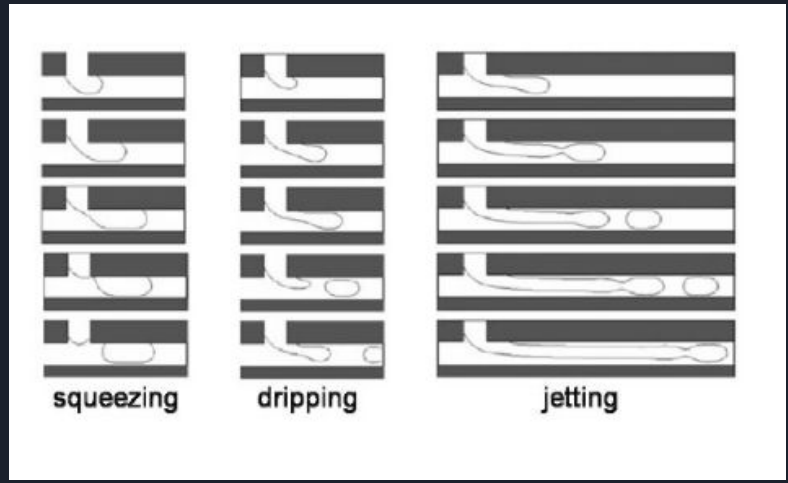
Microfluidics: Tear flow follows Navier-Stokes & capillary action

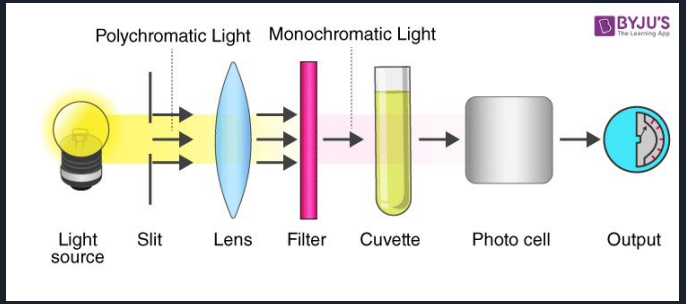
Passive flow: No pump, uses surface tension

Chemical detection: Beer-Lambert Law (A = εcl)

$$0 = -\nabla p + \mu \nabla^2 \mathbf{u} + \mathbf{f}$$

$$Ca = \mu u / \gamma.$$





Tear Drop Analysis

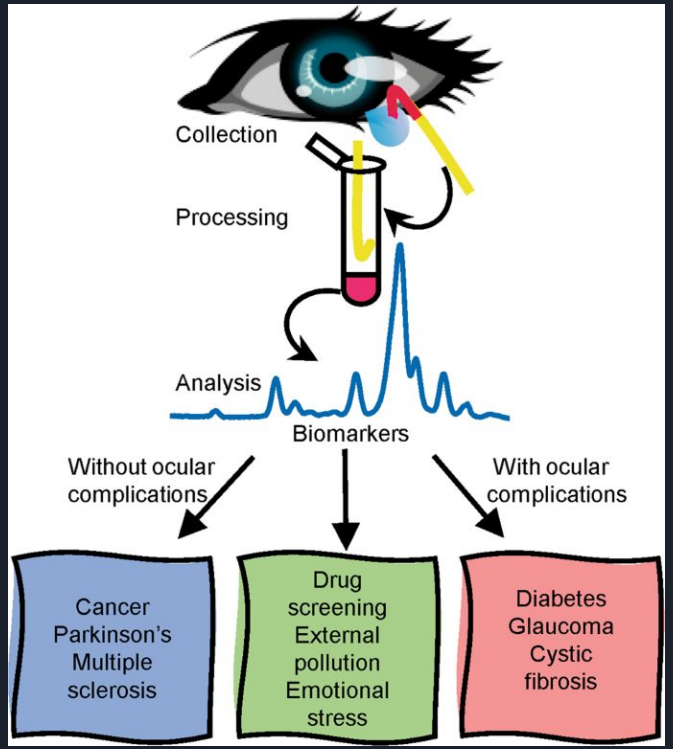
Tear fluid contains key brain chemicals: dopamine, serotonin, cortisol

Linked to mood and stress – reflects mental health state

Non-invasive collection – safer than blood or urine

Emerging method – less common but growing in research

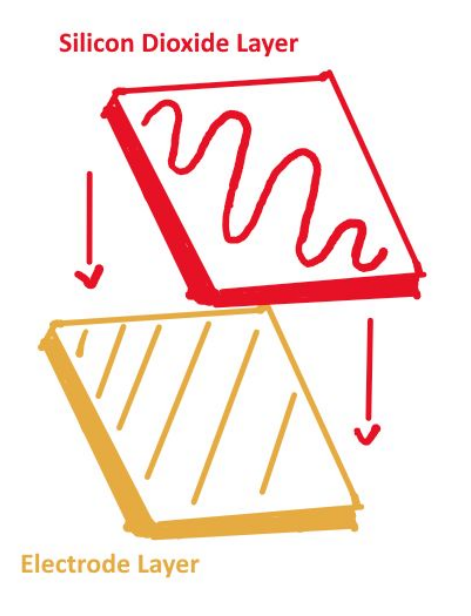
https://www.nature.com/articles/s41433-020-0930-0



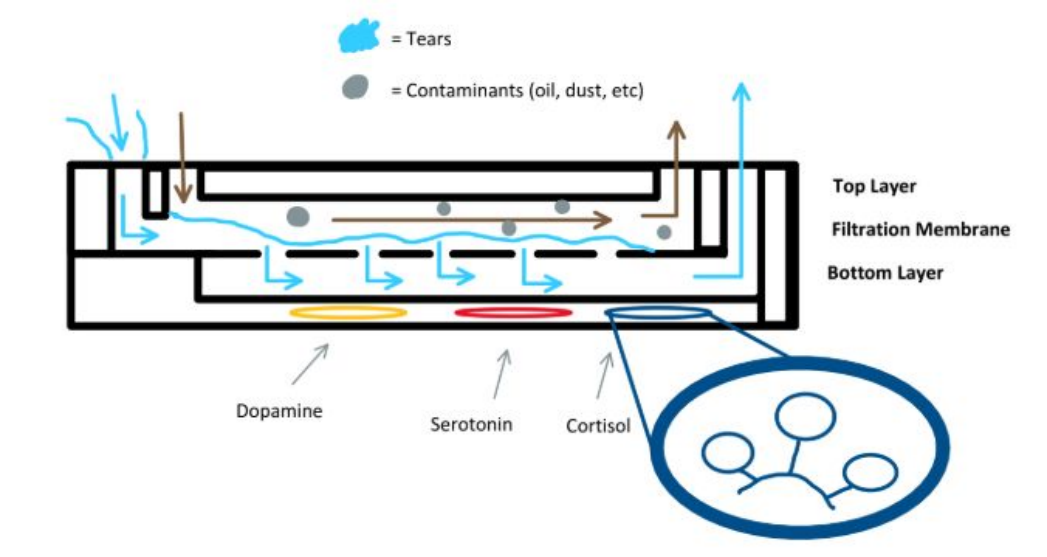
Device Packaging and Form Factor

- Clip-on design with:
  - Embedded Microfluidic chambers
  - Internal, spring-loaded clip-on
- Discrete design, blends in with user's current glasses
- To be designed for user comfort.

Internal Layering

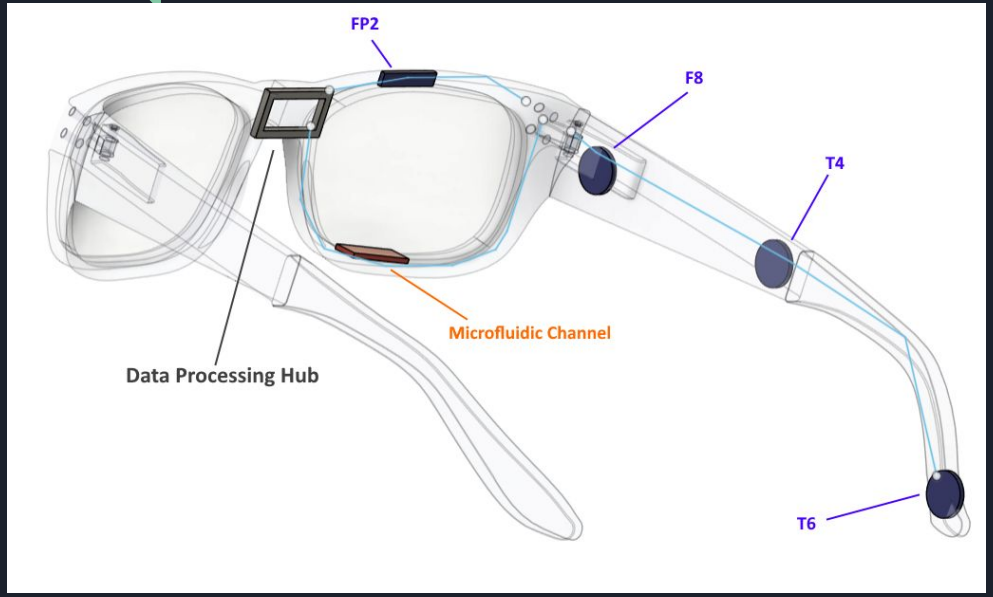


Electrode Design



Microfluidic Chamber Design

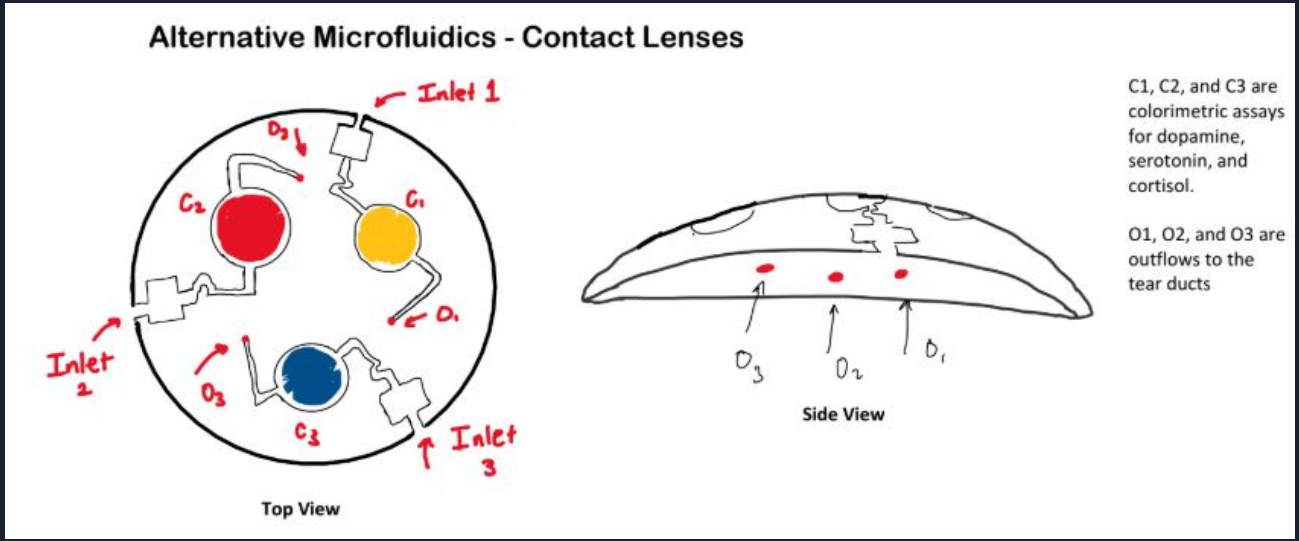
Prototype Design & Build



Three Components:

- (1) Data Processing Hub
  - Filters
  - Amplifiers
  - Bluetooth
  - Power
- (2) Dry Electrodes
  - Frontal Regions:
    - Fp1 and Fp2 → Decision Making
    - F7 → Mood Regulation
    - F8 → Impulse Control
  - Temporal Lobes:
    - T4/T6 → Emotional Distress
    - T3/T5 → Emotional Stability
- (3) Microfluidic Chambers
  - Embedded Assays

Alternative Designs



Contact Lenses:

- **Function:** Microfluidic chambers embedded
- **Pros:** Most efficient method of tear analysis
- **Cons:** Less convenient, needs regulatory approval

Alternative Designs

Functional Near-Infrared Spectroscopy (FNIRS):

- **Function:** Near-infrared light to measure changes in blood oxygen levels
- **Pros:** Relatively effective in behavioral analysis
- **Cons:** Bulky, non discrete, typically used In-Lab, Less mature (Niche)

https://soterixmedical.com/research/monitoring/fnirs

Comparison to Existing Devices

Fitbit, Muse EEG – strengths and weaknesses

- Fitbit Strengths: User friendly; Fitbit Weaknesses: Bulky, no protection
- Muse EEG Strengths: Portable; Muse EEG Weaknesses: Noticeable, not habit-focused
- Both can potentially cause discomfort if worn for lengthened periods of time [4]

How Mindfully fills the gap:

- Design is miniature and discreet, seamlessly integrating into a user's glasses.
- Thus the need for user-specific design fitting is greatly reduced and potentially removed [7]

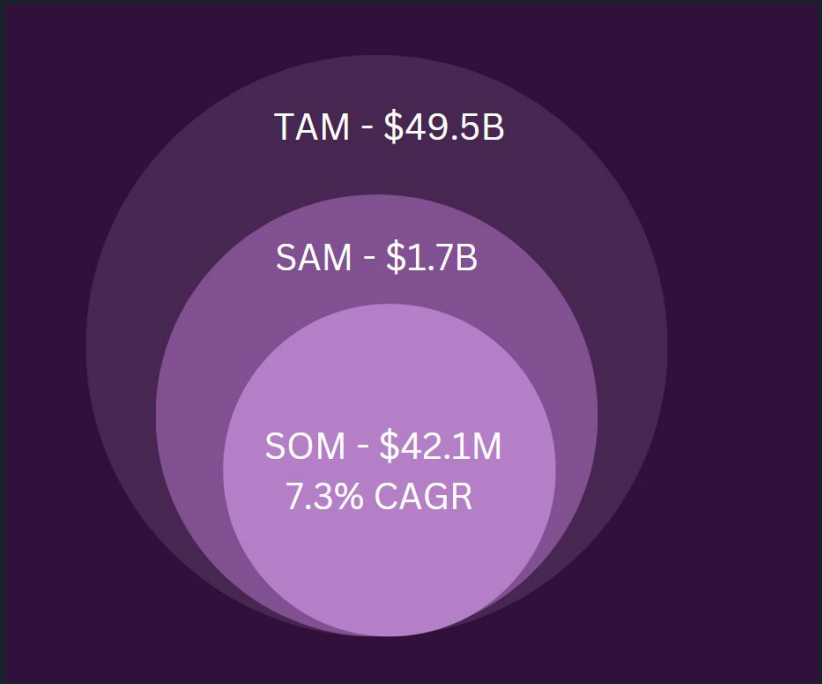
Expected Outcome

Predictive habit relapse detection

Discreet, user-friendly interface

Supports healthcare professionals in intervention planning

Business Model/Go to Market Strategy



BUSINESS MODEL

- B2C: Single-time revenue for the sale of devices
- B2C: Saas Subscriptions
- B2B: Psychologists refferals
- B2B: Insurers will license anonymized data for studies and personalized treatment plans

Design Challenges & Troubleshooting

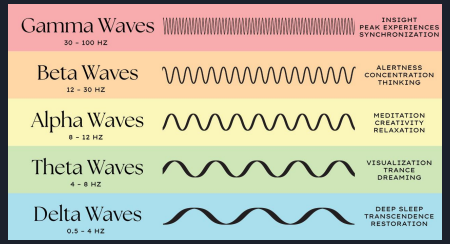
Tear protein degradation

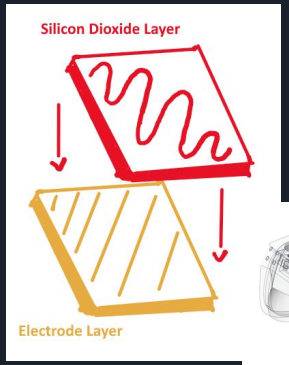
Motion noise in EEG

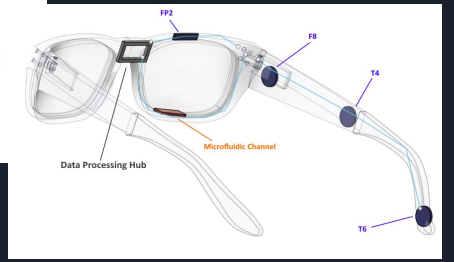
Comfort/Universal fit issues

Future Improvement

Conclusion





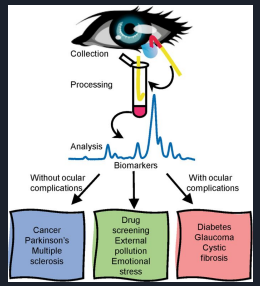


We Identified that there is a real demand for a proactive solution.

We assessed why current technologies fail in habit development.

Primary research supports the feasibility of the development of this technology.

- Mindfully…
- Is the first unobtrusive device designed to predict and prevent relapse in real time.
- Has an integrated design with a glasses clip-on with EEG + microfluidic tear analyzer for stress biomarker monitoring.
- Has functionality as it forecasts relapse risks (e.g., stress-eating) and delivers app-based nudges for proactive control.
- Has challenges ahead such as miniaturizing EEG, stabilizing tear proteins and ensuring comfort for everyday use.
- Will discreetly reduce relapse and improve long-term health outcomes.



Thank You

More References

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