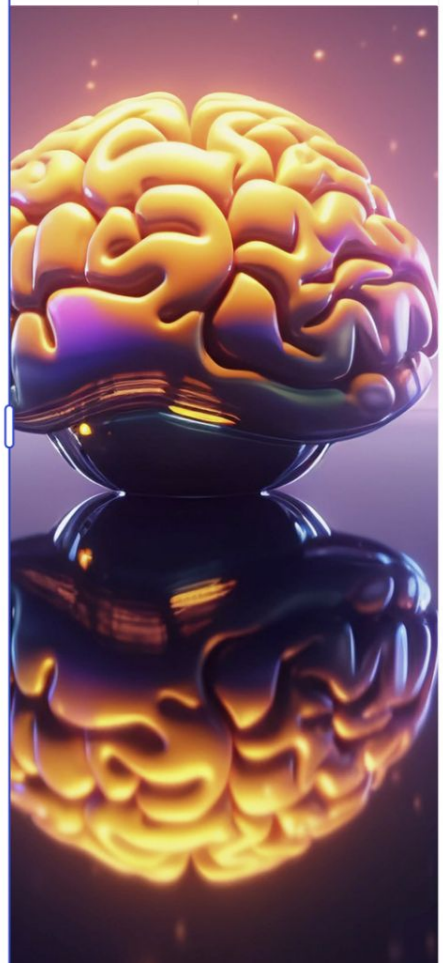
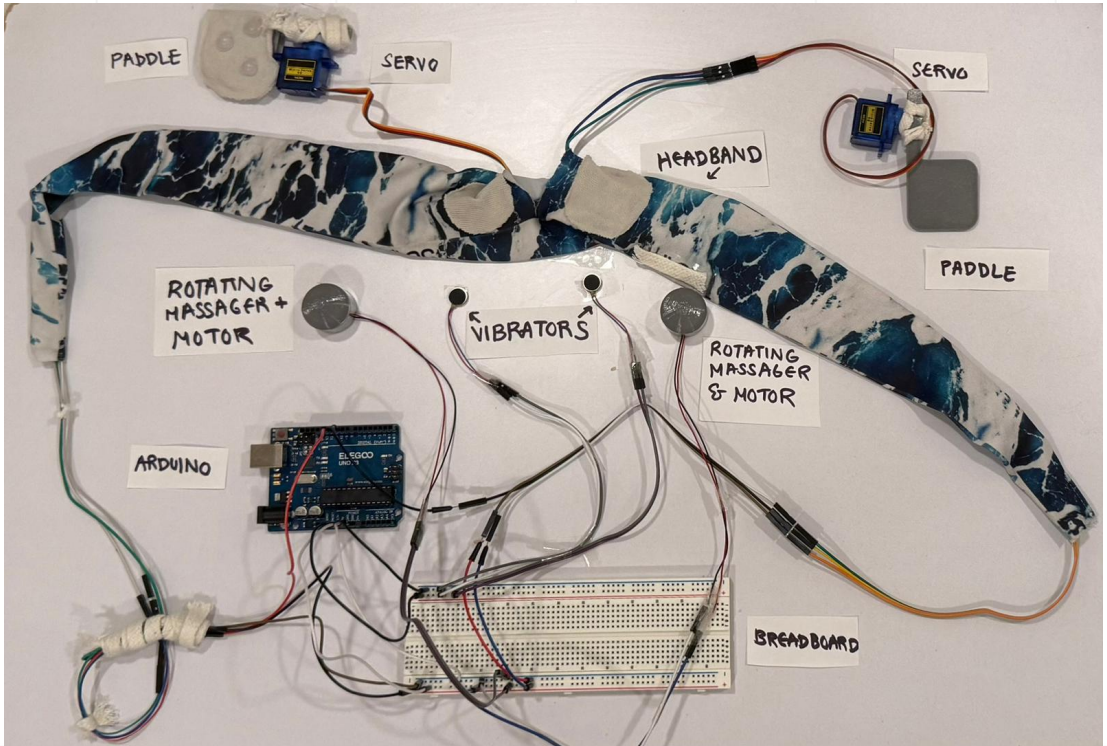
Preliminary Design of a Massage-Based Therapeutic Device for Migraines

Thejo Tattala



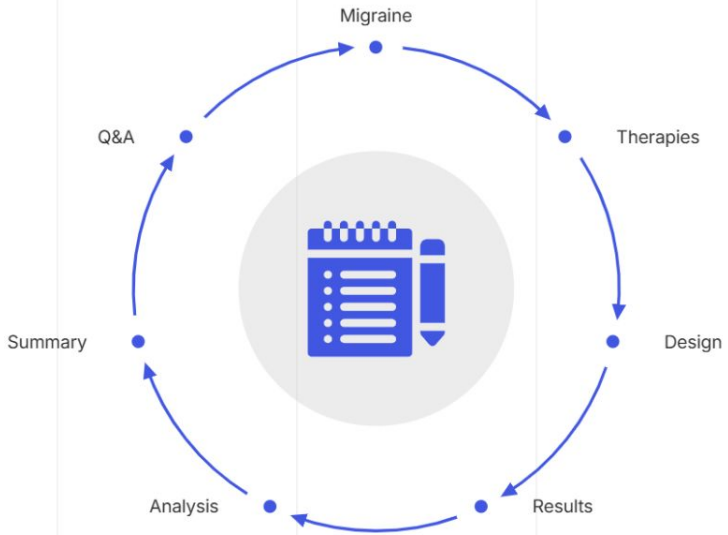
Explore the Wearable Headband's Ergonomic Design

Visualize the compact form and multi-modal stimulation features for migraine relief



Agenda and Presentation Overview

Outline of research and development for a novel wearable migraine device



Introduction: Migraine Challenges and Need for Wearable Therapy

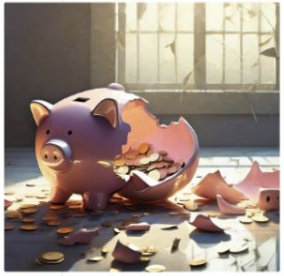
Addressing accessibility and efficacy in migraine external therapy with innovative wearable technology

Highlight the global prevalence and impact of migraines

Migraines are the second most common neurological disorder worldwide, causing severe pain, reduced productivity, and significant treatment expenses.

Identify limitations of current migraine treatments

Conventional treatments such as medication, nerve blocks, and surgery tend to be invasive, expensive, or risk addiction, limiting patient options.



Recognize drawbacks of existing external migraine therapies

Current external therapies—cold therapy, massage, electrical stimulation—are often bulky, costly, and unsuitable for routine daily use.

Emphasize the need for practical, wearable migraine relief

There is a critical demand for a discreet, affordable, and wearable device that provides rapid, temporary migraine relief in everyday settings like work or school.

Introduce novel wearable massage-based therapeutic device

This research presents a wearable device integrating oscillatory pressure, vibration, and rotational massage to enhance accessibility and effectiveness of migraine external therapy.

Literature Review: Evolution of Mechanical and Physical Migraine Therapies

Chronological progression from early cold and mechanical methods to advanced osteopathic interventions

1993

Initial Cold and Mechanical Therapies

Early studies introduced ice packs and rubber disks applying scalp pressure, marking foundational attempts at cold and mechanical migraine treatment.

1998

Massage Therapy Benefits Demonstrated

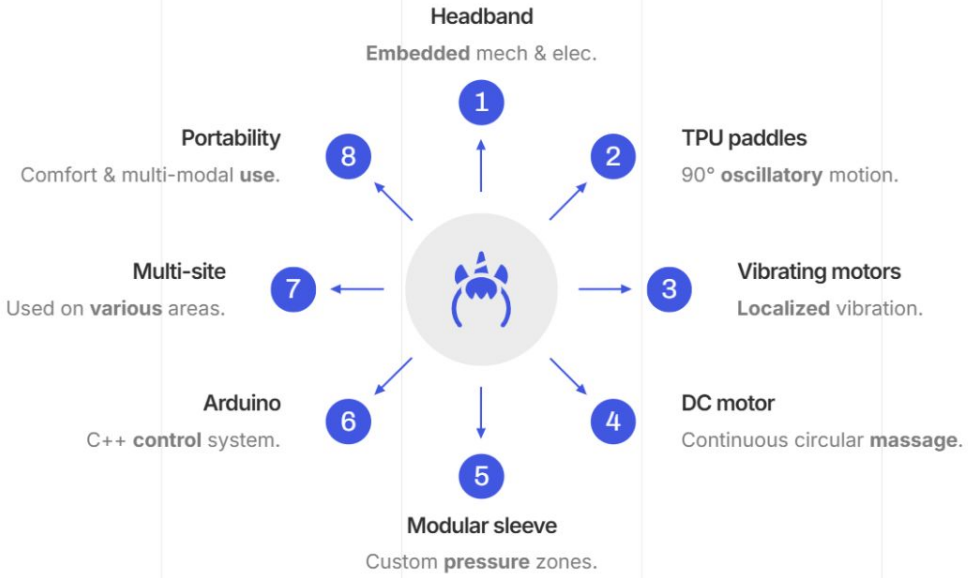
Research showed massage on neck and sub-occipital areas reduced headaches and anxiety, highlighting non-invasive therapeutic potential.

2005

Physical Therapy vs. Massage Comparison

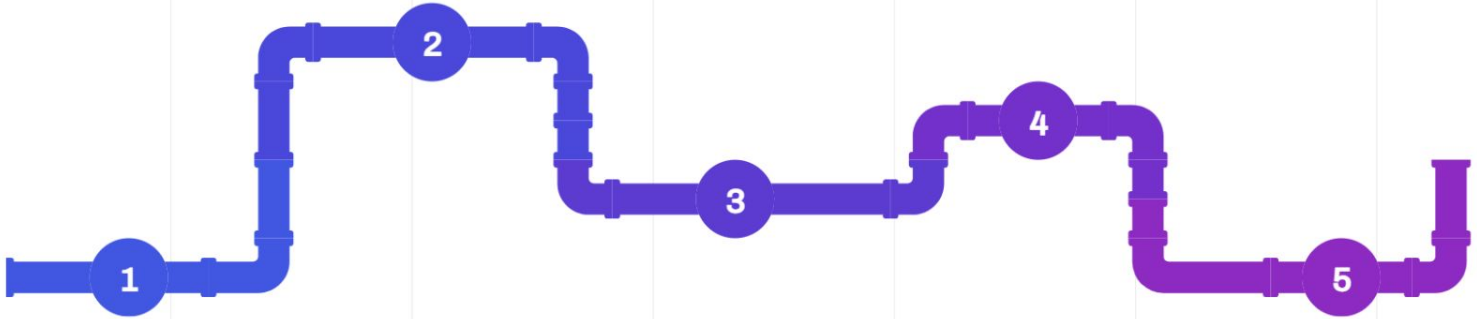
Findings suggested physical therapy might be more effective than massage for certain patients, guiding tailored therapeutic approaches.

Device Design: Wearable Headband with Multi-Modal Mechanical Stimulation



Testing Protocols: Evaluating Device Performance and User Experience

Comprehensive methods assessing device functionality, comfort, durability, and portability



Vibration Testing

Measured stimulation intensity via smartphone accelerometer across three trials to quantify output consistency.

Acoustic Testing

Recorded noise levels using Apple Watch decibel app for overall device and individual components to assess sound emissions.

Usability & Comfort Survey

Surveyed 8–12 adults after 10-minute wear sessions on ease of use, comfort, pressure, soothing effect, and discreteness using 5-point Likert scale.

Durability Testing

Subjected device to 100 on/off cycles, 3 drops from 75 cm, and 50 flex cycles; inspected for mechanical integrity and resilience.

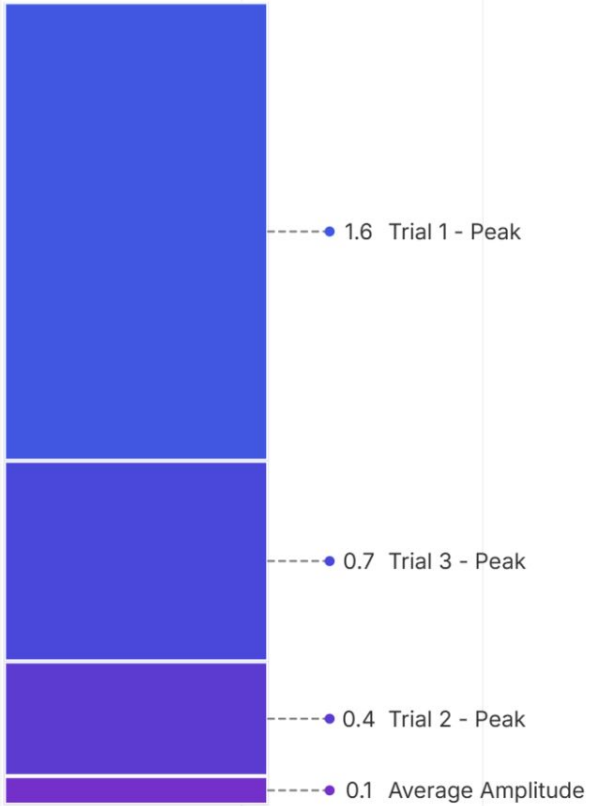
Cost & Portability Assessment

Compiled bill of materials excluding Arduino and breadboard; measured weight and size to evaluate daily use feasibility.

Vibration Testing Results: Mechanical Stimulation Metrics

Analysis of vibration amplitude and peak values across multiple trials

Peak And Average Vibration Amplitudes Across Trials



Internal vibration testing data from device trials

Acoustic Testing Results: Noise Levels and Implications

Acoustic noise measurements and their impact on wearable therapeutic device design for migraines

Mode	Noise Level (dB)
Overall Device	58
Vibrator Only	60
Servo Paddles	45–60 (depending on phase)
Motor Only	55

Usability and Comfort Testing: User Feedback and Ratings

Analyzing user survey scores and qualitative feedback after device wear

1. Conduct usability testing with 8–12 adult participants

Participants wore the device for 10 minutes before providing feedback, ensuring initial impressions on comfort and usability were captured.

2. Achieve median survey scores ≥ 4/5 on ease of donning and comfort

Survey results indicate high user satisfaction with how easily the device can be worn and overall comfort during use.

3. Gather qualitative feedback highlighting device strengths and weaknesses

Users reported the headband as easy to wear, small, and convenient for casual use, while noting noisy operation and uneven paddle pressure as drawbacks.

4. Identify ergonomic acceptance with areas for refinement

Findings suggest good ergonomic design but indicate a need to improve paddle pressure distribution and reduce operational noise for enhanced user experience.

Durability Testing: Mechanical Robustness and Component Integrity

Evaluating device resilience through rigorous mechanical stress tests

Conducted extensive mechanical endurance testing on device

Performed 100 consecutive on/off cycles, three 75 cm drops onto wood surface, and 50 flex cycles of headband fabric to assess durability without critical failure.

Identified weakness in servo paddle attachment under impact

Observed detachment of servo horns during drop tests, indicating a mechanical vulnerability in the design that affects component integrity.

Improved mechanical stability with reinforcement measures

Applied tape and ribbon reinforcements to the servo paddle attachment, resulting in enhanced stability during impact tests.

Recommendation for enhanced mechanical design for reliability

Findings suggest the need to redesign mechanical components to ensure long-term durability and device reliability under repeated stress.

Cost and Portability Assessment: Affordable and Compact Design

Evaluating component costs and device portability compared to commercial alternatives

Component	Cost (USD)
2 × DC motors	8.00
2 × Servo motors	4.00
Vibrator motors	1.30
TPU filament	Negligible
Total	13.30

Feasibility
Validates **affordable**, multi-mode device

Advantages
Affordable, portable, and comfy

Limitations
Noise, pressure, and durability issues

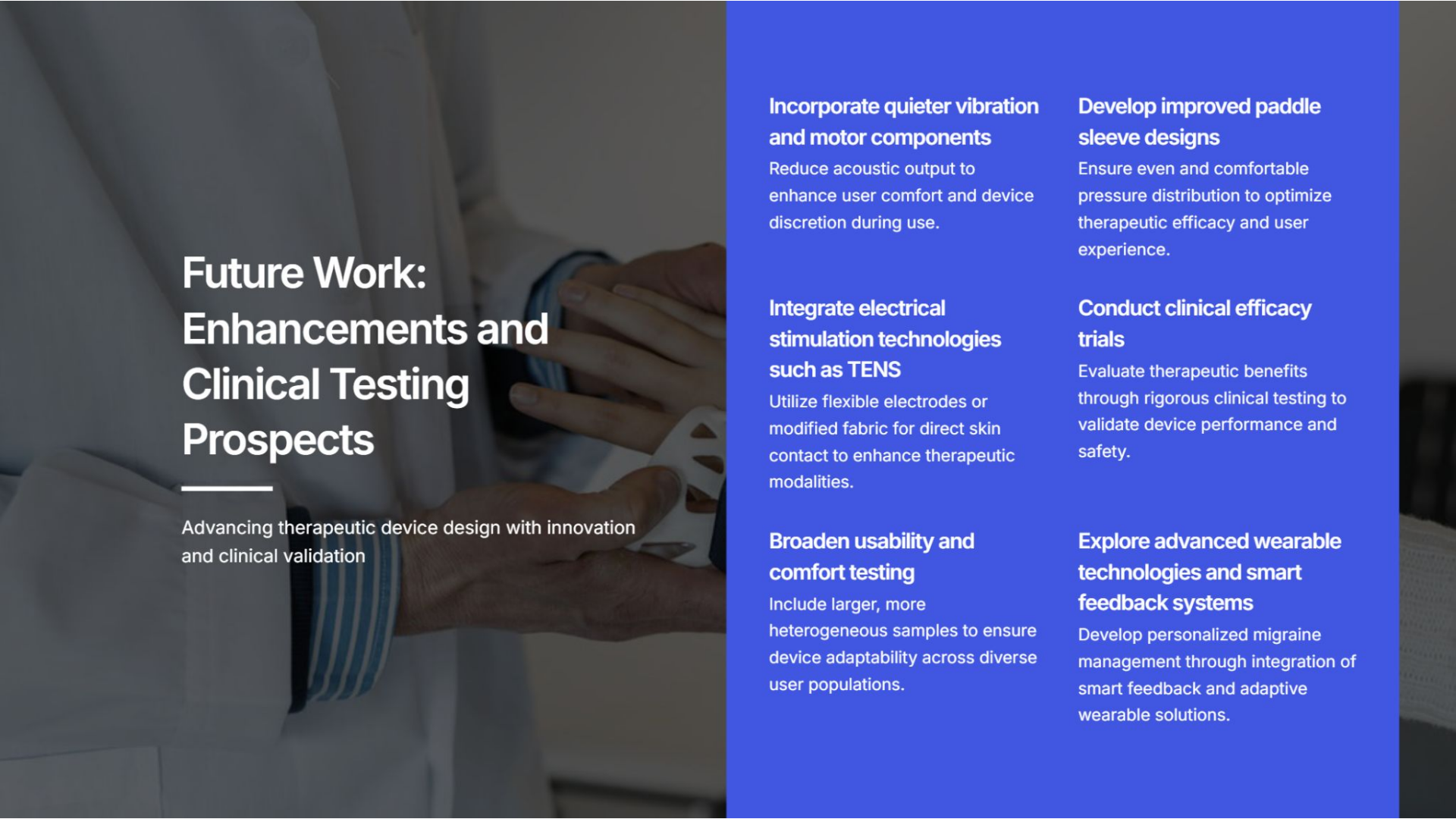
Improvements
Quieter actuators and better control

Integration
Add **electrical** stimulation methods

Testing
Expand to diverse user groups

Discussion: Key Findings and Areas for Improvement

Evaluating prototype performance and future development directions



Future Work: Enhancements and Clinical Testing Prospects

Advancing therapeutic device design with innovation and clinical validation

Incorporate quieter vibration and motor components

Reduce acoustic output to enhance user comfort and device discretion during use.

Develop improved paddle sleeve designs

Ensure even and comfortable pressure distribution to optimize therapeutic efficacy and user experience.

Integrate electrical stimulation technologies such as TENS

Utilize flexible electrodes or modified fabric for direct skin contact to enhance therapeutic modalities.

Conduct clinical efficacy trials

Evaluate therapeutic benefits through rigorous clinical testing to validate device performance and safety.

Broaden usability and comfort testing

Include larger, more heterogeneous samples to ensure device adaptability across diverse user populations.

Explore advanced wearable technologies and smart feedback systems

Develop personalized migraine management through integration of smart feedback and adaptive wearable solutions.

Acknowledgments

Recognize organizational support for research initiatives

Express gratitude to Biomedical Engineering Society UCSD and San Diego Undergraduate Tech Conference organizers for their essential support in advancing the project.

Acknowledge individual contributions to prototype development

Thank Annika O'Rourke and Xavier Lu for their hands-on assistance in prototype development and research efforts.

Appreciate the academic community's role in innovation

Highlight the academic community's fostering of innovation in migraine therapy research, which underpins the progress of this therapeutic device.

Thank you!