SemanticTap: A Haptic Toolkit for Vibration Semantic Design of Smartphone

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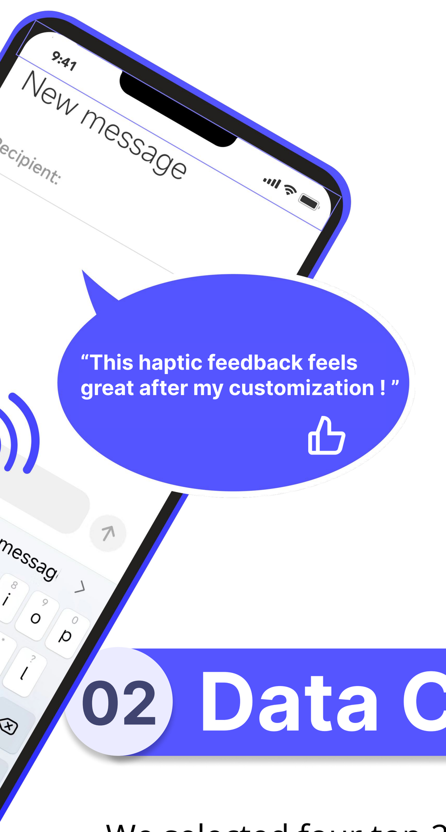
01 Introduction

The role of haptics in multi-sensory interaction is increasingly significant, and the development of smartphone actuator technology has greatly enhanced the haptic feedback experience. The **haptic perception** of users is subjective and diverse, but engineers design and implement the vibration waveform based on **physical parameters** without users' customization.



To explore the relationship between user perception and actuator physical parameters, **17** pairs of adjectives were selected and a haptic perception dataset was obtained through nine daily scenarios of **four** smartphones. Then, we present SemanticTap, a vibration waveform design tool for quickly creating and editing vibration effects based on adjectives for smart phones. Finally, SemanticTap's were evaluated by **14** designers, and its performance and applications were discussed.

An example of designing a smartphone vibration feedback using SemanticTap. (1) A user was unhappy with the excessively strong vibration feedback from his smartphone's keyboard typing. (2) He used SemanticTap, selecting adjectives and corresponding scores to design the ideal vibration effect. (3) After comparing multiple waveforms by different combinations of adjectives, the user finally found his ideal vibration effect.

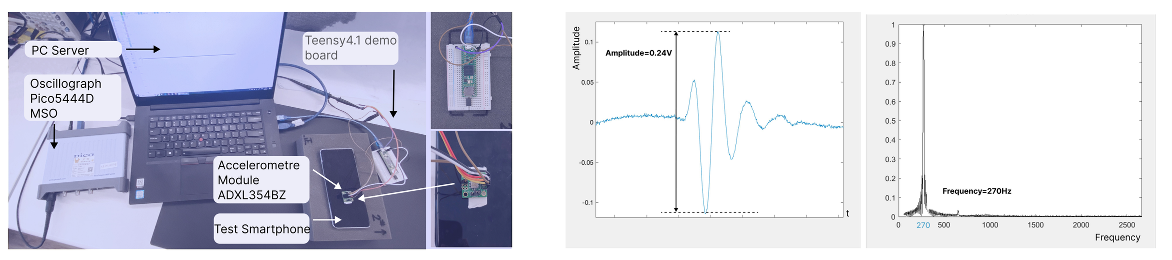
02 Data Collection and Modelling

We selected four top 2023 smartphones: **iPhone 14 Pro Max, Samsung S23 Ultra, OnePlus 11, and Xiaomi 13 Pro**.

There are 9 scenarios: Keyboard Typing, Numeric Dialing, Apps Long Press Editing, Album Long Press Editing, Alarm Setting, Contact Alphabet Index, Swiping Up to Access Recent Tasks, Camera Zoom Adjustment, Side-sliding to Return.

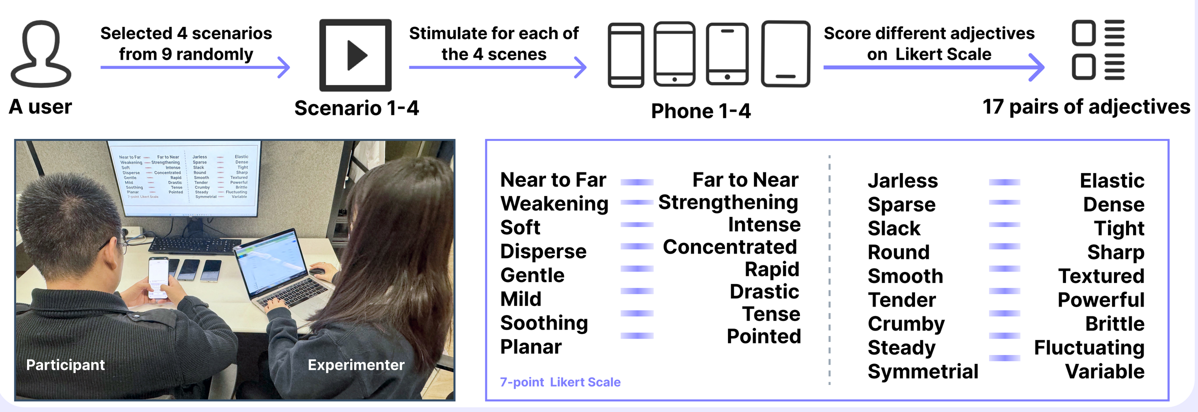
Physical Parameters Measurement

Key physical parameters include **amplitude, frequency, duration.**



User Perception Data Collection

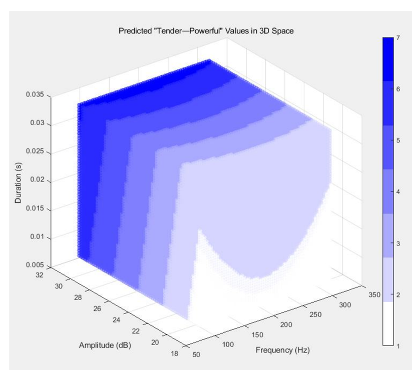
There are **408 datasets**: (7 scenarios × 4 smartphones + 2 scenarios × 3 smartphones) × 12 trials.



Modelling Method and Result

We used **multivariate linear regression** with **least squares**, adding a squared frequency term to capture quadratic patterns. The model predicts mean adjective values using frequency, squared frequency, amplitude, and duration as inputs, minimizing errors through coefficient estimation.

$$y = -3.174 - 0.000018 \cdot frequency^2 + 0.007 \cdot frequency + 0.245 \cdot amplitude + 17.957 \cdot duration$$



For **"Tender—Powerful,"** vibration intensity increases then decreases with frequency, peaking at 193.49 Hz when amplitude and duration are constant. Higher amplitude enhances intensity, while longer duration slightly softens the sensation.

03 SemanticTap Prototype

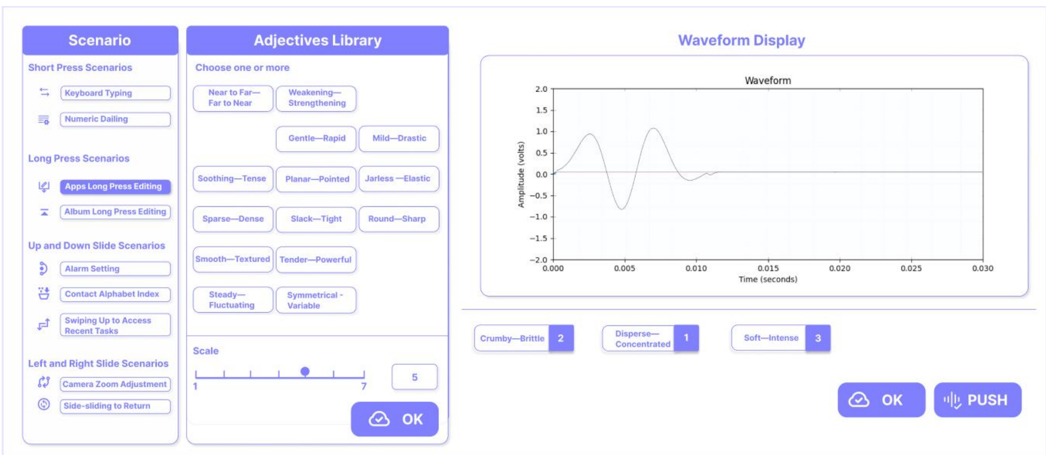
Waveform Creation and Preview

The system employs **PSO algorithm** to generate optimal waveform. Users receive immediate vibration feedback, with synchronized visual and tactile previews in the interface.

Vibration Customization and Adjustment

Scenarios: **9** available for customization.
Adjectives: **17 pairs**, each rated on a **1–7 scale**.
Real-Time Testing & Adjustment:

- Apply waveform instantly for feedback.
- Adjust scores as needed (e.g., raise "Soft—Intense" to 5) to fine-tune the vibration effect.



The user interface of SemanticTap.

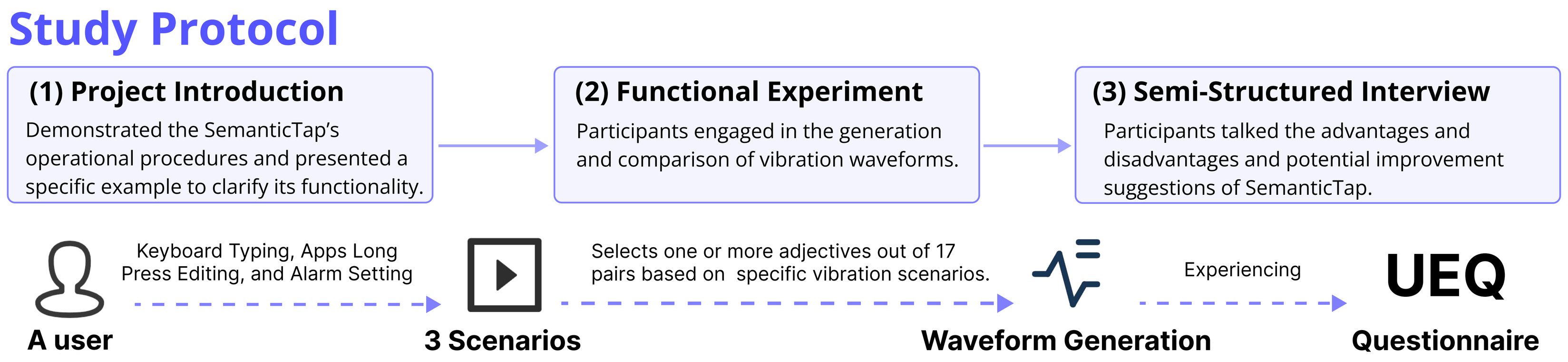
04 Evaluation Study

To understand SemanticTap's capabilities, functionality, usability, vibration design effects. Drawing insights from users in real-life situations, we conduct a evaluation study.

Participants

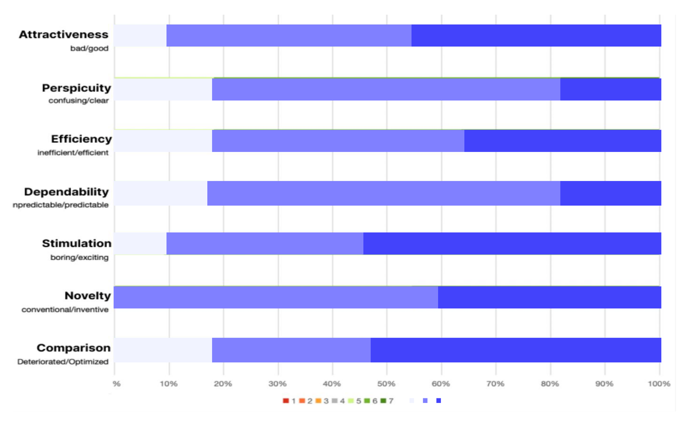
14 designers (aged between 20-38: M = 26.64; **7** male, **7** female) . Industrial designers, interaction designers and user experience designers.

Study Protocol

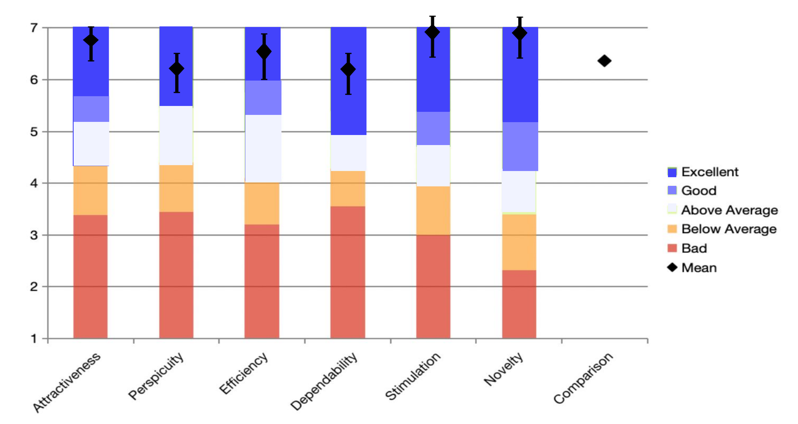


05 Results

The results obtained **"Excellent"** in **5** dimensions: Attractiveness, Efficiency, Dependability, Stimulation, and ovelty, with the "Perspicuity" dimension receiving "good".



Distribution of answers per question.



Mean values for UEQ factors and Comparison (black dot). The colorscale represent UEQ benchmark against other systems/products (468 studies).

06 Discussion and Conclusion

Research Thinking and Methodology

SemanticTap simplifies vibration design by linking user perceptions to physical parameters in daily smartphone use. Unlike prior studies, it **integrates both subjective and physical factors**. Real-world data from multiple smartphones reduces hardware variability, ensuring more consistent results across devices.

Preference of Adjectives Selection

In the experiment, participants typically used about four adjectives for effective vibration customization. Popular choices like ***"Disperse—Concentrated"*** and ***"Tender—Powerful"*** better captured desired haptic effects, while less common adjectives may need more examples for clarity in haptic design.

Comparison with State of the Art Tools

SemanticTap provides precise control over vibration effects with a wide range of adjectives and an intuitive interface. Combining visual and haptic feedback, it simplifies customization and reduces the learning curve, offering more options for fine-tuning smartphone vibrations than other tools like RichTap Muse or Haptic Haven.

Source	Haptikós [36]	Haptic Haven [9]	iMassage U [26]	RichTap Muse [3]
Toolkit Type	App experience	App experience	Phone/Game	PCB
Visualization	Symbolic waveforms	No	Symbolic waveforms	Component modules
Vibration Creation	Physical parameters	Select 1/9 adj.	Select 1/10 noun	Select N/4 adj.
Vibration Adjustment	Frequency/Amplitude	Intensity 0.0-1.0	Low/Medium/High	2 models
Hardware	Linear Actuator	Linear actuator	Linear actuator	Linear actuator
Source	**VITAKI [29]**	**Hapticlabs [32]**	**Affective Handles[44]**	**SemanticTap**
Toolkit Type	VR and games	App experience	Hardware experience	App for everyday usage
Visualization	Reality waveforms	Component modules	Reality waveforms	Symbolic waveforms
Vibration Creation	Physical parameters	4 blocks	10 basis vibrations	Select N/17 pairs of adj.
Vibration Adjustment	PWM resolution etc.	Intensity/Sharpness/Duration	6 attribute	Scale 1-7
Hardware	ERM actuator	Satellite player housing	Amplifier and laptop	Linear actuator

Conclusion

We conducted user experiments on four smartphones and used linear regression to create **17** vibration models linking signals to user perceptions. This led to the development of SemanticTap, a user-friendly toolkit for designing smartphone vibrations with adjective semantics. By integrating **psychophysics and physical parameters**, we expanded the design space for daily smartphone vibrations.

* Both authors contributed equally to this research. † Corresponding Author.