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Touch Test: A Pilot Study Toward Haptic Sensitivity Inclusion

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I. Introduction

Tactile perception varies greatly among individuals: some find everyday textures overwhelmingly sharp or painful, while others struggle to register sufficient tactile feedback from their surroundings [1], [2].

Such contrasts are often accentuated in neurodiverse populations, where "hypersensitivity" (a strong adverse reaction to light touch) or "hyposensitivity" (a reduced awareness of tactile inputs) are common [3]. Yet translating such subjective complaints into objective, quantifiable measures remains challenging, so clinicians and researchers have relied on specialised laboratory assays—such as calibrated monofilaments, two-point discrimination, tactile direction discrimination, vibration detection, and psychophysical vibration thresholds—to characterise the underlying sensory thresholds and compare atypical responders with neurotypical norms [4]. Although these psychophysical methods have long been employed in clinical research, they require dedicated instrumentation, trained personnel, and a substantial time investment [4]. Consequently, routine tactile screening in non-clinical contexts—such as annual health check-ups, workplace assessments—thus remains uncommon, leaving many individuals unable to quantify their own tactile perception or to substantiate requests for environmental accommodations.

To address this gap, we introduce Touch Test is motivated by the need to understand the rich diversity of individual tactile profiles and to promote societal awareness of tactile diversity. By focusing on the variations in touch perception and fostering recognition of these differences, our study aims to provide a more inclusive framework that can inform the design of user-centric haptic systems.

II. Design and Preliminary Workshop

A. Proposed Method

We propose a Touch Testing Toolkit consisting of two key components(Fig. 1): (1) a hardware system comprising two devices—one that delivers frequency-controlled vibration stimuli to the participant's hand and another that initiates and terminates the vibration stimuli, and (2) a software platform that records user responses, processes them, and outputs a scalar value denoting overall tactile sensitivity (hereafter referred to as Touch Acuity).

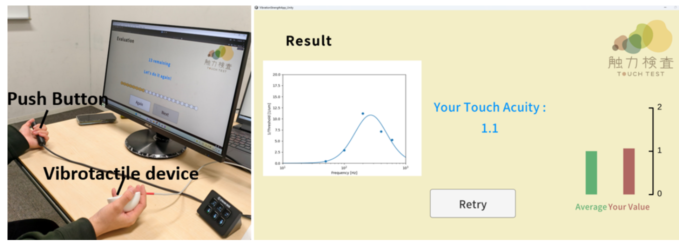

Fig. 1. Left) Participant engaging the Touch Test composed of a vibrotactile device, a simple push-button. Right) The UI showing the test result.

B. Hardware Setup

The hardware system integrates two physical components: a vibrotactile device and a simple push-button (Fig. 1(Left)). The vibrotactile device (FEEL TECH) contains an actuator (639897, Foster Inc.). The vibrotactile device is placed on the user's dominant hand to deliver vibration stimuli directly to the skin. A push-button is held in the opposite hand. Participants press and hold the button to initiate the vibrotactile device vibration, which starts at zero amplitude and gradually increases to a predefined maximum. Upon perceiving the vibration, participants release the button, prompting the system to instantly record the elapsed time. This duration is then used to determine the vibration detection threshold for the given frequency.

C. Software Processing

The vibrotactile actuator was first calibrated with an accelerometer (2302B, Showa Sokki Inc.) and a charge vibration meter (1607, Showa Sokki Inc.). An audio tone set to 0 dB SPL was applied at each target frequency, and the resulting peak displacement was recorded as the reference amplitude $RefAmp$.

For each test frequency f, a 10-second sinusoidal stimulus is delivered, with its amplitude increaseing linearly from 0 to $0.8 \times RefAmp$. This predefined stimulus determines the maximum amplitude $MaxAmp$ used for each frequency. Then, based on the average elapsed time t_f across the three trials, the Threshold is computed:

$$Threshold = MaxAmp \times \frac{t_f}{10} \quad (1)$$

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Subsequent processing adopts the three-stage framework [5] [6] First, a log-Gaussian function is fitted in the frequency–threshold domain to estimate the displacement threshold across 10–1000 Hz. Second, using this interpolated curve, the Pacinian-weighted power $P_s(f)$ is evaluated at each frequency. Finally, the spectrum is reduced to a scalar by summation and logarithmic compression:

$$I_s = \sum_f P_s(f)^{a_f} \tag{2}$$

Aggregates the power spectrum to a single effective intensity $I_s(a_f = 1$ unless refining for specific subject populations).

$$S_T = 10 \log(I_s) \tag{3}$$

Based on preliminary pilot calibration, we obtained a cohort mean stimulus-intensity index of $S_T = 38.3$. However, raw S_T scores (30–50) were not intuitive, making it hard for participants to interpret their tactile profiles; a scale starting at 0 seemed clearer. We therefore normalised S_T with the following equations, remapping it to a 0–2 interval and denoting it as Touch Acuity:

$$TouchAcuity = ((\frac{S_T}{38.3} - 1) \times 3.96 + 1) \times 0.6 \tag{4}$$

D. Preliminary Workshop

A co-design workshop was conducted on October 2024 with nine volunteers aged 10–59 years, seven of whom reported daily tactile difficulties such as personal preferences and aversions related to specific materials and tactile sensations. As illustrated in Fig. 2, after a lecture on neurodiversity, including tactile hypersensitivity and hyposensitivity by the professors. Participants discussed personal episodes—e.g., avoiding "scratchy" fabrics or preferring plush textures—and noted likes, dislikes and daily tactile difficulties situationon on worksheets. Each participant then completed a Touch Test with three-frequency that same as the pilot study (50, 200, 400 Hz; three trials per frequency), finishing the protocol in under 5 minutes.

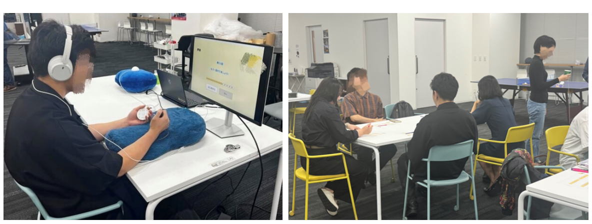

Fig. 2. Left) A participant during the experiment in the preliminary workshop. Right) Group discussion on tactile-related concerns and preferences in the workshop.

III. Discussion

Participants valued the Touch Acuity as it suggested the possibility of objectifying the vague concern of "perhaps I am hypersensitive" into a concrete metric. The numerical result might also serve as a shared reference point for family members and caregivers, opening a dialogue on when and how to provide practical support in daily life.

After the workshop, we applied several modifications to the Touch Test protocol. First, the duration before participants detected the vibrations at each frequency was too short—detection was generally easy, and responses were almost instantaneous. To obtain a better distribution of detection times, and thus more accurate scores, we introduced a gain term into the maximum-amplitude equation ($MaxAmp = 0.8 \times RefAmp \times Gain$), thereby slowing the amplitude change. In addition, we changed the range and number of test frequencies to (50, 100, 200, 400, 600 Hz). During the workshop, we presented the scores and related graphs to participants at the end. Based on their feedback, we iteratively refined the UI design for the result presentation. The latest version is shown in Fig. 1 (right). In the inverse-threshold graph (left side of the UI), higher peaks indicate greater tactile sensitivity.

In the current version, we use a simple ascending method of limits. This procedure can bias threshold estimates upward for several reasons. System latency, reaction time, fatigue and adaptation effect may delay button presses, and detection criteria may vary across trials and individuals. We plan to refine the test design to mitigate these issues in future versions of the Touch Test.

IV. Conclusion

We presented the design and initial deployment of Touch Test, which can convert five vibrotactile thresholds into a single, normalised Touch Acuity score on a 0–2 scale. Hardware calibration, software processing, and a nine-participant workshop showed that the full test can be self-administered in under five minutes and that the metric helps users better understand their own tactile profiles. Workshop feedback prompted immediate refinements, which include expanded frequency coverage, gain adjustment, streamlined scoring, and a simplified visual output and upcoming updates will also mitigate bias from ascending stimuli and reaction-time inclusion. Future works on the system's test-retest reliability, reproducibility, and convergent validity in larger cohorts.

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