# Toward a Device for Reliable Evaluation of Vibrotactile Perception

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## I. Motivation

Somatosensation is essential for interacting with the environment and avoiding potential harm. Somatosensory deficits can lead to a variety of problems that significantly impact daily life, but they can also aid in the early detection or prediction of other disorders, such as peripheral neuropathy [1]. Therefore, accurate and reliable somatosensory assessment is critical in clinical and research settings, e.g., to track disease progression, to guide rehabilitation strategies, to obtain comparable and generalizable results, and to establish normative data. However, reliable somatosensory assessment can be challenging due to the complexity of sensory processing, the subjectivity of sensory experience, and the limitations of assessment tools. For example, most methods currently in use require an expert clinician, or their delivery of stimuli is not automated, and therefore the generalizability of their results is limited by operator skill variability.

## II. Approach

With this motivation, we are developing a portable assessment tool capable of delivering controlled tactile stimuli of different types, including but not limited to pressure, vibration, and temperature. As a first step, we focused on the vibratory stimuli. Therefore, we mechanically modified a widely used recoil-type vibrotactile transducer (TL-002-14R Haptuator Redesign, TactileLabs) and characterized how its response changes in the presence of a representative finger for a wide range of input signal parameters (Fig. 1a).

*Haptuator Characterization:* First, one of the two connectors between the inner magnet and the suspension membrane was modified so that it can easily be touched with a fingertip. A custom brass screw with a 7-mm-diameter hexagonal head was fabricated for this purpose. To measure the vibration of the magnet in the normal direction, the modified Haptuator was then enclosed in a custom-made plastic holder that was clamped to a table. The input signal to the Haptuator was provided by a function generator and a current amplifier and checked with an oscilloscope. Sinusoidal waveforms with three peak-to-peak amplitudes (50, 250, and 500 mV) and 22 frequencies (50–200 Hz in 10-Hz steps and 250–500 Hz in 50-Hz steps) were used as input signals. The vibration of the non-modified end of the magnet was measured by a laser vibrometer (Polytec OFV 534) in the presence and absence of contact with a representative fingertip (Fig. 1a).

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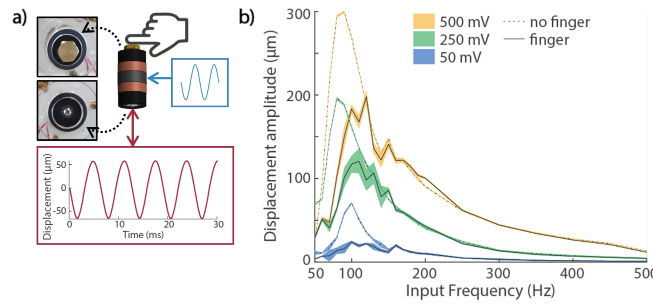


Fig. 1. a) Experimental setup. b) Measured displacement of the Haptuator magnet in the normal direction (mean ± 2 std. dev.) for sinusoidal input at three voltages with (solid line) and without (dashed line) the finger.

*Data analysis:* We calculated the mean and standard deviation of the magnet's maximum displacement from its resting position to characterize the response to the sinusoidal inputs in the time domain. In the frequency domain, the maximum response frequency of the measured vibration was used. The normality of the data distributions was assessed with the Lilliefors test. Then, an aligned-rank transform ANOVA was used to preliminarily investigate the effects of the input parameters (voltage and frequency) and finger presence.

*Results:* The displacement amplitude (Fig. 1b) was significantly affected by both finger presence ($F_{1,84} = 41.05, p < 0.001$) and input parameters (voltage: $F_{2,84} = 469.12, p < 0.001$, frequency: $F_{21,84} = 49.89, p < 0.001$), as well as the interaction between finger presence and input frequency ($F_{21,84} = 4.94, p < 0.001$). The output frequency of the vibration was significantly affected by only the frequency of the input waveform ($F_{21,84} = 14.36, p < 0.001$).

*Discussion and future work:* Although finger contact reduces the vibration below about 160 Hz, increasing the input waveform voltage can enable the amplitude of the Haptuator response to be comparable to that of the stimulation provided by biothensiometers in clinical use (frequency: 100 Hz, amplitude: 0–57.8 $\mu$m, Kilde Medic). In the future, we will further investigate this behavior with more users to better generalize the results and model the response. In addition, we will compare the performance of the modified Haptuator with the stimulus delivered by the devices used in clinics. Then, we will also test the feasibility of using the same actuator to deliver low-frequency pressure stimuli.

## References

[1] A. P. Garrow and A. J. Boulton, "Vibration perception threshold – a valuable assessment of neural dysfunction in people with diabetes," *Diabetes/Metabolism Research and Reviews*, vol. 22, no. 5, 2006.