INTRODUCTION
The performance of vibrotactile actuators is affected by the frequency and amplitude of oscillation, loading on the skin, and the size of the tactork-skin interface. Commercially available vibrotactors include eccentric rotating mass (ERM) devices, which have frequency and amplitude coupled, and linear resonant actuators (LRAs), which use a resonant frequency. The frequency is chosen to be easy to feel, but performance away from that frequency is dramatically diminished. It can also be difficult to assess the contribution of skin loading, which is one of the most important factors in actuator performance [1]. In this paper, we present a vibrotactile actuator design that can stimulate skin with a fixed amplitude that is independent of frequency. It also can be made to have an extremely compact tactork-skin interface of 8mm wide, and can provide constant loading on the skin. We demonstrate that stimulation by tactors providing for increasing amplitude results in increased subjective intensity of stimulation.

DESIGN AND EXPERIMENT
The device is based on a cam-and-follower mechanism attached to a DC motor and a constant force spring that keeps the loading on the skin constant. The amplitude of oscillation is measured using a laser displacement sensor targeting a flag coupled to the tactork-skin interface.

To understand how the change in amplitude of skin stimulation affects the subjective intensity of stimulation, we recruited two subjects. Each subject was asked to sit on a chair with their foot resting on the ground. Subjects wore noise-canceling headphones and were blindfolded to prevent audio and visual cues. A site on their thigh, 5cm proximal from the knee, was stimulated with a random sequence of stimulations using one of four tactors. As shown in figure 1 that can stimulate skin at amplitudes of 0.1 mm, 0.2 mm, 0.33 mm, and 0.58 mm. Each tactor stimulation was also randomly driven at one of 128 Hz, 200 Hz and 278 Hz, all in the perceivable range of hairy and glabrous skin [2]. Tactor amplitude and frequency were randomized by block and the same number of presentations was used for each condition.

RESULTS AND DISCUSSION
Frequency variations did not result in a significant effect on perceived stimulation intensity, but amplitude variations did (Figures 2,3.). Figure 2 depicts the average perceived intensity, averaged across all participants and frequencies of stimulation. Perceived stimulation intensity increased with increased amplitude of oscillation of the actuator. Figure 3 depicts the effect of frequency. The frequencies used were all within the typically accepted range of stimulation for vibrotactors.

REFERENCES