# Tactile substitution of visual information for guiding locomotion

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## Introduction

People with low or impaired vision often rely on assistive devices to help guide locomotion and avoid obstacles and drop-offs. While common aids such as the long cane are useful for short range navigation (2-3 steps), tools for communicating navigation information over intermediate ranges are lacking: There is a need for assistive devices that provide intuitive information for locomotor guidance, such as the direction of goals, obstacles, and clear pathways.

## Previous Research

Previous research on direction perception by using vibrotactile methods [1 - 4].

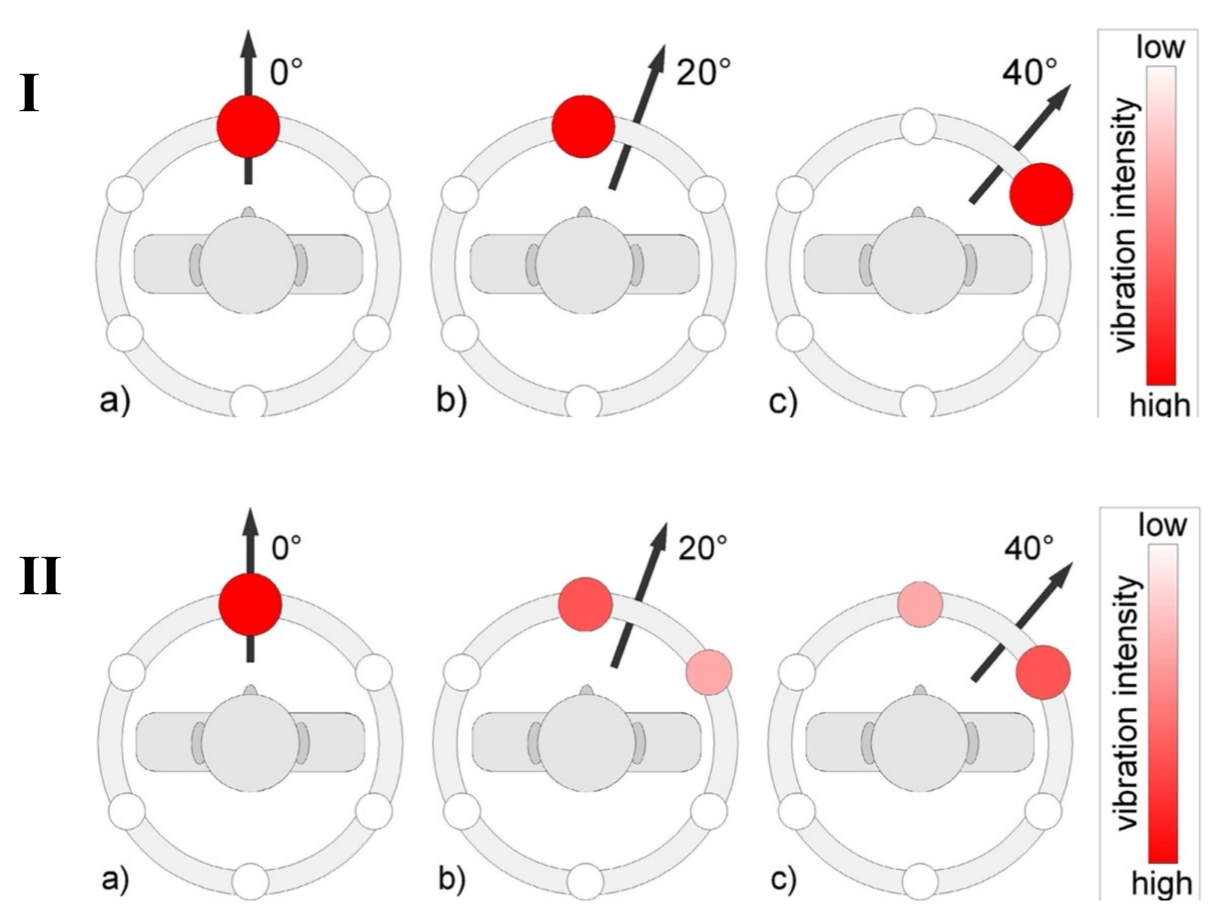


**Figure 1** Two different stimuli using 6 tactors for directions (a) 0 degrees, (b) 20 degrees, (c) 40 degrees. (I) Single vibration with error of 19.4 degrees. (II) Interpolated between 2 vibrations with error of 16.8 degrees. Interpolated presentation takes longer to process [1].

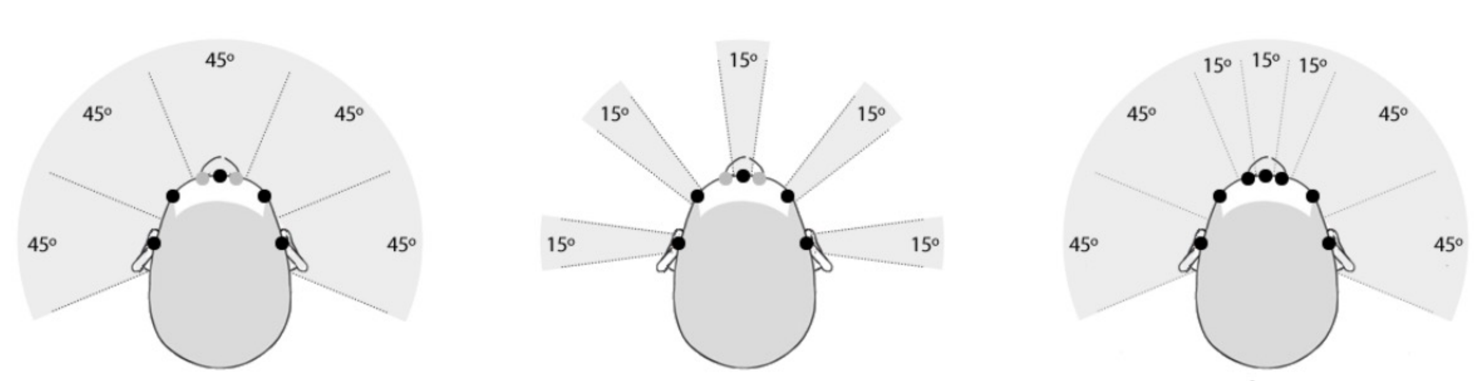


**Figure 2** Tactor coverage of 45 degrees leads to fast but imprecise performance. Increasing density locally can optimize precision [2].

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## Planned Experiments

**Objectives**
- Coding spatial information in a simple vibro-tactile belt
- Determining accuracy and precision of directional perception
- Investigating tactile 'hyperacuity'
- Comparing different methods of vibration pattern
  - Specifying location of goal
  - Providing movement instructions

**Variations**
a) One motor vibrating at a fixed frequency and intensity
b) 3 to 5 vibrating motors with a Gaussian distribution of intensity
c) Variation in the width of the Gaussian

**Implementation**
- 16 positions for single vibration
- 8 positions for Gaussian distributions
- Each stimulus will be repeated 10 times
- Stimuli are randomized within blocks
- Questionnaire

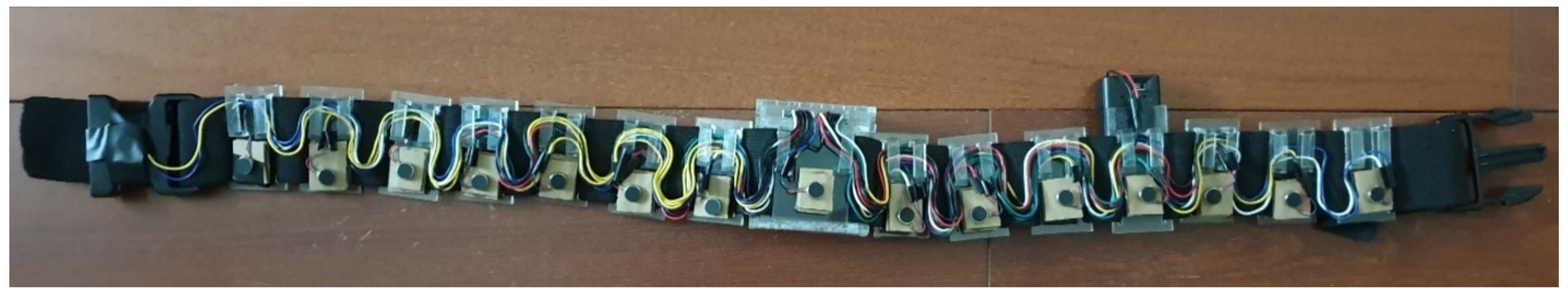

**Figure 3** The vitro-tactile belt is equipped with 16 motors which are evenly-spaced around the waist, 22.5 degrees apart.

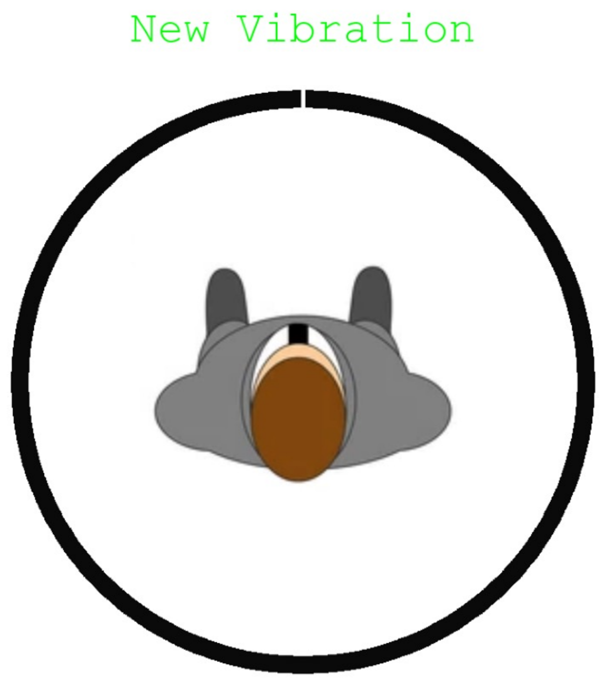


**Figure 4** Participants will receive tactile vibration and click on a computer display to indicate the perceived direction in space corresponding to the source of stimulation.

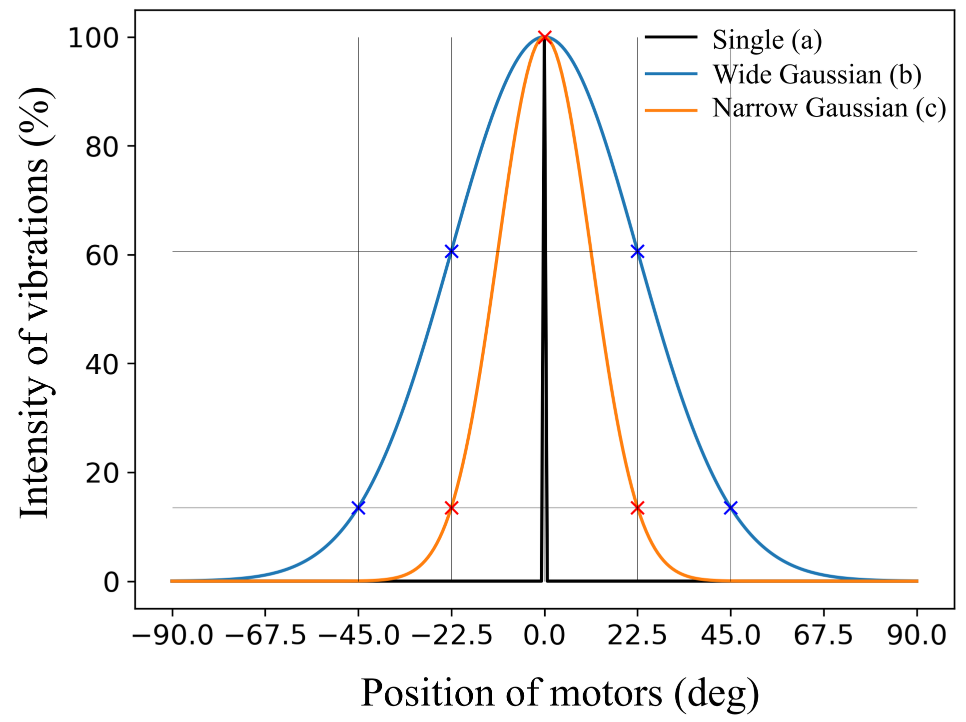


**Figure 5** The vibration pattern will be manipulated. (a) single vibration with 1 motor, (b) a wide Gaussian distribution with either 5 or 3 motors, (c) a narrow Gaussian distribution with 3 motors. Intensities are indicated as x.

## Pilot Results

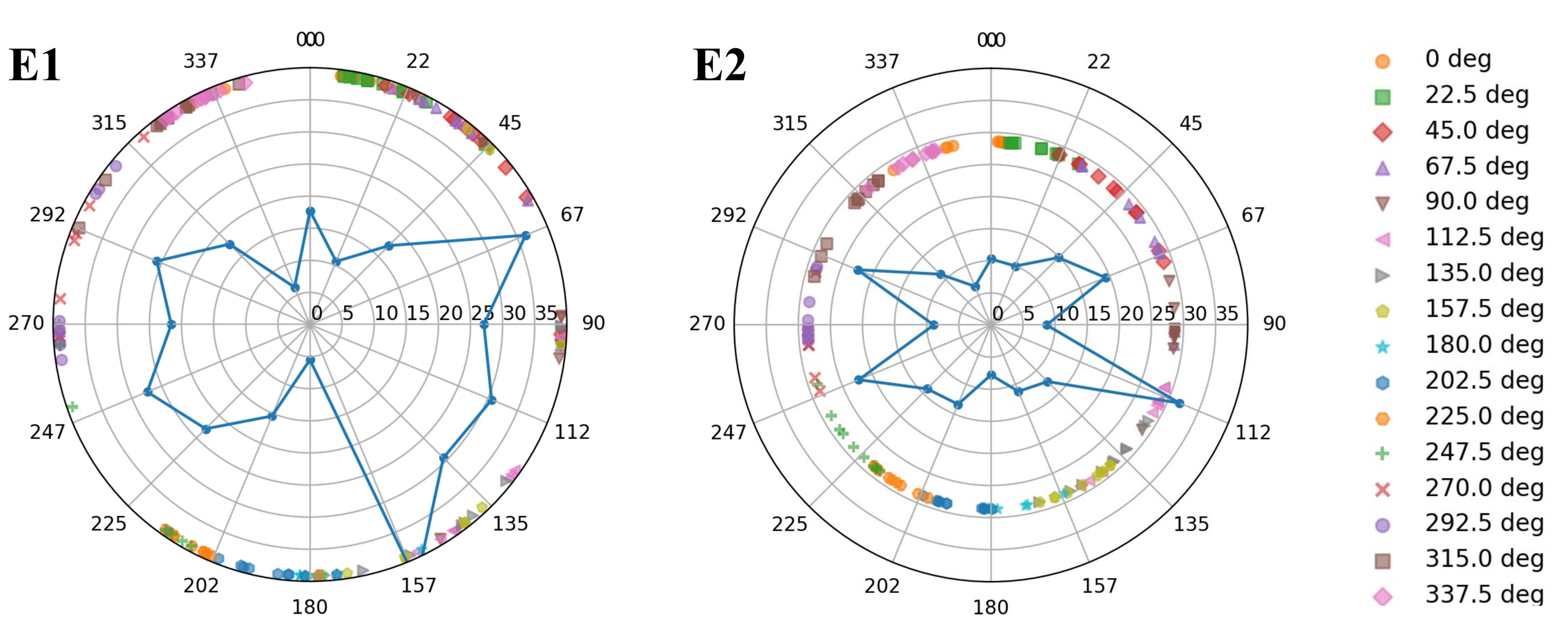


**Figure 6** Recorded perceived direction of single vibrations for experimenters E1, E2. The mean absolute error for all 16 positions is represented as blue dots connected by a line.

- This will enable us to estimate the spatial resolution of perceived direction, depending on the direction and type of vibration.
- The results will be used to design intuitive methods of coding spatial information in a vibro-tactile belt.

## References

[1] Pielot, M., Henze, N., Heuten, W., Boll, S. (2008). *Evaluation of Continuous Direction Encoding with Tactile Belts*. In: Pirhonen, A., Brewster, S. (eds) Haptic and Audio Interaction Design. HAID 2008. Lecture Notes in Computer Science, vol 5270. Springer, Berlin, Heidelberg. doi: 10.1007/978-3-540-87883-4_1

[2] Oliveira, V. A., Nedel, L., Maciel, A., Brayda, L. (2016). *Localized Magnification in Vibrotactile HMDs for Accurate Spatial Awareness*. 9775. 10.1007/978-3-319-42324-1_6.

[3] Faugloire, E., & Lejeune, L. (2014). *Evaluation of heading performance with vibrotactile guidance: the benefits of information-movement coupling compared with spatial language*. Journal of Experimental Psychology: Applied, 20(4), 397-410. doi: 10.1037/xap0000032

[4] van Erp JB. (2008). *Absolute localization of vibrotactile stimuli on the torso*. Percept Psychophys. 70(6):1016-23. doi: 10.3758/pp.70.6.1016. PMID: 18717387.