

# Gait Entrainment with Periodic Vibrotactile Stimuli

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## Introduction

Gait entrainment is a unique phenomenon where the neuromuscular system synchronizes gait to a rhythmic external stimulus. Entrainment research is currently an emerging field, and has been shown to have great potential for gait rehabilitation [1].

The mechanism underlying entrainment remain unclear. Early studies demonstrated entrainment using mechanical perturbation and suggested that it may arise from the dynamics between the robot and human gait [2]. However, mechanical perturbations also inherently provide tactile sensory input, making it difficult to distinguish the effects of mechanical assistance from those of sensory feedback. To better understand the mechanism of entrainment, this study used periodic vibrotactile stimuli to examine the contribution of sensory input.

## Methods

Data was collected for 13 healthy subjects (8 male, 5 female, aged 19-31), using three vibrational stimulation bands (VSBs), one on the ankle (VSB-A), thigh (VSB-T), and wrist (VSB-W). The subject's preferred walking speed and heel strike frequency were determined, and each VSB was tested providing stimulus at 103% of the subject's heel strike frequency for five two-minute trials, with a two-minute break between bands. Treadmill force data was collected and the stride phase each stimulus started was used to determine periods of entrainment, defined as any set of at least 20 strides for which the stimulus phase for 80% of the strides was within 10% of the mean phase of the period.

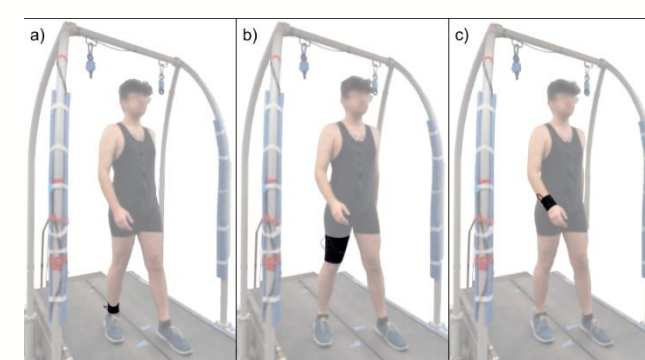


Figure 1. Experimental setup for trials of (a) VSB-A, (b) VSB-T, (c) VSB-W.

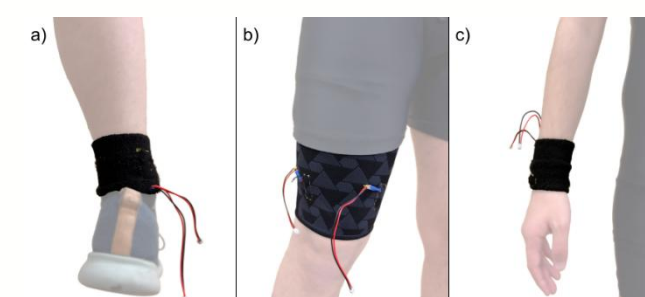


Figure 2. Close-up views of the position of (a) VSB-A, (b) VSB-T, (c) VSB-W.

## Results

Entrainment success was evaluated in three ways: the percentage of subjects that successfully achieved entrainment, the percentage of trials that achieved successful entrainment, and the percentage of strides that fell within a period of entrainment.

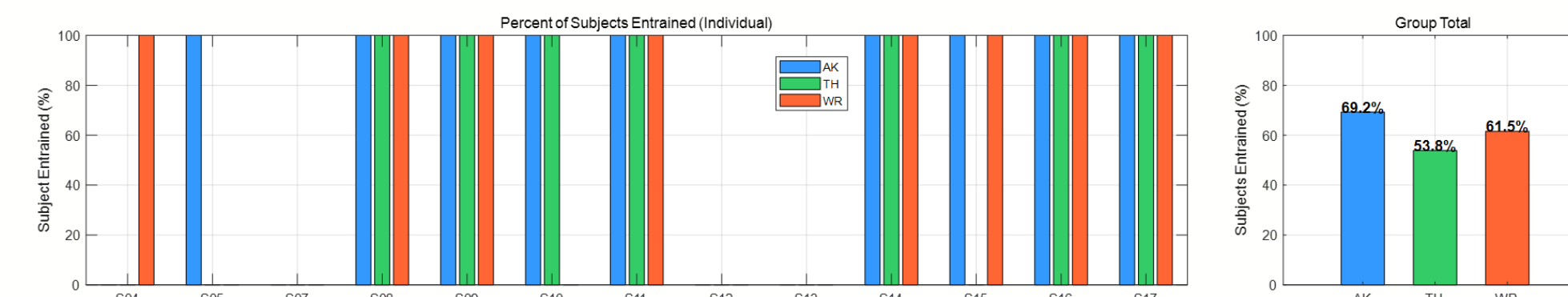


Figure 3. Total Subject Entrainment Rate. Percentage of subjects that successfully entrained to each band. Individual results (left) show success/failure for each band.

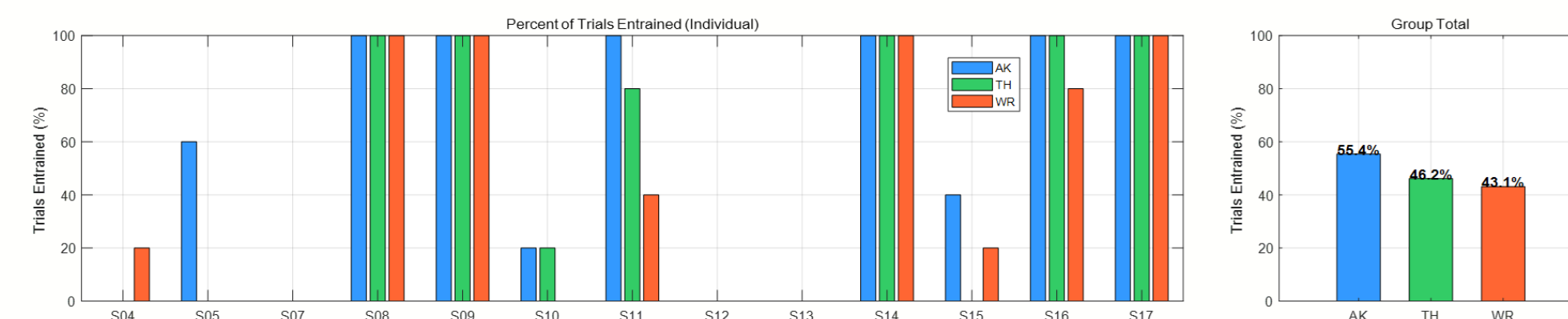


Figure 4. Total Trial Entrainment Rate. Percentage of trials that successfully entrained for each band. Individual results (left) show their percentage of trials entrained for each band.

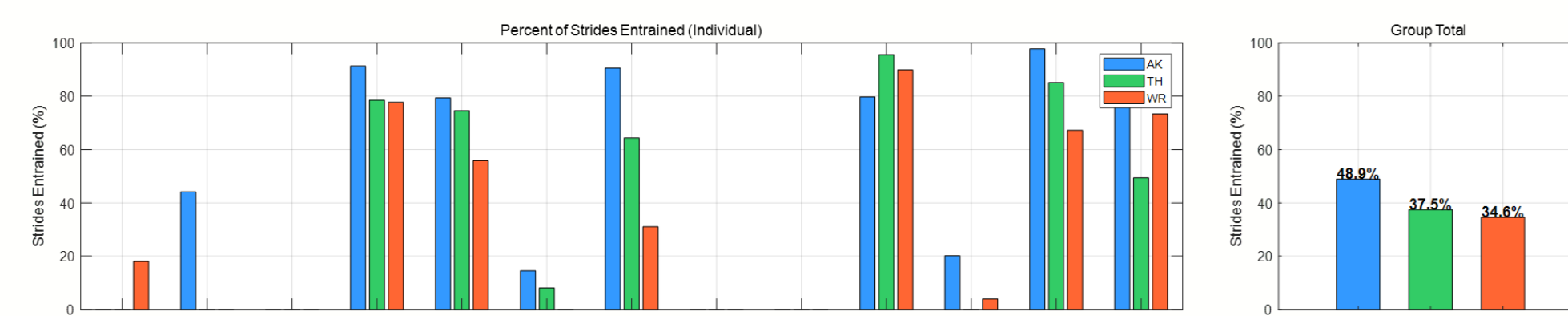


Figure 5. Total Stride Entrainment Rate. Percentage of strides successfully entrained for each band. Individual results (left) show their percentage of strides entrained for each band.

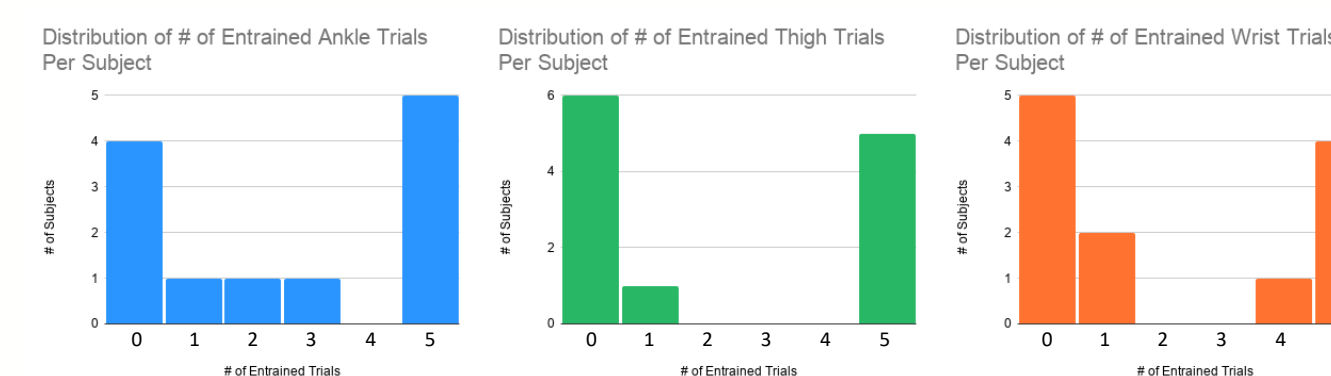


Figure 6. Subject Trial Entrainment Distribution. Number of subjects entrained to a given number of trials for each band.

## Conclusion

This study sought to determine whether gait entrainment could be achieved with a purely sensory stimulus. Some participants were entrained to the sensory stimulus, implying it may induce entrainment. Vibrotactile stimulus to the ankle was most effective across all metrics. Subjects either entrained for most of the trials or very few of them for all VSBs, as seen in Fig. 6.

## Discussion

This study demonstrated that sensory stimulus may contribute to gait entrainment, but it remains unclear whether the observed entrainment was driven by conscious control or more automatic somatosensory processes. In the future, the research team intends to study the effect of vibrotactile entrainment in dual-task trials to investigate the role of cognitive involvement, and to quantify how this form of entrainment affects gait.

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## References

