

RESTORATION OF KINESTHETIC SENSATION IN UPPER EXTERMITY PROSTHESES

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Introduction

For those with upper limb (UL) amputation the absence of movement and touch sensations impedes prosthetic control and is often identified as a factor in prosthetic rejection¹. An approach to address this challenge is targeted reinnervation (TR) surgery, which reroutes residual nerves which once innervated a patient's amputated limb to chest or residual limb muscles. This restores sensation in the missing limb and aids prosthetic control².

It is hypothesized movement feedback can be provided through TR surgery and the kinesthetic illusion; a phenomenon where vibration of a muscle group induces sensations of limb movement³ in that limb.

Methods

Four transhumeral amputees who have undergone TR surgery were recruited. Varying combinations of vibration amplitude and frequency were systematically introduced. Participants' vision and hearing was occluded. Following, a series of questions were answered to quantify the strength of movement sensations.

Lastly, a prosthetic hand was linked to the vibration such that movement sensations were induced in time with the prosthetic movement (Figure 1). The participant was asked to pantomime sensations of movement with their intact side, and movements were recorded.

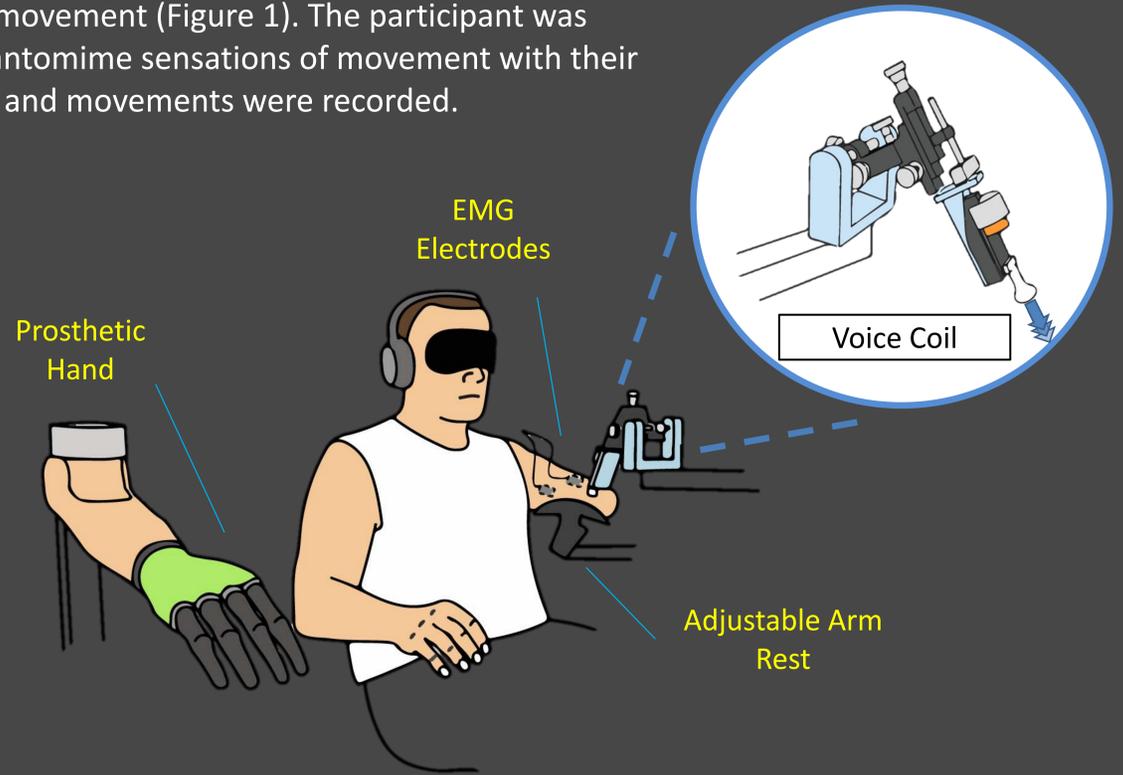


Figure 1: Experimental Setup

Results

All 4 participants experienced hand close sensations and 2 participants reported hand open sensations in their missing limb (Figure 2). Vibration at 90 Hz frequency and 0.5 mm amplitude most consistently elicited sensations of hand movements (Figure 3). Participants were able to accurately interpret the kinesthetic illusion and these sensations could be readily matched to prosthetic movement.

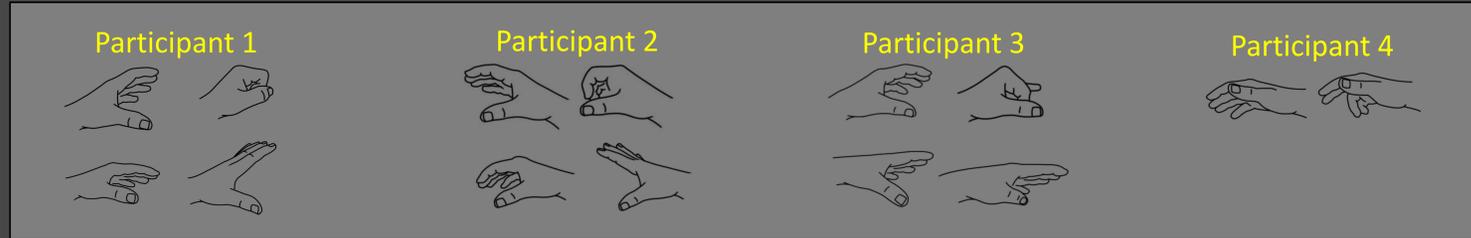


Figure 2: Movement sensations experienced in participants' missing limbs

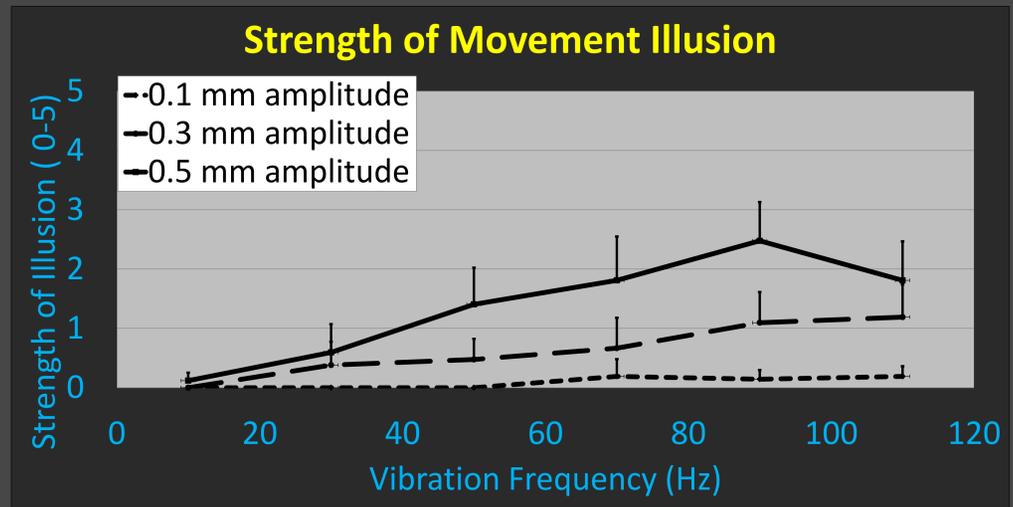


Figure 3: Strength of illusion across vibration frequency and amplitude

Discussion

This work presents encouraging data suggesting a method to access kinesthetic sensations in an amputee's missing limb for use in communicating prosthetic movement. Follow up work is currently underway to develop systems capable of being incorporated in functional prostheses for evaluation of clinical and long term utility.

References [1] Biddiss E, et al. Disabil Rehabil Assist Technol. 2007 [2] Hebert JS, et al. Crnt Srg Rprts 2014 [3] Goodwin GM, et al.. Brain. 1972