Grasping at Illusions: Stimulating the skin to make you think your fingers are moving
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BACKGROUND
Sensory feedback from receptors in the muscles, skin, and joints provides crucial information about limb movement. This "movement sense," also known as kinesthesia, is believed to be primarily informed by muscle receptors (i.e., muscle spindles). When we move, these muscle spindles discharge as the muscles lengthen. Thus, most kinesthetic research has focused on them. Receptors in the skin (i.e., cutaneous receptors) also discharge when we move, although their role in kinesthesia remains less clear. Therefore, this project aims to investigate the role of cutaneous receptors in kinesthesia by exploring the effect of electrical stimulation on perceived movements.

METHODS
- Participants (n=18) seated with hands relaxed over a stable surface
- View of the right hand blocked by a cardboard divider
- Electrical stimulation applied to the right, "test" hand to stimulate axons from cutaneous receptors and mimic their discharge during movement
- If they perceived movement in their right hand, they were instructed to mimic the movement with the left, "matching" hand
- Perceived ("illusory") movements were quantified using motion capture

RESULTS
- Electrical stimulation (ES) was delivered in 3 patterns (frequency, intensity, combined) and a "Sham" trial
- Frequency or intensity increased then decreased sinusoidally over 5 seconds (Figure 3)
- 5 cycles of stimulation per trial, each trial was presented 3 times in a random order
- "Sham" trial was included to verify participants' perception of movement due to ES
- Frequency: cycled between 55–250 Hz; Intensity at perceptual threshold (PT)
  - (increased, then decreased, to mimic changes in discharge frequency of receptors during finger movements)
- Intensity: 1x perceptual threshold (e.g., when the participant first felt the stimulation pulses; frequency constant at 55 Hz
  - (increased, then decreased, to mimic changes in the number of receptors activated during finger movements)
- Combined: both frequency & intensity increase and decrease together
- "Sham": frequency held at 55 Hz; intensity held at PT

CONCLUSIONS/LIMITATIONS
1. When electrical stimulation was applied to the skin of the hand, almost 60% of participants thought their fingers were moving, when they were not. The skin plays a role in the perception of finger movements (kinesthesia)
2. The size of the illusory movements was not different when increasing stimulation intensity, frequency, or increasing both together.
3. To produce illusions of movement, changing stimulation intensity and frequency are equally effective.

Limitations: In only ~50% of participants were movements in the predicted direction. Difficult to assess how accurately participants "matched" movements.

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