Do receptors in the skin contribute to the perception of movement in the hand?

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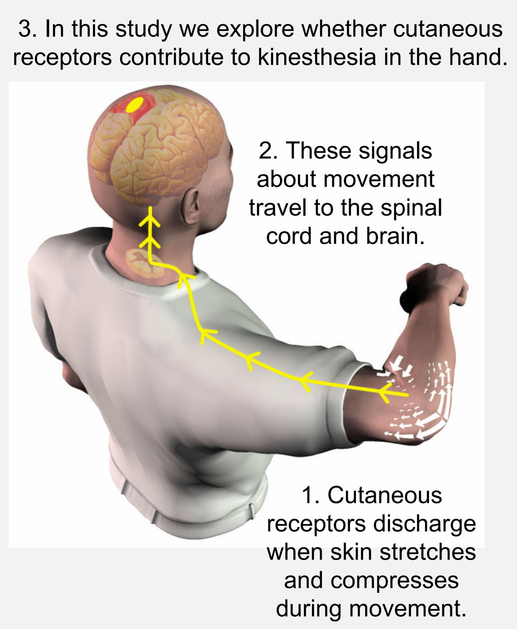
BACKGROUND

Receptors in muscles, joints, and skin discharge when humans move and these signals can **contribute to** our conscious perception of movement, or "***kinesthesia***".



Muscle spindles are thought to be the most important receptors for kinesthesia, however, receptors in the skin may be equally important[1] but are less well-studied. In part, this may be due to a lack of effective methods to explore their role.

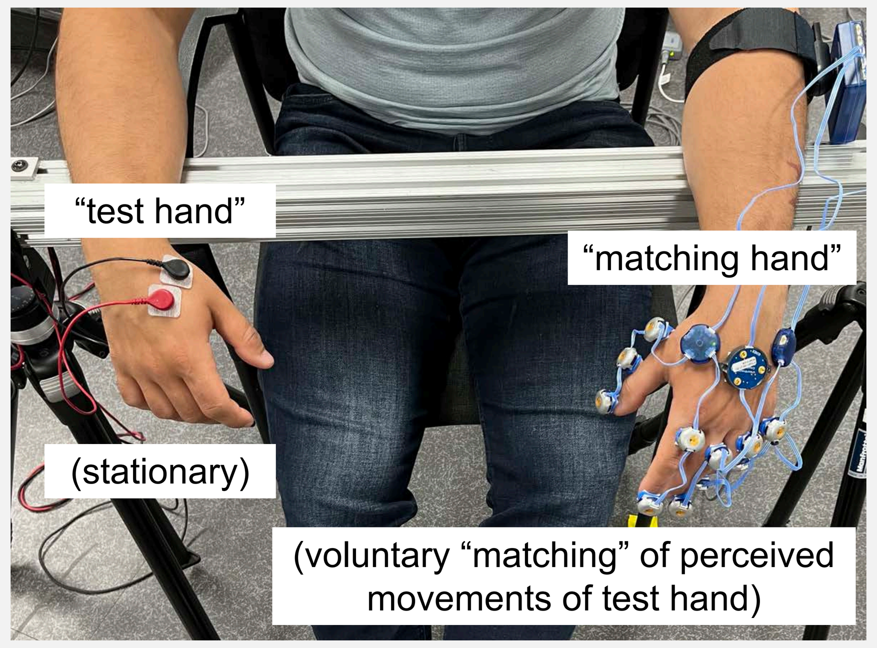
A 1994 abstract[2] reported that electrical stimulation (ES) of the skin of the hand could be used to mimic the discharge of cutaneous receptors and produce illusions of movement but peer-reviewed results were never published.

This project focused on altering the frequency of the electrical stimulation to determine whether increasing the speed of the pulses would increase the illusion of movement.

HYPOTHESES

1) Electrical stimulation of receptors in the skin will cause participants to perceive movement (when the hand is not moving),
2) Participants will perceive that the fingers are flexing when the stimulation is on,
3) Higher stimulation frequencies will produce stronger illusions of movement.

METHODS

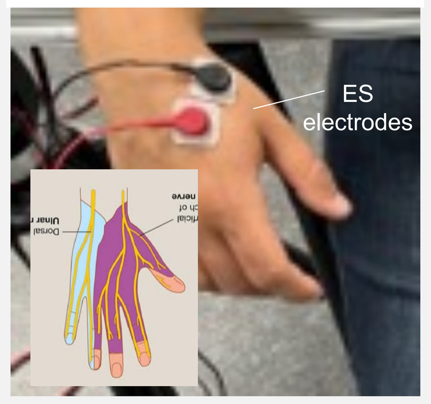


Participants sat with hands relaxed over the edge of a stable surface and eyes closed.

ES was applied over the superficial nerve to the right, "test hand" to stimulate axons from cutaneous receptors to mimic their discharge during movement.

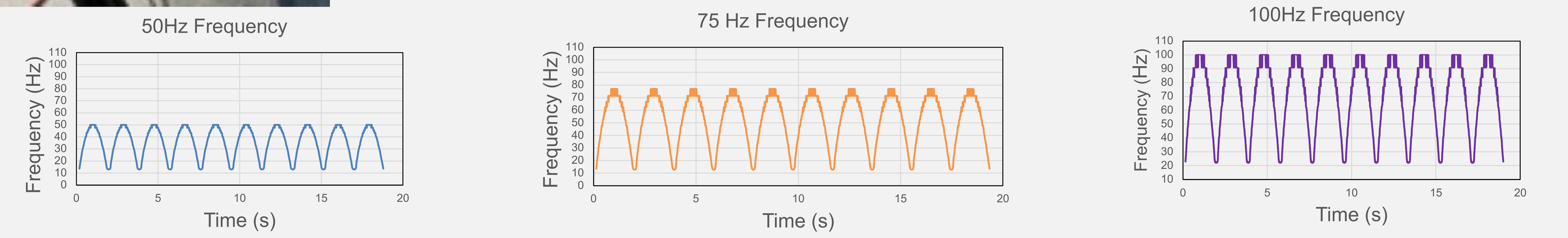
Participants were asked how the stimulation felt, recreating protocols from other research[3]. If participants perceived movement, they were instructed to mimic it with their left, "matching" hand

The "test hand"



ES was delivered at an intensity so single pulses felt like tapping on the back of the hand, second and third fingers

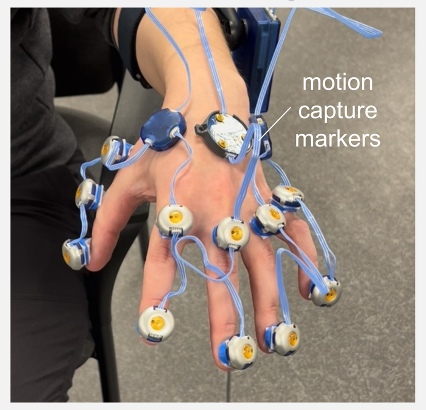
To mimic receptor discharge during movement, ES was delivered in "trains", with frequency increasing for ~3 s then decreasing for 3 s



In one trial 10 trains were delivered with ~10 s between. In separate trails maximum pulse frequency was 50, 75 or 100 Hz (pulses/s) based on discharge rates of these receptors as noted in previous research2. In most trials, the stimulation was delivered for 6 seconds

METHODS

The "matching hand"



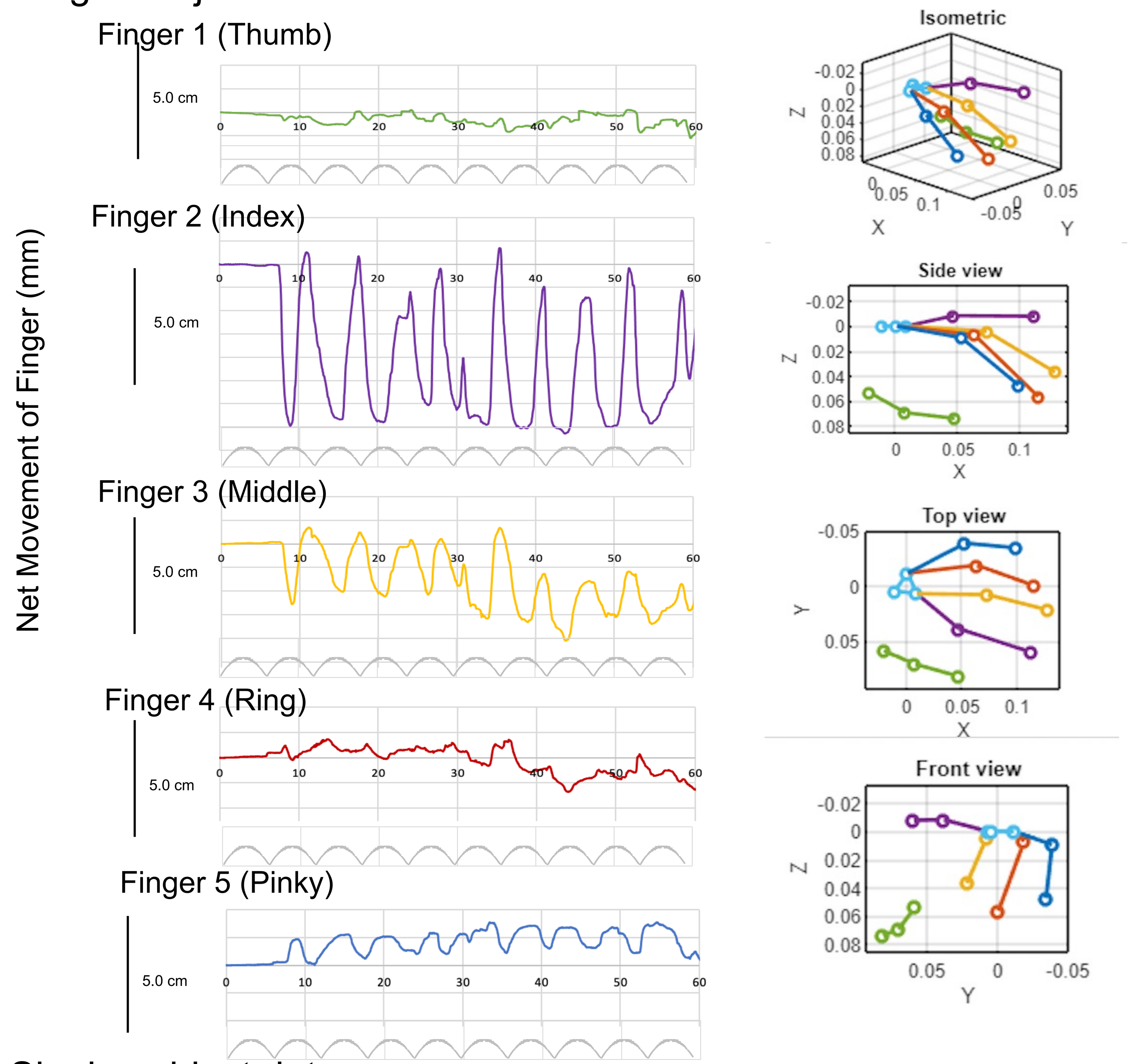
When the electrical stimulation was on, participants mimicked the movement perceived in their right hand.

Motion capture markers were placed over the left hand to track the movements perceived by the participant, which allowed tracking markers located on the left hand to record the amount of movement occurring.

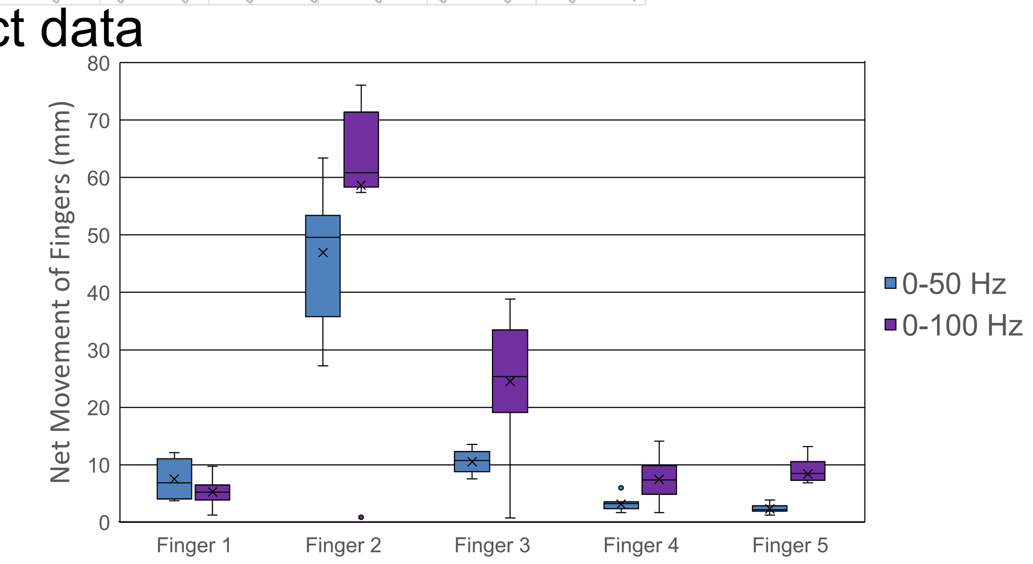
Data collection and analyses: 10 trials of each frequency were recorded, and the average of these trails was used to estimate the amount of movement perceived at each finger. Collected data was analyzed to determine the net movement of each finger respective to the hand itself. In the figures, 0 represents resting position, with positive numbers indicating flexion and negative indicating extension.

RESULTS

Single subject data

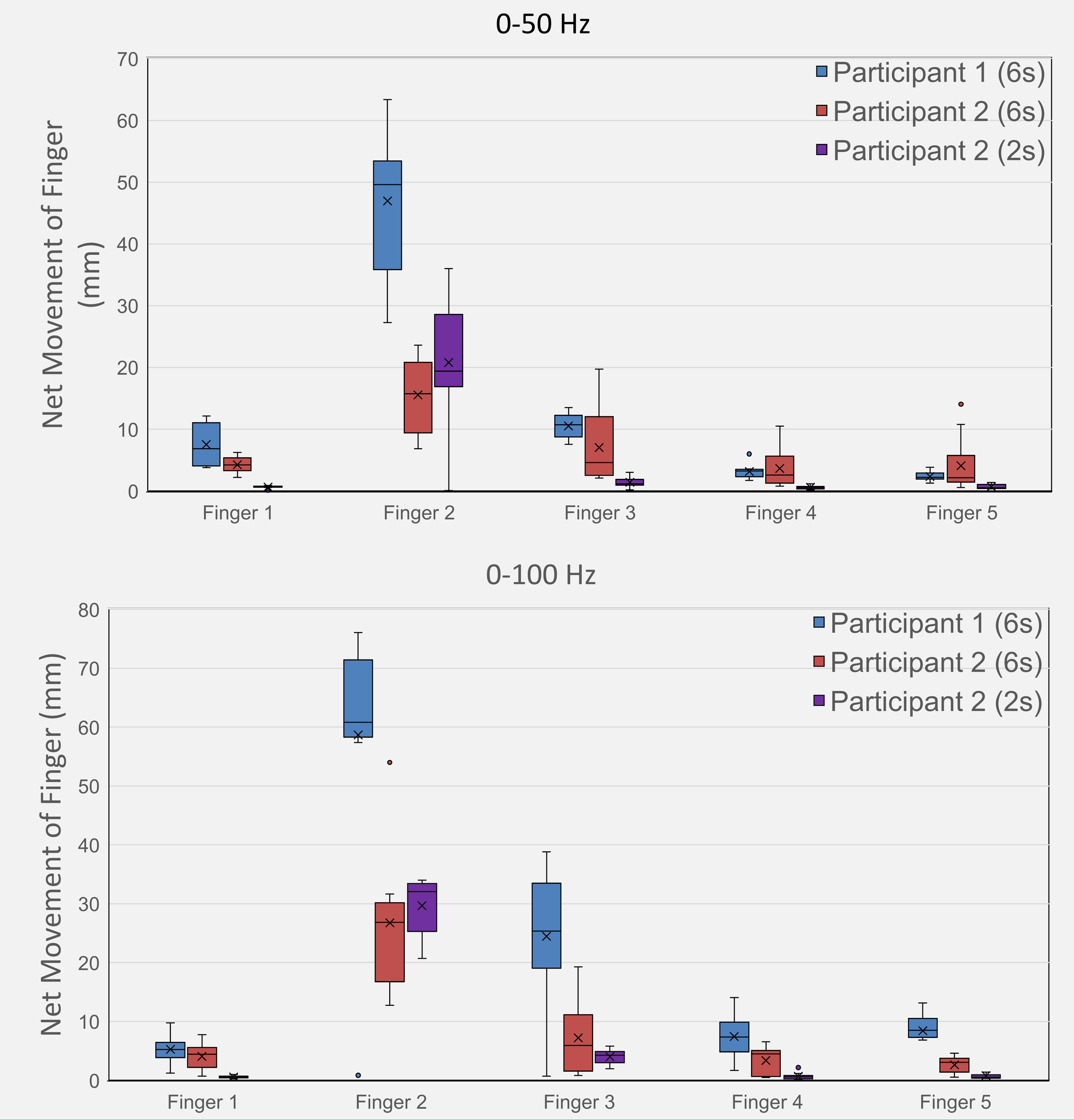


Single subject data



RESULTS

Group data



CONCLUSIONS

ES produced illusions of movements of the hand in all 3 participants tested thus far, supporting the idea that receptors in the skin contribute to kinesthesia of the hand, consistent with our first hypothesis.
Perceived movements, however, were not always in the predicted direction (flexion), contrary to our second hypothesis although illusory movement amplitude was larger as ES frequency increased, supporting our third hypothesis.
These results suggest that this approach may prove to be an effective way to explore the role for cutaneous receptors in the perception of movements of the hand.

REFERENCES

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[2] Gandeva SC. (1994). Kinaesthetic illusions involving the hand which are not dependent on muscle afferents. *Proceedings of the Australian Physiological and Pharmacological Society, 25*(1). [Unpublished Abstract].

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