Effect of Vibrotactile Stimulation on the Response Time to Handle Perturbation

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MOTIVATION

- Every year, more than 20,000 American workers get injured by falls from ladders [1].
- The direct compensation and medical costs associated with these falls are $5.3 billion/year [2].
- Cutaneous sensation at the hand (increased pressure on the hand) was the earliest cue available for people to detect handle perturbation during simulated ladder fall (as opposed to proprioception) [3].
- Cutaneous sensation can be improved by applying vibrotactile stimulation (Fig 1) [4].

OBJECTIVE

- To determine if vibrotactile stimulation can shorten a person's response time to handle perturbation

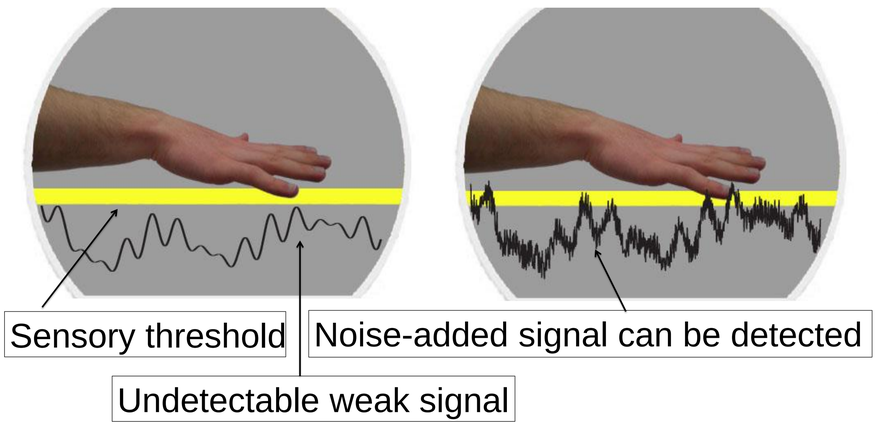


Fig 1. Weak signal may not be detectable (left). If subthreshold random noise is added to the signal, the noise-added signal may be detectable (right), increasing tactile acuity.

METHODS

Subjects:

- 19 right-handed healthy young adults
- 15 males and 4 females, age = 25 ±6 years
- The nondominant hand was tested since people usually use the dominant hand to perform works while holding rung with the nondominant hand.

Procedure:

- To simulate a ladder fall, a sudden upward load was applied at a random time to a handle that subject was lightly grasping (Fig 2).
- Subjects were instructed to stop the handle from moving up when they detected the perturbation.

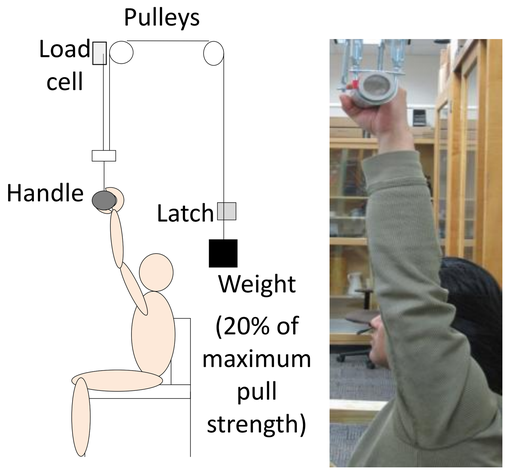


Fig 2. Experimental setup. The handle moved up at a random time. The subjects were instructed to stop the handle as soon as they noticed perturbation.

Vibrotactile Device:

- The device (Fig 3) applied subthreshold random noise (<500 Hz) vibrotactile stimulation at 50% of the sensory threshold.

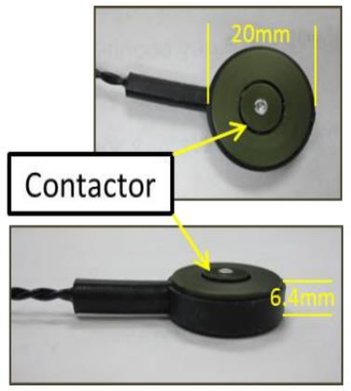
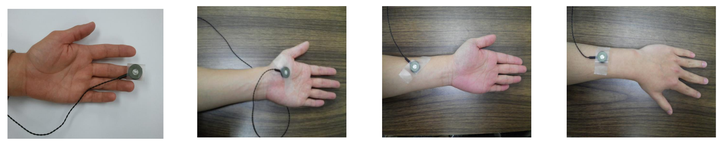


Fig 3 Vibrotactile device (C-3 Tactor, Engineering Acoustics, Inc., Casselberry, FL).

Test Conditions:

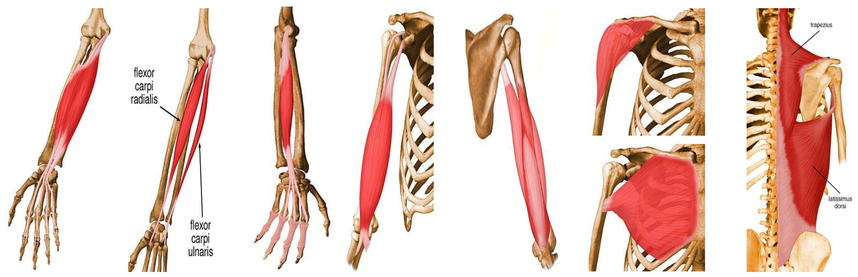
- Location: The device was attached at 4 different skin locations.



- Stimulation: ON vs. OFF
- All location and stimulation conditions were repeated 3 times in a random order.

Measure:

- Response times of the following 8 muscles using surface EMG [5]



Flexor Digitorum Superficialis | Flexor Carpi Ulnaris | Extensor Digitorum Communis | Biceps Brachii | Triceps Brachii | Anterior Deltoid (Top) Pectoralis Major (Bottom) | Latissimus Dorsi

Data Analysis:

- Among 8 muscles' response times, the fastest response time determined the *reaction time*.
- Repeated measures ANOVA was used to determine the effects of stimulation and location on the *reaction time*.

RESULTS

The *reaction time* significantly reduced with stimulation (p=0.026, 99±3 ms vs. 95±3 ms, pooled for 4 sites). The location and interaction between stimulation and location did not significantly affect the reaction time (p>.05). The pairwise comparison showed that the *reaction time* significantly decreased with the fingertip stimulation (p=0.018, 99±3 ms vs. 91±3 ms).

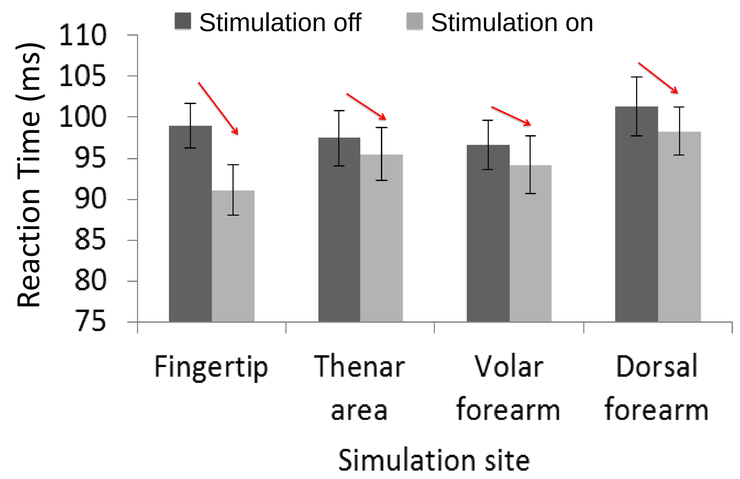


Fig 4 The *reaction time* to handle perturbation. Vibrotactile stimulation enhanced the reaction time regardless of the stimulation location.

CONCLUSION

- The application of vibrotactile stimulation enhanced persons' reaction time to handle perturbation.
- Enhanced reaction time using vibrotactile stimulation may help reduce falls from ladders.

ACKNOWLEDGEMENT

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