Multi-modality Sensory Feedback

BACKGROUND

Prostheses for clinical use restore the lost motor function of the hand, but not the sensory function. Implementing sensory feedback (SF) in prostheses can increase the grasping capability, introduce a feeling of embodiment of the prosthesis, and reduce phantom limb pain [1], [2]. The current non-invasive SF systems normally only incorporate one-modality (electrotactile, mechanotactile, or vibrotactile). By integrating multi-modality (MM) SF more information about the object and the manipulation itself can be provided to the user.

AIM

The aim of this study is to test the hypotheses that a multi-modality sensory feedback device, incorporating mechanotactile and vibrotactile feedback can increase the subjects' performance in localization and intensity discrimination.

METHOD

Eleven subjects participated in the study: two amputees, one with a referred phantom sensation (A1) and the other without (A2). Remaining nine subjects were non-amputees (N1-N9).

Incorporating eccentric rotating mass (ERM) and linear DC servomotor, the hybrid stimulation device sequentially expresses vibrotactile and mechanotactile modalities. The stimulation array was arranged according to A1's map of referred sensations (MoRS), while for the others the stimulation array was evenly distributed around the forearm (A2 and N1-N3) or V-shaped (N4-N9) placed on the dorsal side of the arm. The subjects were given 74 stimuli and were required to report the location (D1 to D5) and the intensity (level 1 to 3).

RESULTS

High detection accuracy was shown when applying stimuli on the MoRS (A1) and a lower accuracy in the case of A2 and H1-H9 (Figure 1). The figure, also shows that the V-shaped array has better performance with respect to the evenly distributed array. This was assumed since the V-shaped array has better correspondence with psychological attributes and, therefore, easier for users to distinguish the position of each actuator.

Figure 1 shows that MM stimulation has comparable performance to mechanotactile stimulation, but in this study the vibration provides an extra dimension. The subjects spontaneously reported that the extra feature relieved the mental load, since the vibration made them alert to the upcoming mechanotactile stimulation.

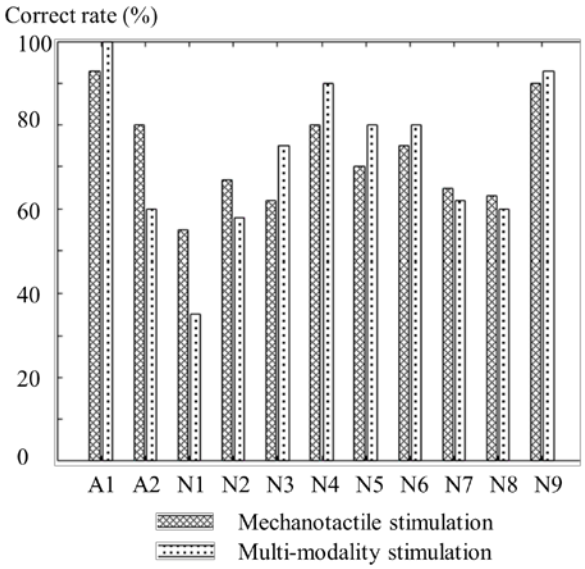

Figure 1. Individual detection performance during mechanotactile and multi-modality stimulation.

DISCUSSION & CONCLUSION

To the best of our knowledge, this is the first attempt combining mechanotactile and vibrotactile into a single SF device.

For persons without MoRS, the localization of the stimulations has to be memorized and predicted from previous stimulations.The outcome of this study shows that the hybrid stimulation relieves the mental load, but in future work activating both modalities simultaneously could increase haptic vocabulary. Hybrid stimulation also improves the performance for subjects with MoRS,.

REFERENCES

1. Antfolk, A. et al., 2013, Expert review of medical devices
2. Dietrich, C. et al., 2012, Neuroscience Letters