Mechanical skin properties and psychophysical characteristics with parallel oriented vibrotactile stimulation at three locations on the arm

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Introduction

Feedback about gripping force and level of hand opening is essential in the optimal control of a (myoelectric) forearm prosthesis, but lacking in current prostheses. Vibrotactile stimulation seems to be a good solution to provide this feedback in a comfortable and non-obtrusive way. However, the best method and parameters of stimulation are not yet known. Furthermore, the interpretation of the stimulus is also influenced by the mechanical characteristics of the skin and the mechanoreceptor properties (as shown in figure 2). In this study, skin characteristics and psychophysical aspects are evaluated during vibrotactile stimulation.

Methods

- Small pager motors (see figure 1), providing parallel oriented vibrotactile stimulation
- Frequency of stimulation controlled by a PI-controller
- Displacements measured via an accelerometer mounted on the vibrator
- 3 measurement locations on the arm of 10 healthy subjects

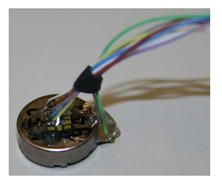

Figure 1: pager motor with accelerometer

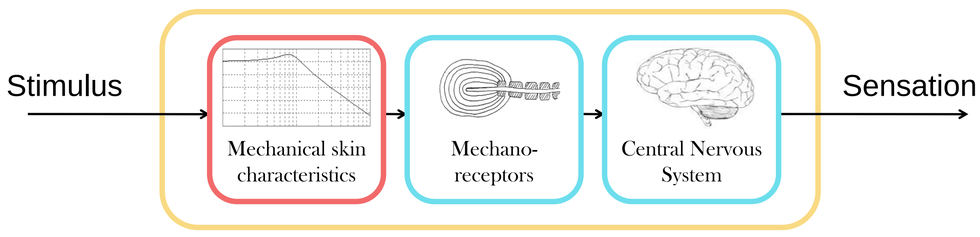

Figure 2: Stimulus interpretation chain and its separate components

Second order model fitted on the displacements data
➢ Mass, Stiffness and Damping constants of the system were derived.

1) Forced choice determination of just noticeable differences (JND's)
➢ differences in stimulation frequencies
2) Magnitude estimation of single stimuli
➢ interpretation of absolute frequencies
➢ distinguishable stimulation levels

From the first characterizations, insight in the properties of the other two blocks is provided.

Results

Displacements & transfer plots differ significantly for the 3 locations of stimulation (see figure 3).
➢ The mass, stiffness and damping constants are higher for the measurements at the dorsal side of the elbow.

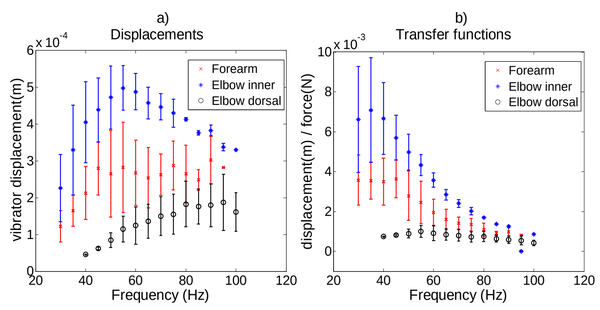

Figure 3: displacements and transfer plots for the 3 stimulation sites

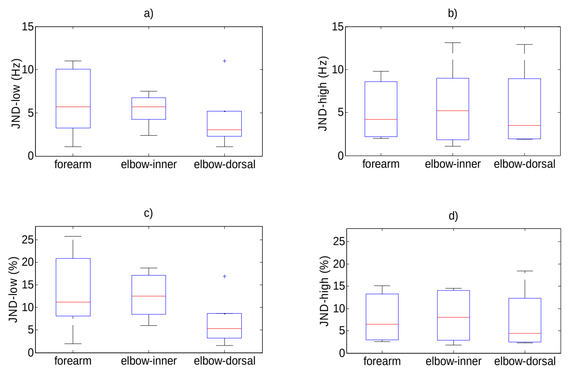

Figure 4: Just Noticeable Differences at the 3 stimulation sites

JND's expressed in hertz and percentages and per reference frequency (low and high) are shown in figure 4.
No significant differences were found between stimulation locations.

Interval between absolute stimulation frequencies should be at least 16 Hz to be distinguished.
No significant differences were found between stimulation locations.

Discussion and Conclusion

- Mechanical characteristics at the dorsal side of the elbow are different from the other locations
  - ➢ Mass, Damping and Stiffness constants were all significantly higher
- No differences in psychophysical properties between the stimulation locations
  - ➢ Probably due to the mechanoreceptor characteristics
- JND's much smaller (± 6 Hz) than the distinguishable intervals of single stimulation frequencies (> 18 Hz)
  - ➢ Use differential stimuli instead of absolute intensities to provide feedback in future applications

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