Effects of **stimulator type**, **array orientation** and **inter-stimulator distance** on localization performance with vibrotactile stimulation

Heidi Witteveen[1], Tom Knoop[1], Hans Rietman[2,3], Peter Veltink[1]

[1] Biomedical Signals and Systems, MIRA institute for biomedical engineering and technical medicine, University of Twente, Enschede

[2] Roessingh Research and Development, Enschede

[3] Biomechanical Engineering, MIRA institute for biomedical engineering and technical medicine, University of Twente, Enschede

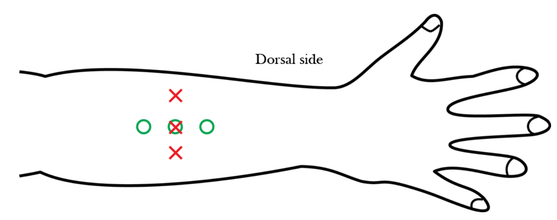
Introduction

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 [1]. Vibrotactile stimulation through an array of stimulators seems to be a good solution to provide hand opening feedback in an intuitive, comfortable and non-obtrusive way. The C2 tactor (Engineering Acoustics, Inc.) is a common used vibrotactile stimulator, but rather expensive and bulky in comparison to small coin motors, used in mobile phones, which may be applicable as well. Furthermore, the optimal array orientation and inter-stimulator distance to provide hand opening feedback are not investigated yet. In this study we have investigated the effects of the stimulator type, array orientation and inter-stimulator distance on the performance in a localization task.

Methods

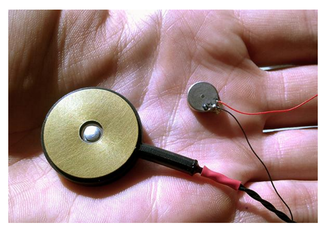
Array orientation (X_1)

Longitudinal *or* Transversal



Stimulator type (X_2)

C2 tactor *or* Coin motor



Inter-stimulator distance (X_3)

2, 4, 6 cm

- 10 healthy subjects (26 ±4.7 yrs.)
- 3 stimulators, placed halfway on the dominant forearm

- 60 stimuli of 1 s per measurement condition
- Random selection of 1 stimulator
- Subjects asked to indicate the active stimulator

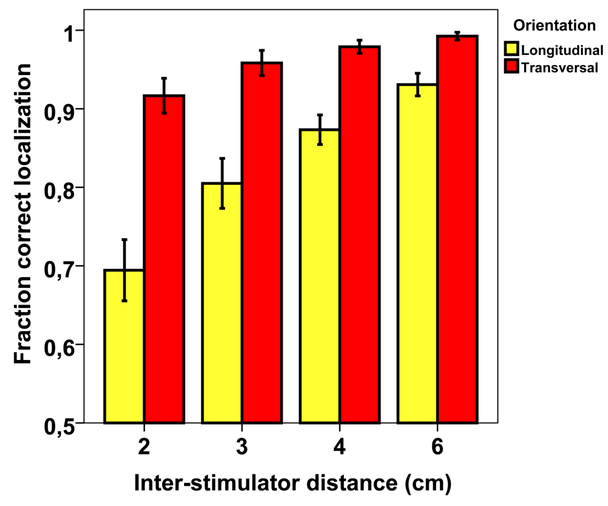
- Calculation of proportion (p) correctly identified stimulators
- Results fitted by a logistic model:

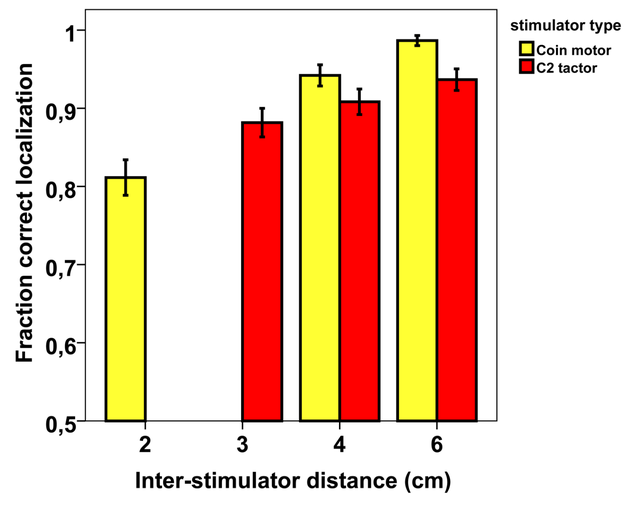
$$ln\left(\frac{\hat{p}}{1-\hat{p}}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$$

- Evaluation of the influence of the different factors (X_i) on the localization performance (p) through calculation of the $\beta_i's$

Results

- Mean localization performance of 0.93
- Increased performance with increasing inter-stimulator distance
- Localization performance significantly better for transversally oriented stimulator arrays ($p<0.001$)
- No differences in performance between both stimulator types ($p=0.30$)





Discussion and Conclusion

- High performance in localization task with an array of 3 stimulators on the forearm
  - ➢ Good opportunities for position feedback in prostheses, but further research (with more stimulators) is necessary
- Better localization performance with transversally oriented stimulator arrays
  - ➢ Probably because receptive fields of mechanoreceptors in the forearm are larger in the longitudinal direction
  - ➢ Transversally oriented arrays more useful on short stumps of forearm amputees
- No differences in stimulator type
  - ➢ Preference for the use of coin motors in future applications of hand opening feedback, because they are cheaper and smaller

[1] Peerdeman, B. et al. Myoelectric forearm prostheses: State of the art from a user-centered perspective. *JRRD,* 48(6), 719-738, 2011

UNIVERSITY OF TWENTE.

MIRA BIOMEDICAL TECHNOLOGY AND TECHNICAL MEDICINE

Myopro