Roll Tilt Self-Motion Direction Discrimination: First Evidence for Perceptual Learning

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Introduction

- Perceptual learning (PL) refers to a change in sensory experience through repeated exposure to stimuli (Seitz, 2017)
- Perceptual training leads to more sensitivity, reflected in *decreased sensory thresholds* for detection and discrimination
- A previous study on PL of self-motion direction discrimination found a decrease in yaw and y-translation thresholds when subjects trained self-motion with eyes open (Hartmann et al., 2013)
- However, no PL was found when subjects trained self-motion perception with their eyes closed
- **The goal of the present study was to investigate PL of self-motion perception in the dark with roll tilt stimuli, which are known to lead to simultaneous semicircular canal and otolith input**

Method

- Self-Motion direction discrimination on a Moog 6DOF motion platform

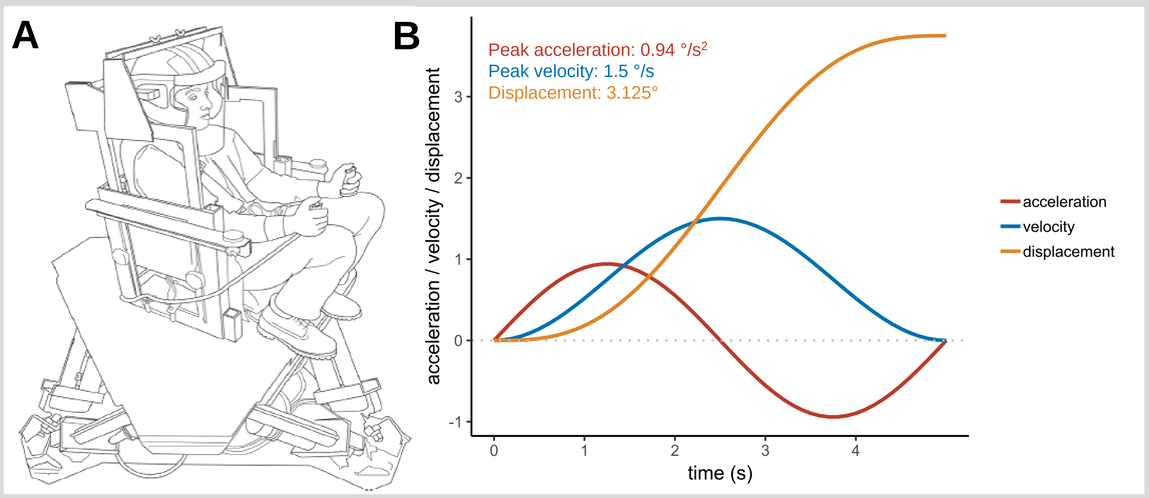

Fig. 1: (A) Motion Stimuli were delivered on a Moog 6DOF Motion Platform. After each rotation, participants indicated with 2 response buttons whether the previous stimulus was to the left or right (forward or backward for pitch motion stimuli). (B) Motion stimuli consisted of Single-cycles of sinusoidal acceleration profiles, resulting in bell shaped velocity curves, here for an example of an easy roll 0.2 Hz stimulus.

Design

Pre Measurement:
Direction discrimination performance before training

Psychometric Functions:
Roll 0.2 Hz (trained)
Roll 1 Hz (transfer)
Pitch 0.2 Hz (transfer)
Y-Axis 0.2 Hz (transfer)

Training Group:
Roll 0.2 Hz self-motion perception training for 6 days

Control Group:
Wait for 6 days

Post Measurement:
Direction discrimination performance after training

Psychometric Functions:
Roll 0.2 Hz (trained)
Roll 1 Hz (transfer)
Pitch 0.2 Hz (transfer)
Y-Axis 0.2 Hz (transfer)

Fig. 2: Overview of the design. Before and after the training, psychometric functions were measured for the trained condition (Roll 0.2 Hz) and in transfer conditions (Roll 1 Hz, Pich 0.2 Hz, Y-Axis 0.2 Hz). The training consisted of 1800 trials of a Roll 0.2 Hz left-right direction discrimination task. The stimulus level was chosen based on the pre measurement to reach ~65% accuracy at the start of the training. Subjects received feedback when they made a mistake during training.

Data Analysis

- Bayesian hierarchical generalized linear model with a probit link function
- **Pre/Post comparison:** response ~ velocity * group * condition
  - Trained motion: Roll 0.2 Hz
  - Transfer motions: Roll 1 Hz, Pitch 0.2 Hz, y-Axis 0.2 Hz
- **Training effect:** response ~ direction * block

Results

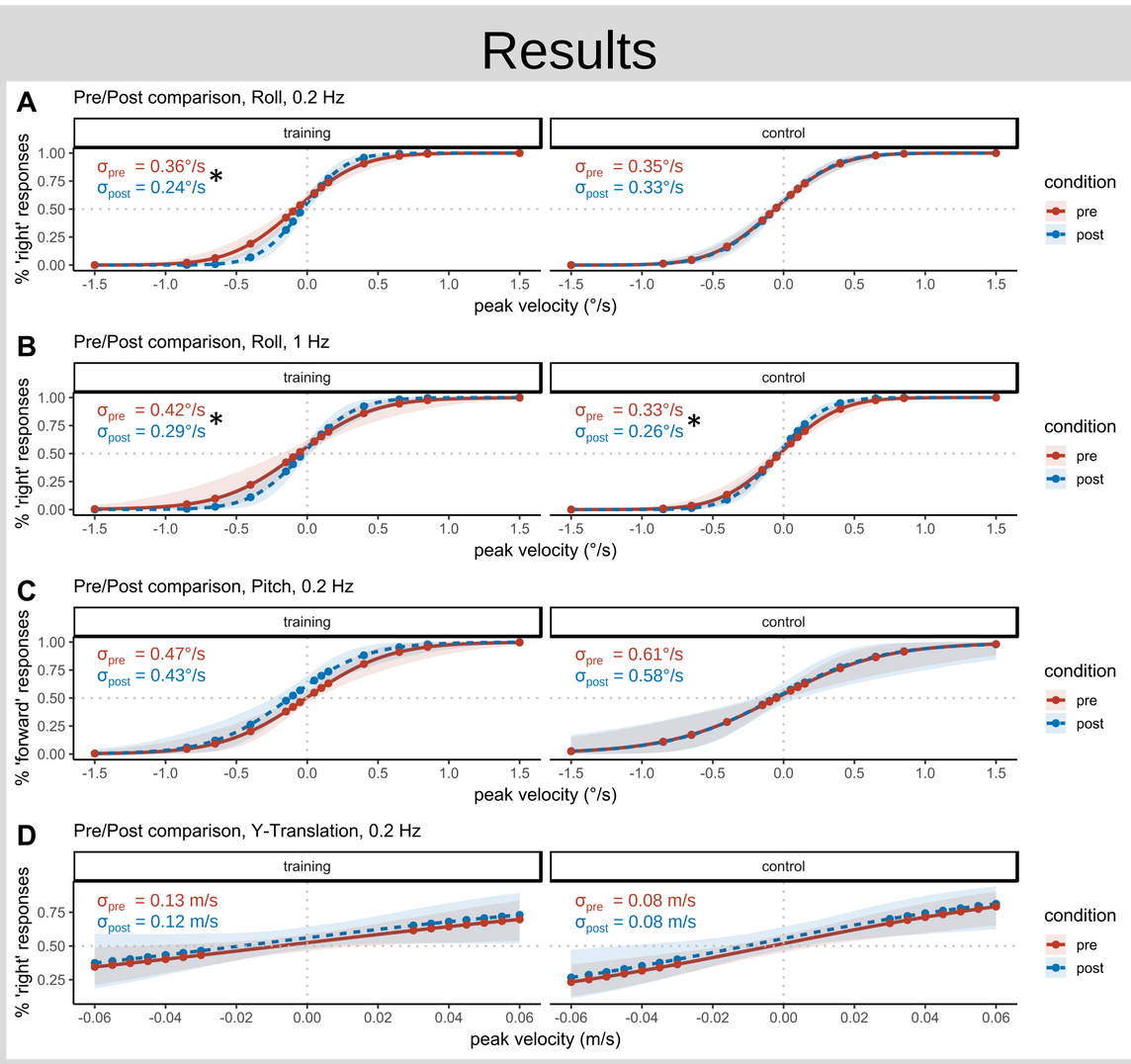

Fig. 3: Fitted psychometric functions for all pre/post motion conditions for the training and control group, before and after the training. In the Roll 0.2 Hz condition, there was a decrease in threshold for the training group, but not for the control group. In the Roll 1 Hz condition, there was a decrease in threshold for the training and for the control group. There was no change in threshold for the Pitch 0.2 Hz and the y-Axis 0.2 Hz motion conditions. Shaded areas represent 95% Credible Intervals. Meaningful differences in threshold are marked by *.

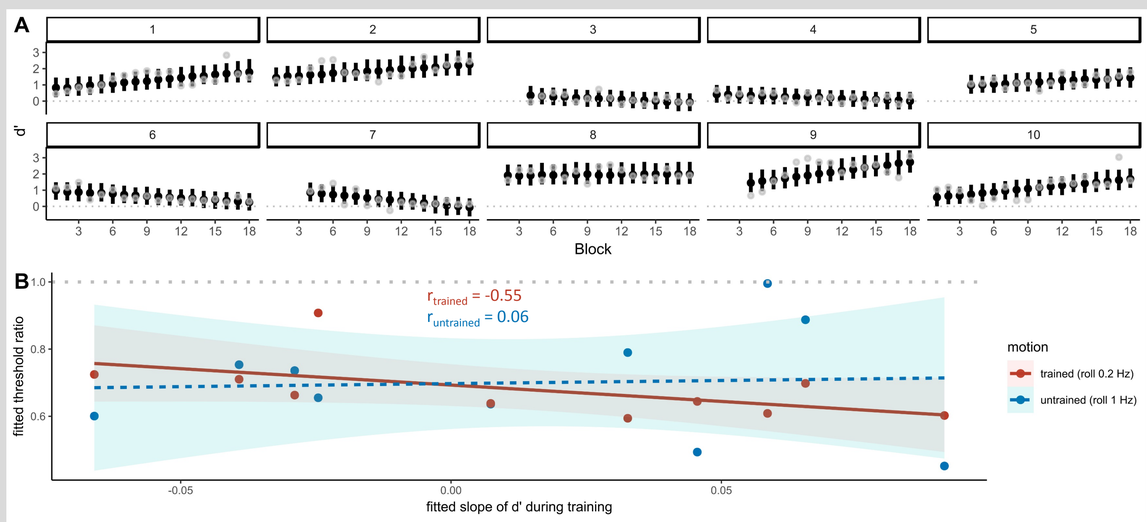

Fig. 4: (A) Black dots represent predicted sensitivity (d') as a function of training block for each subject with 95% Credible Interval. Grey dots are d' estimated based on hits and false alarms. While most subjects show a positive slope indicating learning, some subjects show no or even slightly negative slopes. (B) Illustration of the correlation between individuals learning curve during the training (x-axis) and their threshold ratio of the pre and post measurement. There is a negative correlation for the trained condition (red), suggesting that people who learned the most during training had improved thresholds after training in the trained motion condition. There is no correlation between learning during training and the threshold ratio for the untrained condition (Roll 1 Hz).

Discussion

- Roll-tilt self-motion thresholds were decreased after a week of training
- Improved sensitivity was specific to the trained motion
- Given the strong correlation between roll 0.2 Hz thresholds and balance (Karmali et al., 2017), future studies should investigate whether training of self-motion perception can improve balance
- Training as a therapeutic tool to compensate loss of vestibular function and increased risk of falls (Agrawal et al., 2013; Bermùdez Rey et al., 2016) should be investigated

References
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