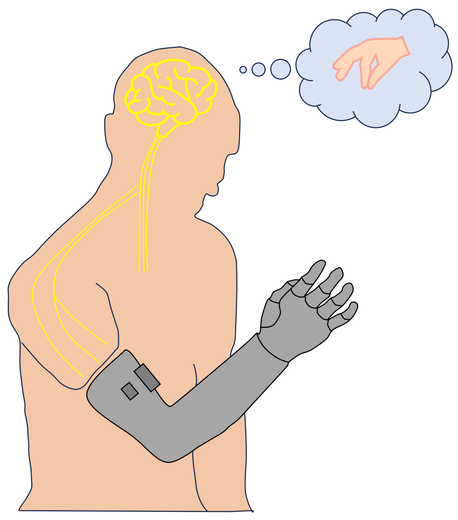
The Role of Muscle Property Changes in Identifying Motor Adaptation Stages for Myoelectric Control

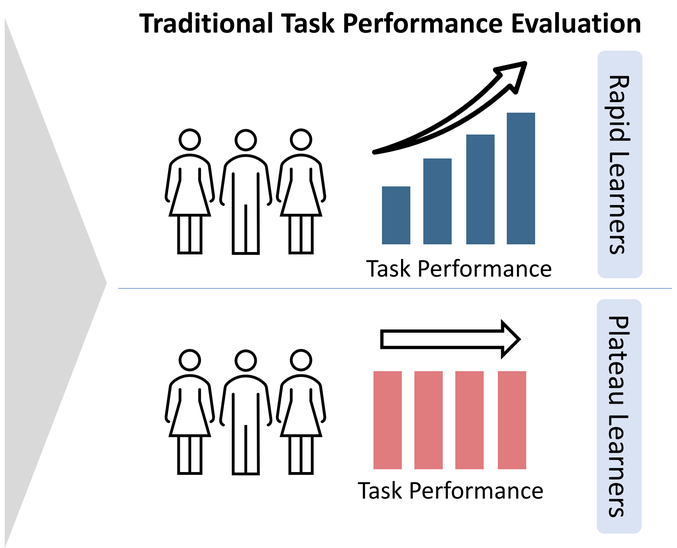
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1. BACKGROUND & MOTIVATION

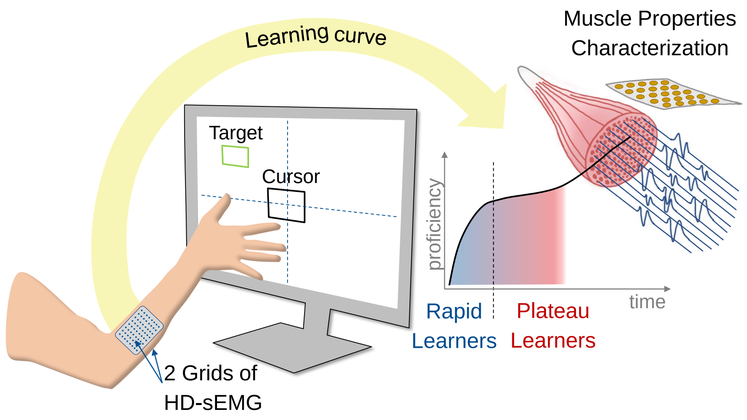




Prosthetic users exhibit significant differences in baseline myoelectric control capacity and the rate of improvement observed during training [1], [2]. However, standard task-performance metrics used to quantify training progress may miss critical neuromuscular adaptations underlying effective control. This work explores muscular markers to better capture individual differences in myoelectric control adaptation.

2. MATERIAL AND METHODS

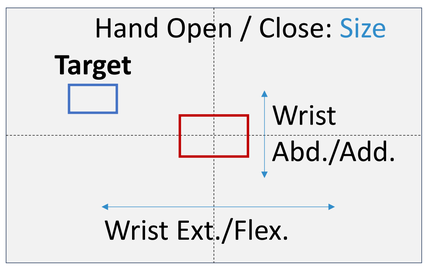
A. EXPERIMENTAL SETUP:



- 10 Able-Bodied Participants
- 26.7 ± 3.4 Years
- 3 Female 7 Male

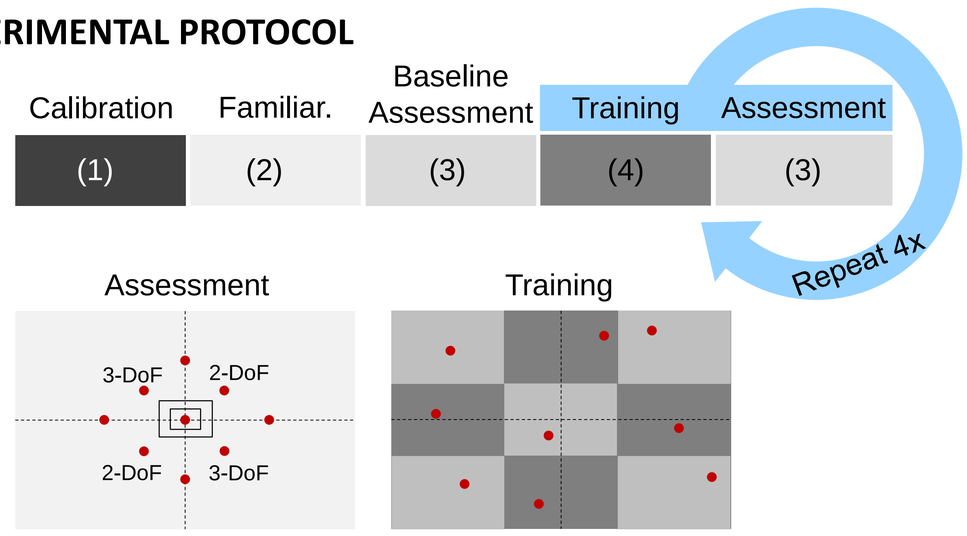
B. EXPERIMENTAL TASK:

Goal-Reaching Task:



- Multi-output SVR-based control of 3 DoFs
- Four EMG features extracted: Integral Absolute Value, Slope Sign Change, Willison Amplitude, and Power Spectrum Deformation.
- Training dataset augmented by incorporating linear combinations of single-DoF EMG signals to improve multi-DoF estimation [3].

C. EXPERIMENTAL PROTOCOL



- **Calibration:** Record training data for regressor training. Each single DoF movement was collected three times following a trapezoid-shaped target.
- **Familiarization:** Participants had 2 minutes to familiarize with the interface
- **Assessment:** Subjects were asked to match the targets for 15s without getting an indication if they were matched correctly. Assessment included 10 targets: six single DoF movements, two 2 DoF targets, and two 3 DoF targets.
- **Training:** Participants were asked to match the target for 2s, then next target appeared. Training included 9 targets, all involving multiple DoFs.

D. PARTICIPANT GROUPING

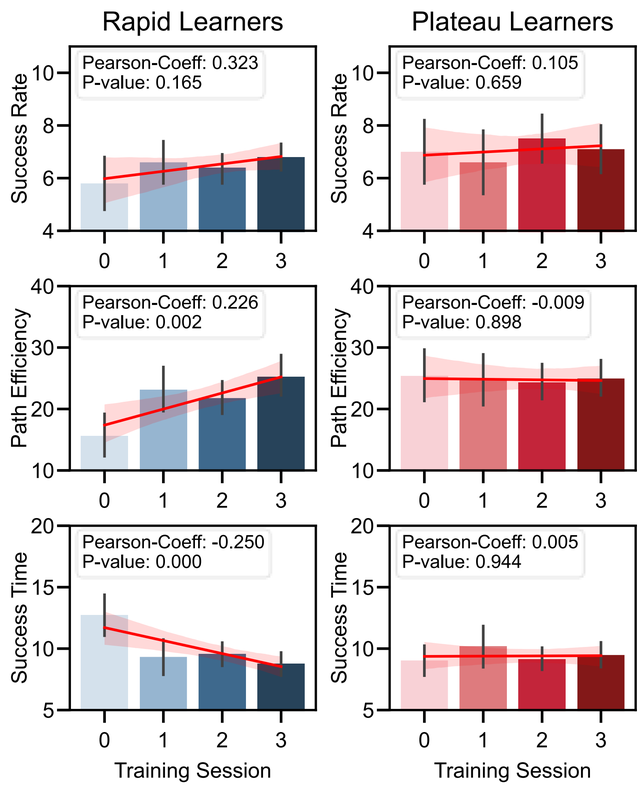
$$PEM = mean(\Delta PE) - mean(\Delta ST) + \Delta SR$$

PE: Path Efficiency, ST: Success Time, SR: Success Rate

Participants were divided into two equally sized groups – rapid and plateau learners – based on their *performance evolution measure* (PEM) scores.

3. EXPERIMENTAL RESULTS

A. TASK PERFORMANCE EVOLUTION



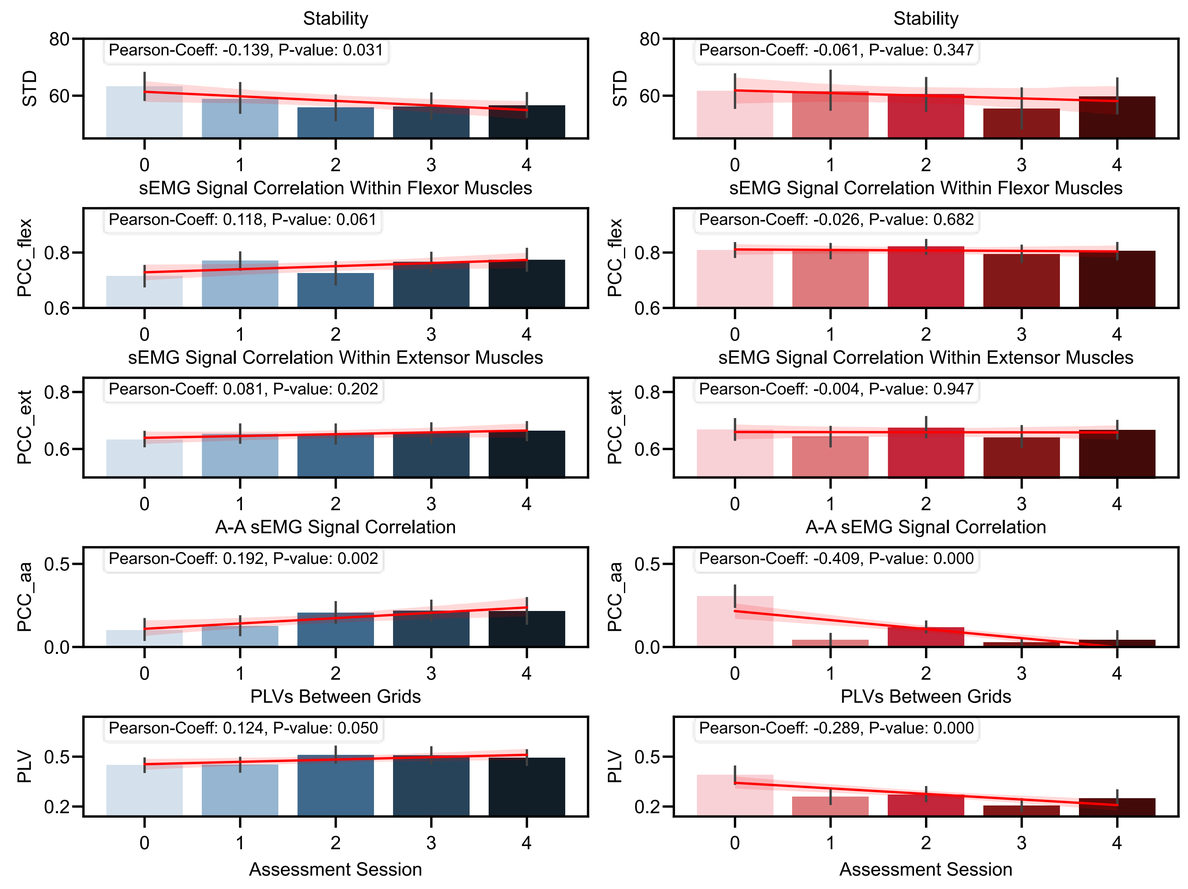
Rapid learners demonstrated significantly lower **baseline** PE compared to plateau learners ($p = 0.002$) and significantly longer ST ($p < 0.001$).

Rapid learners showed a positive correlation in PE and a negative correlation in ST across sessions, indicating improvement in task-specific metrics.

Plateau learners exhibited no significant changes in task-specific performance metrics across sessions.

→While task-level evaluations indicate insufficient adaptation for plateau learners, motor adaptations might primarily occur at the muscular level rather than in immediate performance metrics.

B. MUSCLE PROPERTIES EVOLUTION



Rapid learners exhibit greater stability in muscle contractions (negative correlation in the STD of sEMG signals) over sessions. Increased co-contraction (positive PCC_aa) may enhance joint stiffness, improving task performance, but potentially reducing individual muscle activation for fine control. Neural coordination patterns (PLV) remain consistent, prioritizing stability.

Plateau learners showed no significant changes in sEMG stability, consistent with steady task performance. Moreover, they start with high task performance, potentially needing less co-contraction to stabilize movements (negative correlation of PCC_aa). Combined with the decrease in PLVs, this suggests greater independence in activating antagonistic muscles.

4. CONCLUSION & FUTURE WORK

→**Rapid learners (participants starting with lower baseline performance)** focus on stabilizing muscle activation to reach a solid level of task performance.

→**Plateau learners (participants with higher baseline performance)** show limited improvement in task metrics due to high baseline performance. Yet, their progress is evident at the muscular level, which may enhance endurance and enable refinement in neuromuscular control.

→Muscle differences should be considered when assessing adaptation and learning effects, as some individuals may not show task-specific improvements but still benefit from training in muscle conditioning and control strategy refinement.

Future Work: should explore motor adaptation strategies across various controllers and populations, investigating whether rapid learners eventually reach a plateau where task performance stabilizes and neuromuscular adaptation becomes more refined.

EXCELLENCE STRATEGY of the German federal & state governments
HIGHTECH Agenda Bavaria
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