Development of a bimanual rehabilitative device, TrayBall

Motivation

Someone in the United States has a stroke every 40 seconds, it represents 800,000 cases per years. Stroke survivors are experiencing lost of motor functions and independency, they need to retrain motion abilities, coordination and daily life activities. Bilateral rehabilitative strategies allow to retrain everyday functions, new intensive training inspired by Activity of the Daily Life are design using immersive technology with visual distortion.

Objectives

1. Design new structural iteration of the LookingGlass for clinical use
2. Integrate new visual tracking system, create ready-to-use system and implement rehabilitative treatment
3. Experiment a new rehabilitative strategy with the new system

Development

The LookingGlass is a virtual display system used to superimpose a virtual screen within the user’s arm workspace. The reflection enables virtual objects to be superimposed onto the real world or onto the user’s limbs.

In addition to the display setup, haptic robotic force feedback and data from tracking limb segments are combined within the system to create a highly immersive environment, that aims to answer neurophysiological control questions.

Functional analysis:

- Thrusort or caregiver can adjust easily the system to the patient.
- Structure has to be modular and adapted to clinical use
- System has to be functional within full body-sized workspace
- Tracking system can record patient’s or therapist’s hand kinematic
- The new structure have to solve an hindrance issue and allow side-by-side therapy

Implementation

Bimanual Error Augmentation

Motor Learning is a feedforward control that tends to correct the error. Error augmentation allows to increase learning rate.

- The error vector, defined as the instantaneous difference in position between the participant’s hands
  \[
  \bar{e}(t) = X_{\text{target}}(t) - X_{\text{arm}}(t) - \bar{e}_{\text{static}}(0) - \bar{e}_{\text{static}}(0,0)
  \]
- Displayed position is visually error augmented

Balancing reaching task

The users control with their hand the tray position and have to keep the ball on the plate during the reaching. The error commit on the hand horizontal coordination is doubled for the EA group. The task combines target reaching (forward motor control) and balancing task (cognitive and feedforward control)

Experiment

Does error augmentation in bimanual reaching task with a balance challenge bring benefit to stroke survivors?

However original study was designed for neurological impaired individual, the experiment was made with healthy subjects.

Objectives:

1. Ensure the safety and toleration of the proposed treatment
2. Set healthy baseline
3. Measure effects of the treatment

- 8 healthy subject: 4 Control and 4 EA group
- Baseline and Evaluation block with quasi-static ball and training with challenging balancing task

Results

- No statistical differences between healthy group (EA and Control)
- EA treatment allow to reduce horizontal error
- Number of trial during one session statically increase with training

Key Findings

- Error augmentation with balancing task increase motor learning.
- Participant-specific motor strategy for completion of the task.
- Reaching number significantly differs for patient, difficulty of the training should be patient specific. Therapy is now IRB approved and tested at Shirley Ryan Ability Lab at Chicago.