# Cerebellar anodal transcranial direct current stimulation (CB atDCS) to modulate cerebello-cerebral networks in bimanual coordination in young and older adults

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**REVAL** REHABILITATION RESEARCH

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## Background

Complex **bimanual coordination** requires a good coordination between different neurological networks. Despite a crucial role of the **cerebellum** in motor coordination and motor learning, little is known about the cerebellar role in bimanual coordination, especially in aging. Although the cerebellum is also consistently activated during finger and hand movements in young adults, it is the strongest predictor of bimanual coordination performance only in children and in **older adults** (Boisgontier et al., 2018). We performed an **ALE meta-analysis** to determine the cerebellar structures involved in different types of bimanual coordination (in-phase, anti-phase, complex). In addition, we used cerebellar anodal transcranial direct current stimulation (**CB atDCS**) to investigate the crucially implicated cerebello-cerebral networks in bimanual coordination in young and older adults.

## Methodology

### ALE meta-analysis

Title/abstracts screened (n = 189)
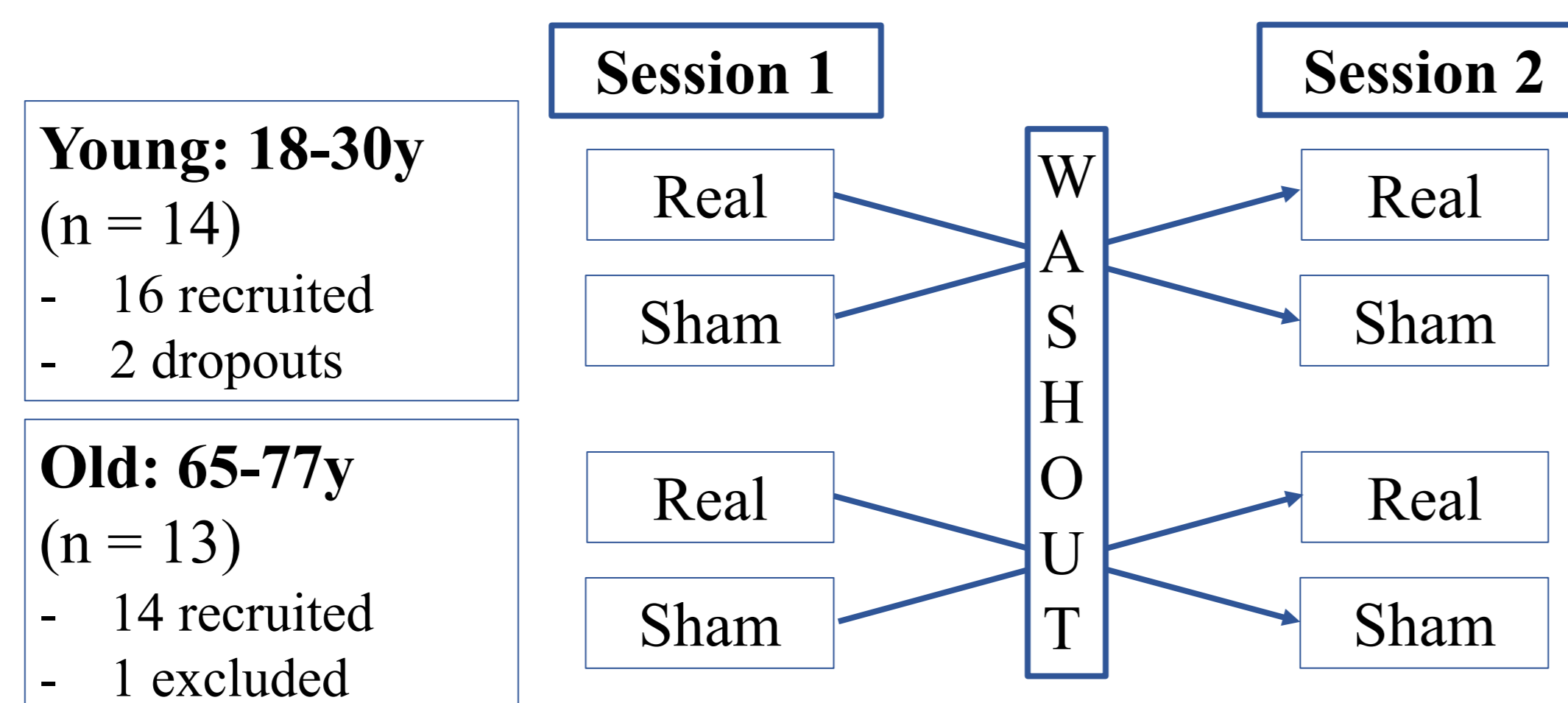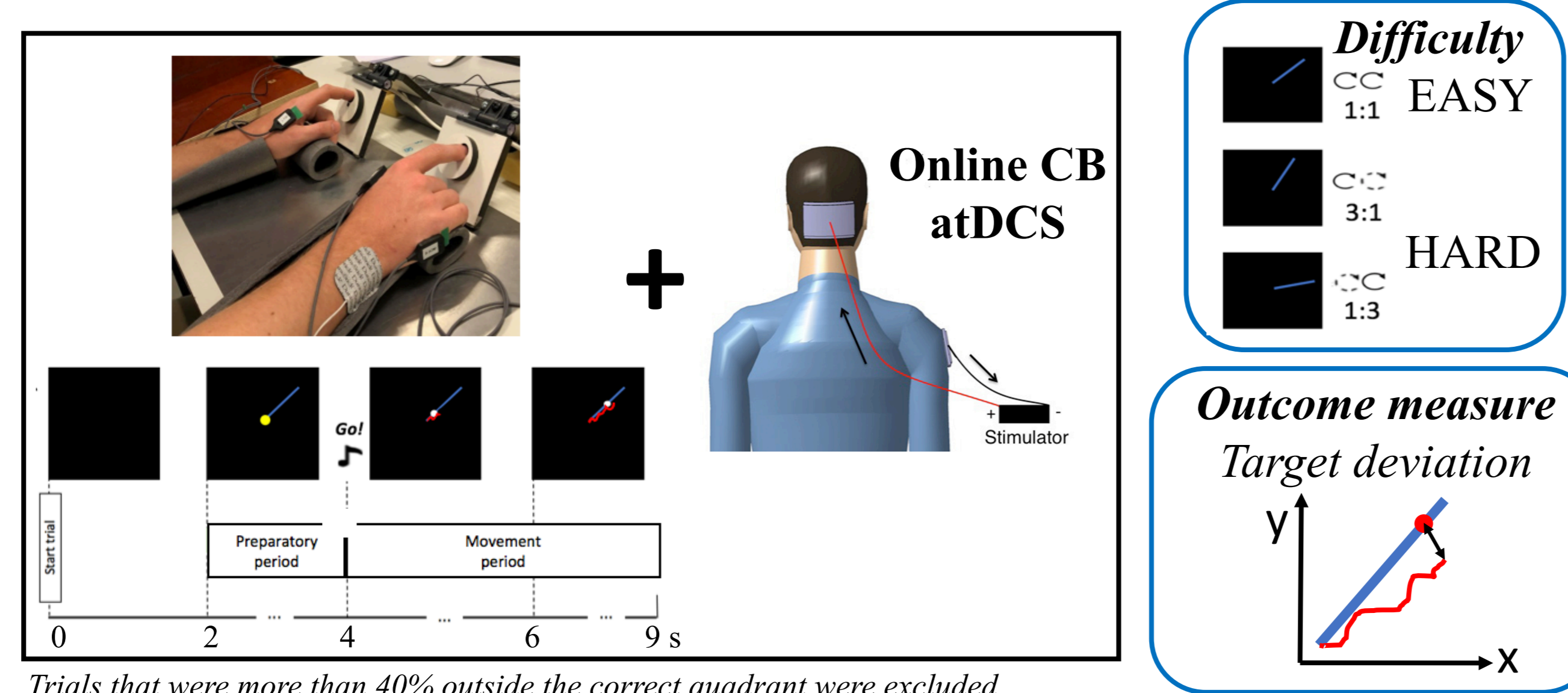↓
Full-texts screened (n = 77)
↓
Articles included (n = 41)
#Comparisons = 97
- In-phase > Rest (n = 10)
- Anti-phase > Rest (n = 9)
- Complex > Rest (n = 7)

### Parameters

MNI coordinates
Cluster-level inference thresholding
• Thresholding p<0.05
• 5000 permutations
• Cluster-forming FDR pID<0,01

### Bimanual tracking task (BTT)



**Online CB atDCS**

***Difficulty***
CC 1:1 EASY
CC 3:1 HARD
CC 1:3

*Trials that were more than 40% outside the correct quadrant were excluded.*

***Outcome measure***
*Target deviation*

**Young: 18-30y**
(n = 14)
- 16 recruited
- 2 dropouts

**Old: 65-77y**
(n = 13)
- 14 recruited
- 1 excluded

| Session 1 | WASHOUT | Session 2 |
|---|---|---|
| Real | | Real |
| Sham | | Sham |
| Real | | Real |
| Sham | | Sham |

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## Results

### ALE meta-analysis

| Article | #foci | #Experiments | Total #subjects |
|---|---|---|---|
| **IN-PHASE > REST** | 99 | 10 | 126 |
| **ANTI-PHASE > REST** | 118 | 9 | 113 |
| **COMPLEX > REST** | 126 | 7 | 72 |



z = -23    z = 4    z = 58

Complex    In-phase    Anti-phase
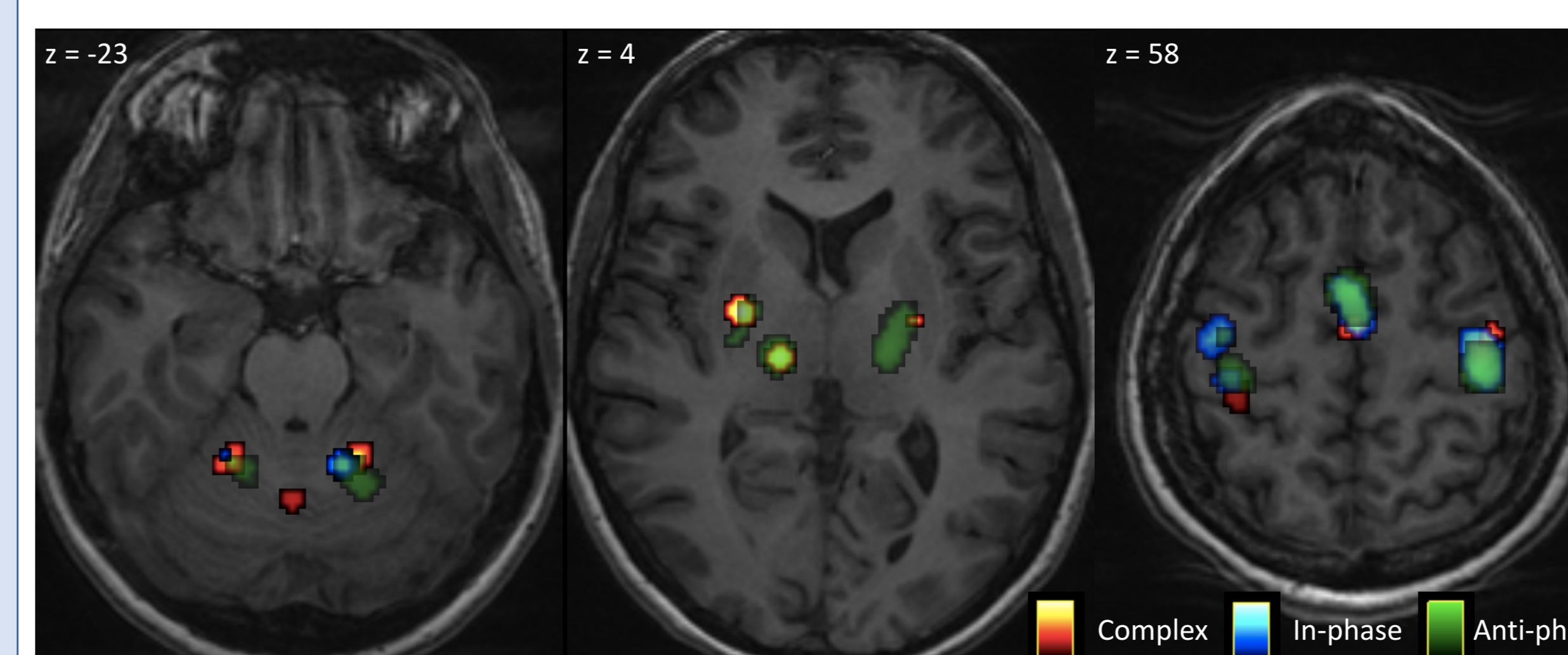
| Contrast | Cluster | Cluster size (mm³) | Cluster center | Cluster label | #Contributors |
|---|---|---|---|---|---|
| **IN-PHASE > REST** | | | | | |
| | 1 | 1680 | -37 -19 57 | L Precentral gyrus | 8 studies |
| | 2 | 1632 | 1 -4 58 | R Medial frontal gyrus | 8 studies |
| | 3 | 1552 | 40 -21 54 | R Postcentral gyrus | 6 studies |
| | 4 | 272 | -13 -52 -21 | Left DN | 3 studies |
| **ANTI-PHASE > REST** | | | | | |
| | 1 | 1384 | 2 0 60 | R Medial frontal gyrus | 7 studies |
| | 2 | 1344 | -37 -22 58 | L Precentral gyrus | 6 studies |
| | 3 | 1264 | 36 -24 53 | R Precentral gyrus | 7 studies |
| | 4 | 1224 | -19 -13 4 | L thalamus (VPL) | 6 studies |
| | 5 | 1152 | 15 -18 5 | R thalamus | 6 studies |
| | 6 | 520 | -17 -55 -23 | L DN | 4 studies |
| | 7 | 400 | 25 -7 4 | R Globus Pallidus | 4 studies |
| **COMPLEX > REST** | | | | | |
| | 1 | 408 | 35 -31 63 | R postcentral gyrus | 4 studies |
| | 2 | 392 | 2 -62 -18 | R antCB | 4 studies |
| | 3 | 360 | 20 -50 -26 | R antCB | 3 studies |
| | 4 | 328 | -17 -49 -25 | L antCB | 2 studies |
| | 5 | 304 | 27 -5 3 | R putamen | 3 studies |
| | 6 | 288 | 1 -9 56 | L medial frontal gyrus | 3 studies |
| | 7 | 256 | 15 -19 5 | R thalamus | 3 studies |
| | 8 | 184 | -40 -12 56 | L precentral gyrus | 2 studies |

### Bimanual tracking task (BTT)
Linear mixed model

*Post – Pre tDCS Average target deviation in arbitrary units*



**Difficulty x tDCS \***

**Age x tDCS \***

Young    Old
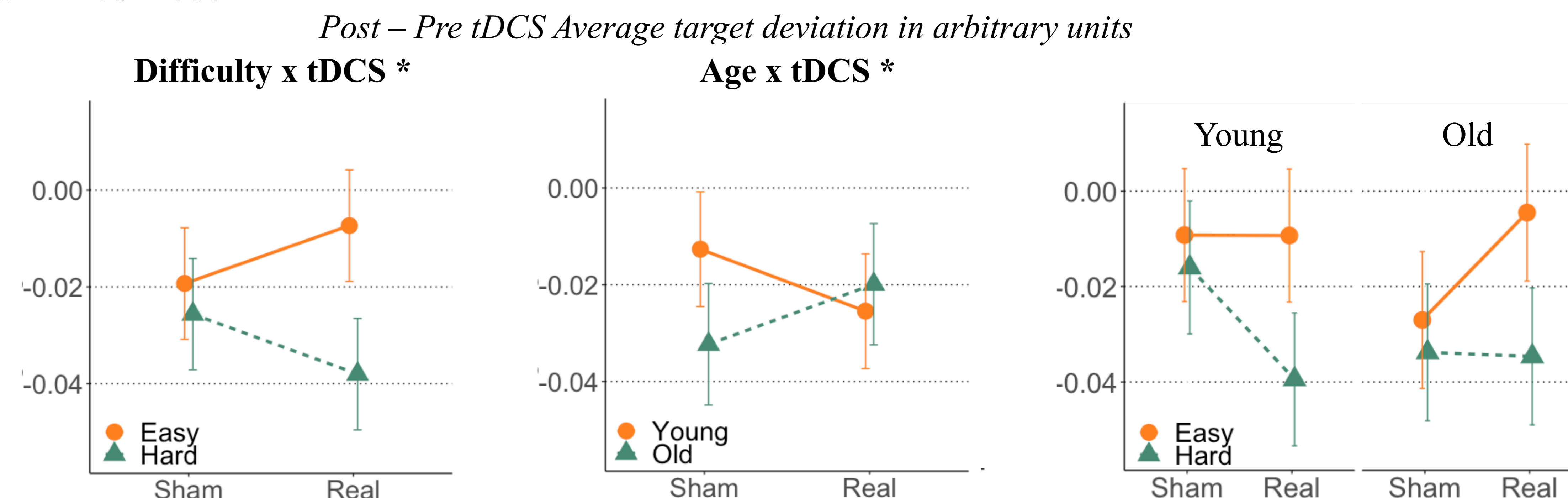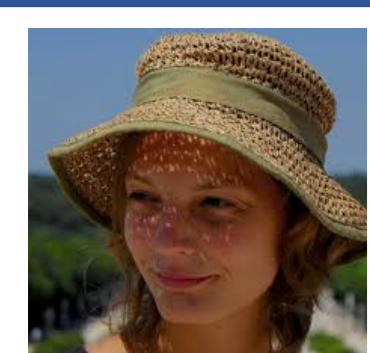
## Discussion

The ALE meta-analysis revealed that the **cerebellum** is particularly involved in **complex** bimanual movements, in collaboration with the **subcortical** structures. By stimulating the cerebellum during a bimanual coordination task, it was shown that this stimulation had a **significantly different impact on difficult conditions** (3:1 or 1:3 frequency) **as compared to easy conditions** (1:1). However, the effect of tDCS was not the same for both age groups. While CB atDCS seemed to have a **beneficial effect** on target deviation in young adults, the **opposite appeared to be true for older adults**. This pilot study shows that more studies are needed on the exact role of the cerebellum in aging.