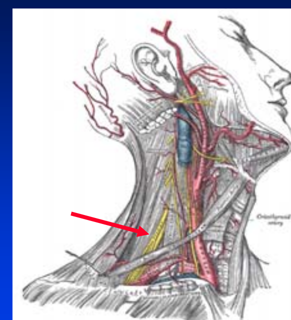
# Paper Discussion

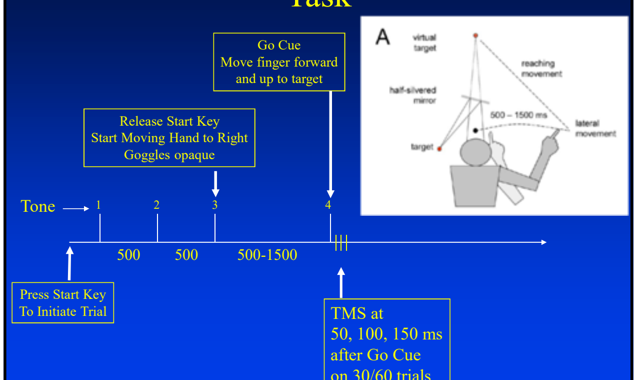
Miall RC, Christensen LO, Cain O, Stanley J (2007) Disruption of state estimation in the human lateral cerebellum. PLoS Biol 5:e316.

# Brachial Plexus



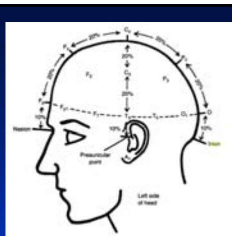
Network of nerves providing cutaneous senses and muscular control of the upper limb

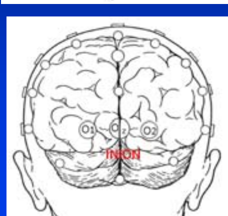
# Task




# Deeper Stimulation

Double Cone Coil

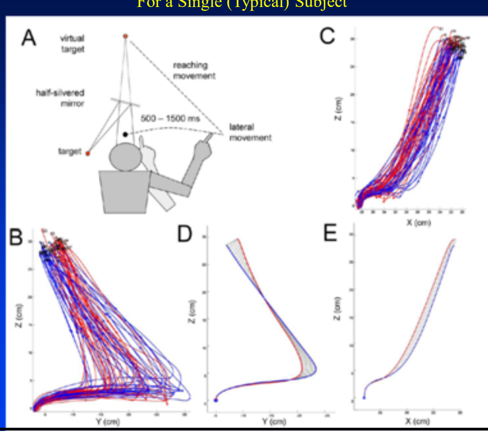




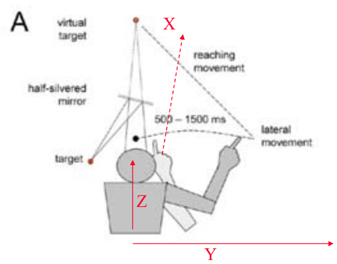

# Inion

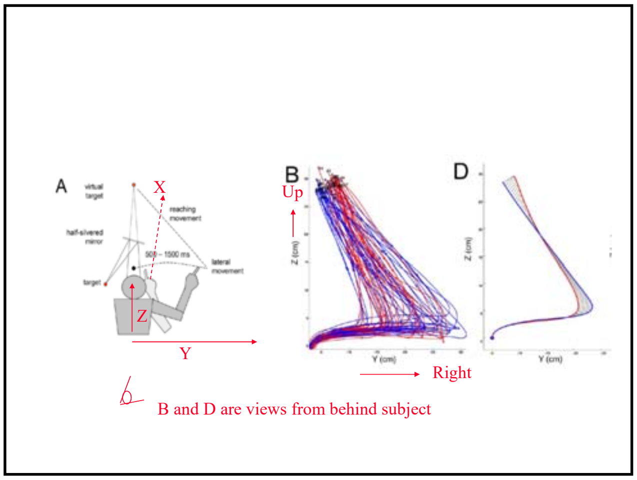
# Motion Tracking: Polhemus

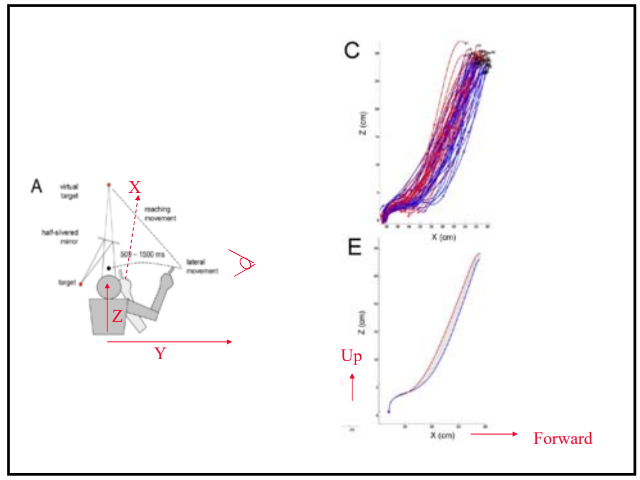

Figure 1: Digitized Trajectories
For a Single (Typical) Subject

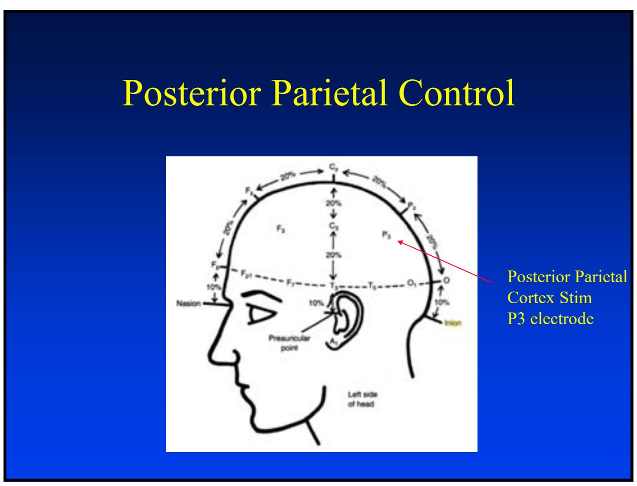


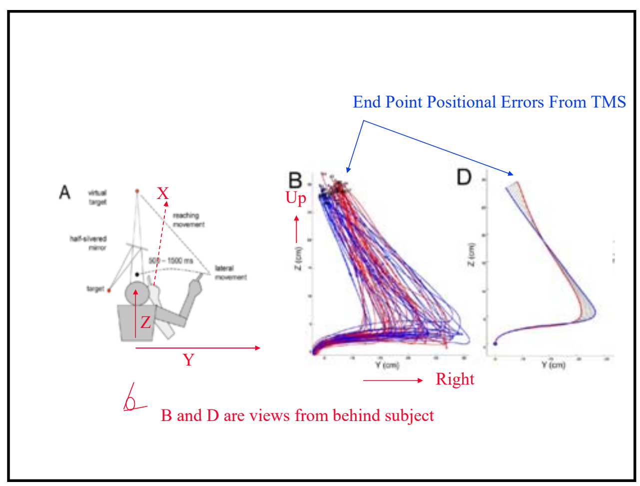

# Axes




A
X
Z
Y
B
Up
D
Right
B and D are views from behind subject


A
X
Z
Y
C
E
Up
Forward


Posterior Parietal Control
Nasion
Preauricular point
Inion
Left side of head
Posterior Parietal
Cortex Stim
P3 electrode


End Point Positional Errors From TMS
A
X
Z
Y
B
Up
D
Right
B and D are views from behind subject

## Figure 2: End Point Errors
## TMS and Control Conditions

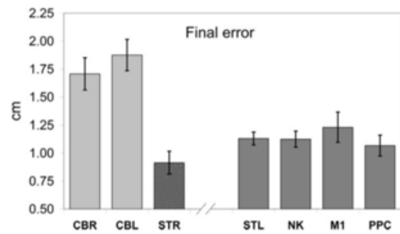



**Figure 2.** TMS-Induced Difference in Mean End-Point Error
Each bar is the group mean difference for TMS versus non-TMS trials (+1 SEM). TMS was applied over the cerebellum during rightwards and leftwards movement (CBR, $n = 32$, CBL, $n = 13$) and when stationary (STR, $n = 9$). Control conditions included during startle trials (STL, $n = 11$), stimulation of the ipsilateral neck (NK, $n = 10$), the hand area of contralateral primary motor cortex (M1, $n = 20$), and the contralateral posterior parietal cortex (PPC, $n = 12$).

## Figure 3: Trajectories Averaged over All Subjects

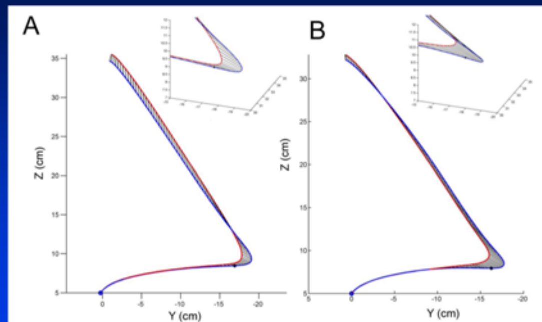
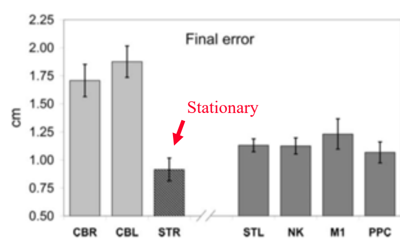



**Figure 3.** Group Mean Trajectories
Group mean trajectories (A) for TMS trials (red) and non-TMS trials (blue) applied over the cerebellum ($n = 32$). (B) Results from startling TMS or auditory trials, without cerebellar disruption ($n = 11$). In both panels, the curved path followed from bottom left to right is during the pre-cue period. Shortly after the go cue and TMS, a rapid reach-to-target towards the upper left target position is made. The 3-D inset figures show an expanded view of the reach-to-target initiation. Black dots mark the position on the non-TMS mean trajectory (blue line) from which a similar angular deviation between start and maximum velocity would be found as seen in the TMS trials.
doi:10.1371/journal.pbio.0050316.g003

## Figure 2: End Point Errors
## TMS and Control Conditions

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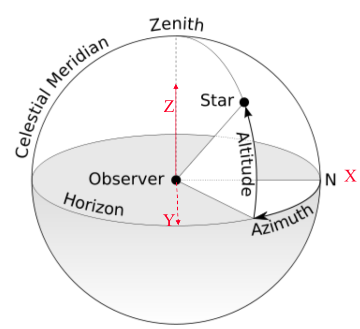
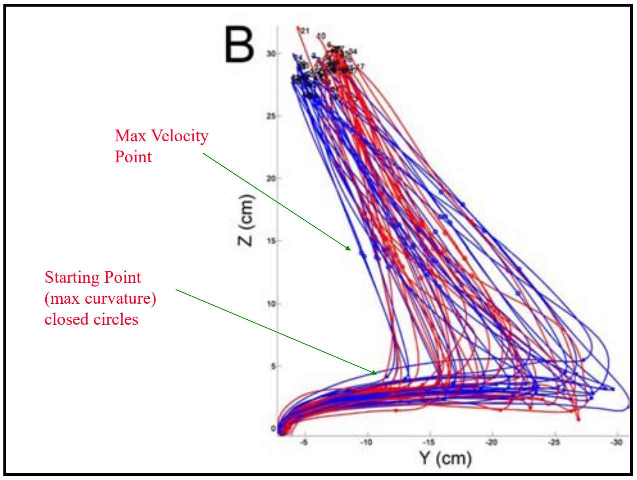
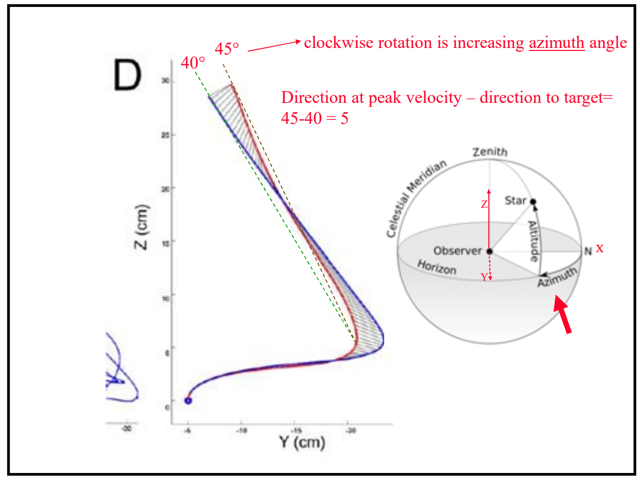
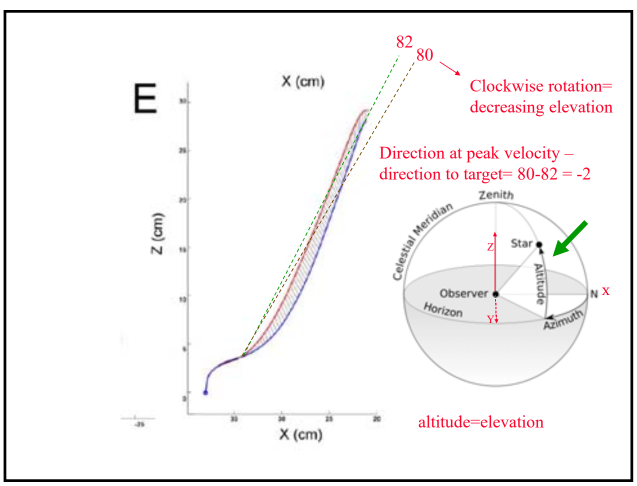
## Azimuth and Elevation (Altitude)





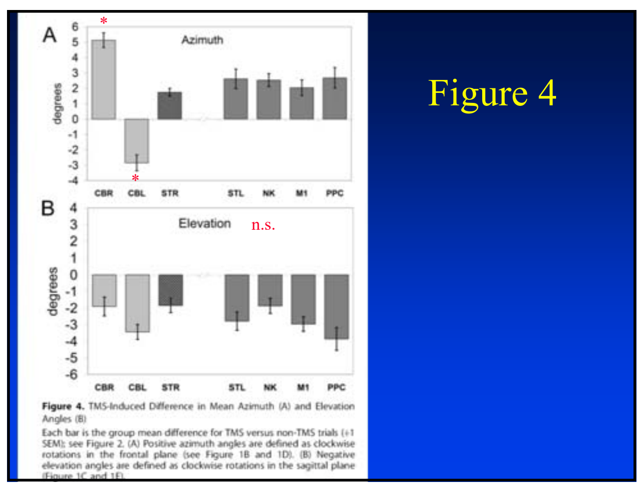
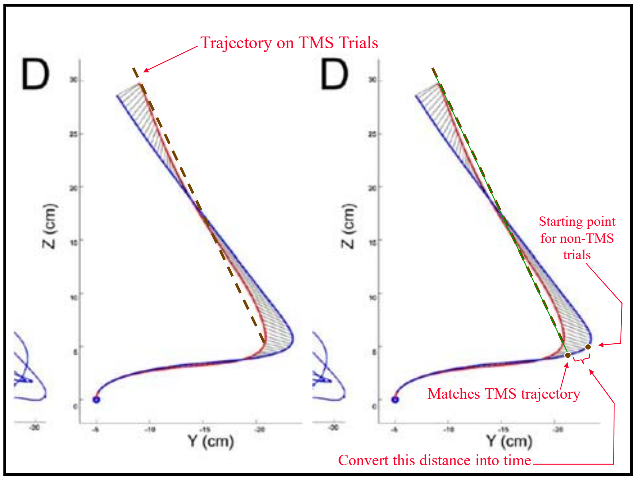



**Figure 4.** TMS-Induced Difference in Mean Azimuth (A) and Elevation Angles (B)
Each bar is the group mean difference for TMS versus non-TMS trials (+1 SEM); see Figure 2. (A) Positive azimuth angles are defined as clockwise rotations in the frontal plane (see Figure 1B and 1D). (B) Negative elevation angles are defined as clockwise rotations in the sagittal plane (Figure 1C and 1E).


Trajectory on TMS Trials
D
D
Z (cm)
Z (cm)
Y (cm)
Y (cm)
Starting point for non-TMS trials
Matches TMS trajectory
Convert this distance into time

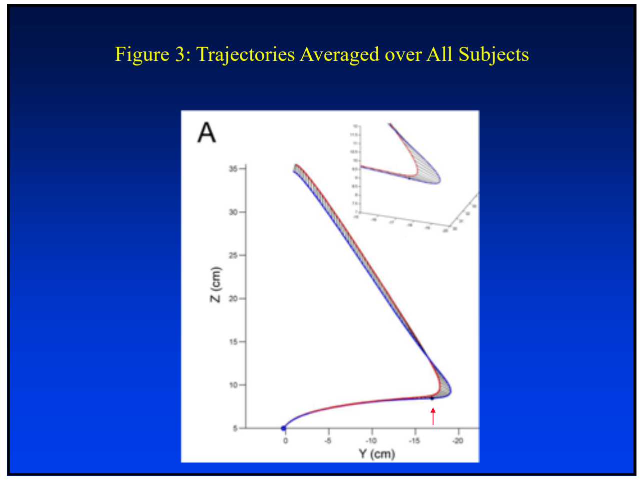


Figure 3: Trajectories Averaged over All Subjects
A
Z (cm)
Y (cm)

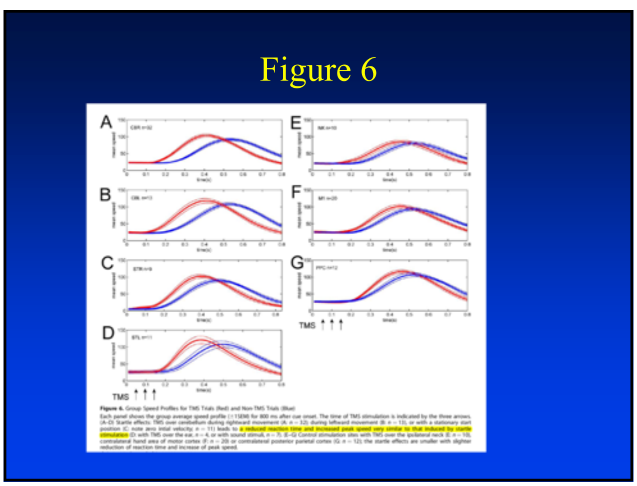
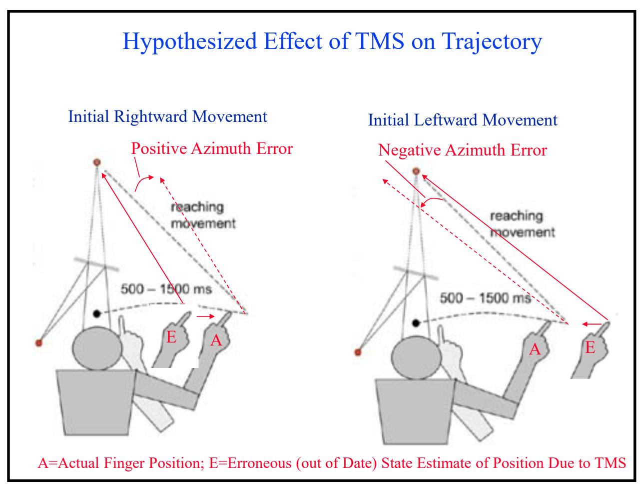
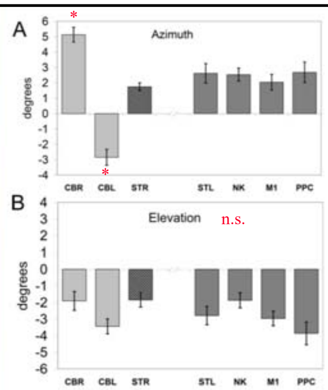


Figure 6
A
B
C
D
E
F
G
TMS
TMS


Hypothesized Effect of TMS on Trajectory
Initial Rightward Movement
Positive Azimuth Error
reaching movement
500 – 1500 ms
E
A
Initial Leftward Movement
Negative Azimuth Error
reaching movement
500 – 1500 ms
A
E
A=Actual Finger Position; E=Erroneous (out of Date) State Estimate of Position Due to TMS

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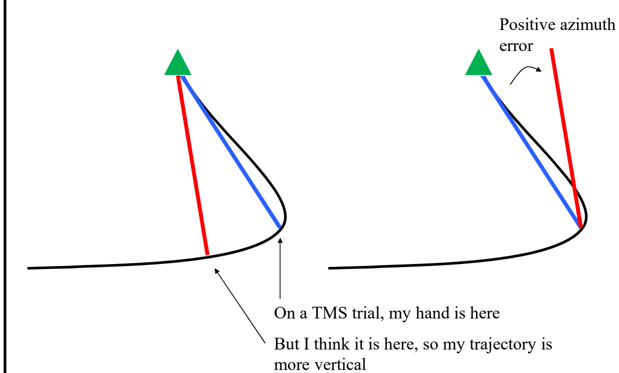
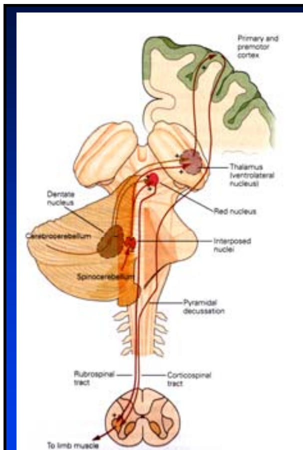
# Figure 4




## M1 TMS Control: Lateral Cerebellar TMS could stimulate Motor Cortex via Thalamus

## Figure 3: Startle Does not Alter Direction the way that TMS Does