Movement kinematics and brain lateralization predict interlimb transfer of prismatic adaptation for each individual

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Introduction

Humans can adapt their reaching behavior to various perturbations such as prismatic deviations, visuomotor rotations or novel limb dynamics (Criscimagna-Hemminger et al. 2003; Malfait & Ostry 2004; Wang & Sainburg 2004; Sarlegna et al. 2007). However, how does the adaptation process experienced with one arm can lead to an improvement of the subsequent, opposite arm movement?

Pioneer work on prism adaptation reported no transfer (Martin et al. 1996) or very limited transfer (Harris 1963; Cohen 1967; Redding & Wallace 1988) based on averaged data across subjects.

Between-subject differences are often treated as a source of noise, and discarded by averaging data from a group of participants. However, heterogeneity of performance is inevitable as individuals' actions reflect natural variations of neuropsychological attributes as well as genetic, environmental and biological factors (Kanai & Rees 2011).

Here, we investigated whether inter-individual differences may be linked to transfer of learning and tried to identify factors which could qualitatively and quantitatively predict interlimb transfer of prism adaptation.

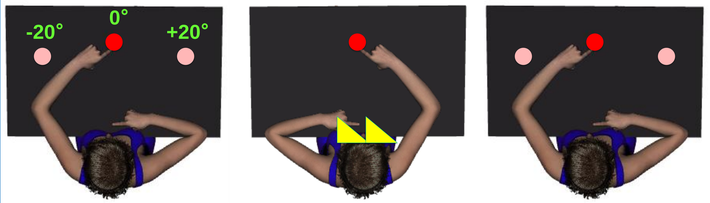
Methods

Young adults had to reach toward flashed visual targets, with the dominant and the non-dominant arm, before, while and after they wore prisms.

Prisms deviated the visual field by 17.1 deg. rightward.
Subjects had to reach as fast and as accurately as possible.

Experimental Conditions

Pre-adaptation | **Prism adaptation** | **Post-adaptation**



1- Dominant arm (DA)
2- Non Dominant Arm (NDA)
(30 trials each)

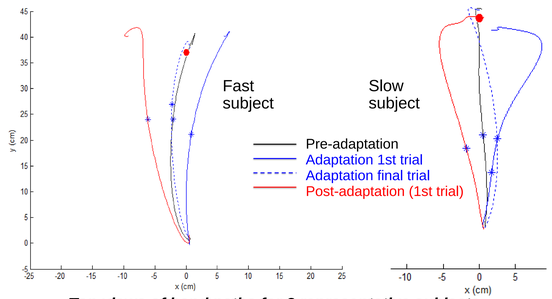
3 - Dominant arm (DA)
(100 trials)

4- Non Dominant arm (NDA)
5- Dominant arm (DA)
(30 trials each)

N=20, mean age: 24 years
13 males and 7 females
12 right-handers and 8 left-handers *according to Oldfield (1971)*

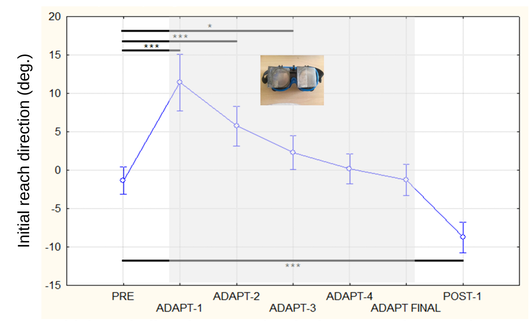
Results

1- Adaptation (Dominant Arm)



Top views of hand paths for 2 representative subjects

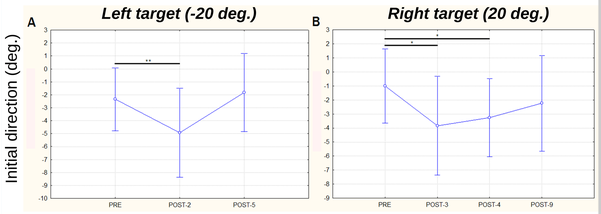
Mean movement time = 343 ± 36 ms ; Mean peak velocity = 3.1 ± 0.7 m/s



Initial reach direction at peak velocity across the experiment

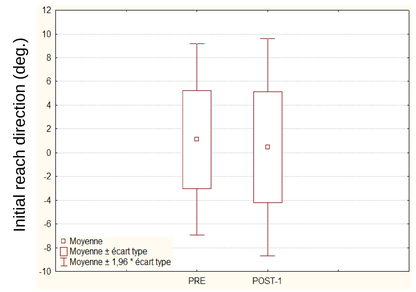
2- Generalization across movement direction (Dominant Arm)

Adaptation of reaching toward a central target influenced reaching toward lateral targets.

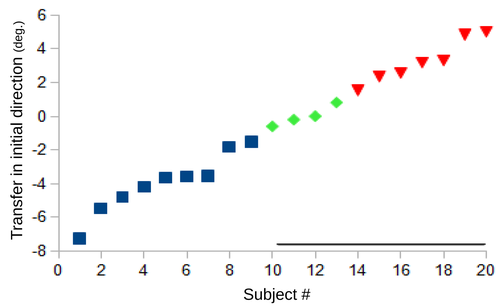


Initial reach direction at peak velocity across the experiment

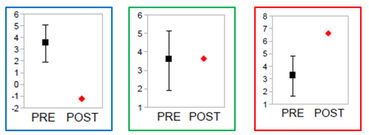
3- Interlimb transfer (Non Dominant Arm)

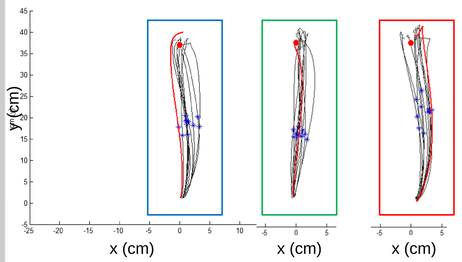


No significant transfer on average (t=0.8 ; p=0.43)
but large heterogeneity across subjects
Similar findings on final reach direction (t= -0.42 ; p=0.67)



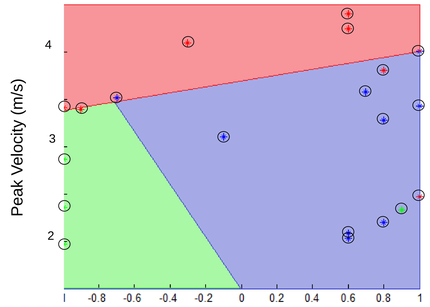
Each subject could be classified as
'Negative Transfer', 'No Transfer' or 'Positive Transfer'



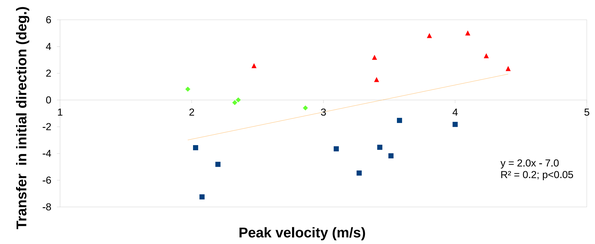


Top views of hand paths for 3 representative subjects of each class: 'Negative Transfer', 'No Transfer' and 'Positive Transfer'

4- Prediction of interlimb transfer



Peak Velocity during the last 10 trials of the Adaptation and Laterality Quotient predict whether subjects will be 'Negative Transfer', 'No Transfer' or 'Positive Transfer'



Discussion

Although no significant interlimb transfer of prism adaptation was observed on average, each subject could be classified as transferring or not. Tools such as linear discrimination analyses, correlations and multiple regressions were used to exploit the heterogeneity in our data.

Here the key factors determining interlimb transfer were peak velocity as well as laterality quotient.

These are similar to factors identified in a previous study on interlimb transfer of adaptation to new limb dynamics (Lefumat et al. in press):

Our findings were consistent across right-handers and left-handers. They highlight how individual characteristics shape the way the nervous system can generalize sensorimotor adaptation.

References

- Cohen MM (1967) Perceptual and motor skills, 24(3c) , 1295-1302.
- Criscimagna-Hemminger SE, Donchin O, Gazzaniga MS, Shadmehr R (2003) Journal of neurophysiology, 89(1), 168-176.
- Harris CS (1963) Science, AAAS, 140(3568), 812-813.
- Kanai R & Rees G (2011) Nat. Rev. Neurosci., 12, 231-242.
- Lefumat HZ, Vercher J-L, Miall RC, Cole J, Buloup F, Bringoux L, Bourdin C & Sarlegna FR Journal of neurophysiology, in press
- Malfait N & Ostry DJ (2004) Jneurosci 24(37), 8084-8089.
- Martin TA, Keating JG, Goodkin HP, Bastian AJ & Thach WT (1996) Brain 119, 1199-1211.
- Oldfield RC (1971) Neuropsychologia, 9(1), 97-113.
- Redding GM, Wallace B (1988) Perception & Psychophysics, 44(1), 59-68.
- Sarlegna FR, Gauthier GM, Blouin J (2007) J. Mot. Behav., 39(4), 247-258
- Wang J, Sainburg RL (2004) J. Neurophysiol., 92, 349-360.