Does learning transfer during Prism Adaptation?

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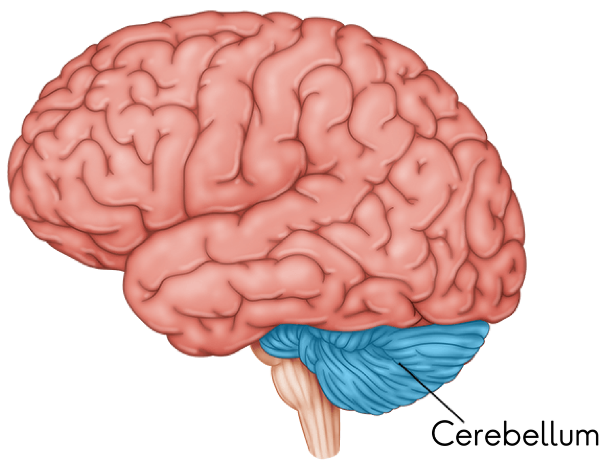
Background

The cerebellum is a brain structure located at the base of the brain, which is primarily responsible for coordinating movement and motor control. However, research has shown that the cerebellum also plays a key role in learning, particularly in the acquisition and refinement of motor skills. [1,2] One way the cerebellum contributes to learning is through its ability to predict the consequences of our actions. When we engage in a motor task, the cerebellum compares the intended movement with the actual movement, and then adjusts the motor commands accordingly. This process, known as error correction, helps us refine our movements and improve our performance over time.



Prism adaptation

Prism adaptation is an experimental treatment that induces cerebellar motor learning that involves the use of prism glasses to induce a visual shift of the world, which in turn leads to the adaptation of posture, adaptation of planning strategies, and vision compensation [1,2].

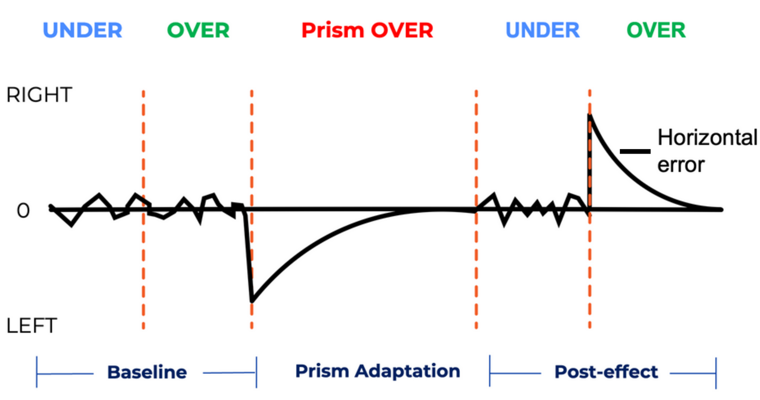
We aim to investigate whether the learning can be transferred between different movements when utilising an adaptation prism. Additionally, we seek to explore the relationships between post effects in independent movements.

Hypotheses

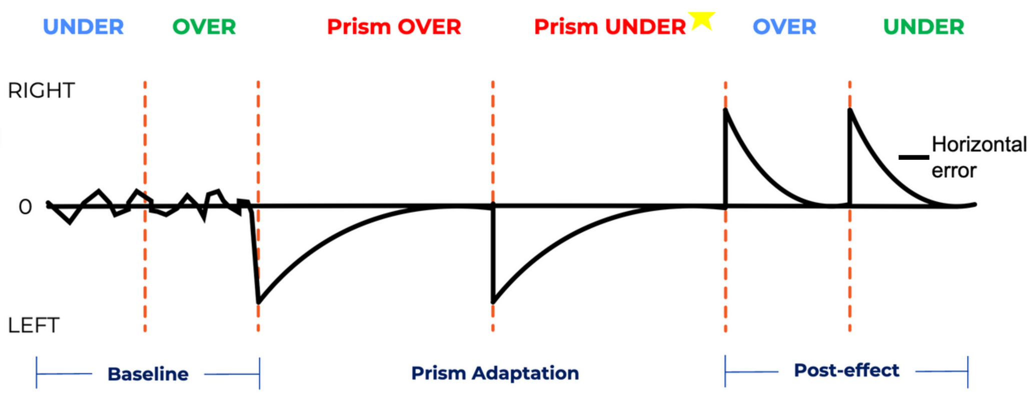
H1: Learning is not transferred between different hand movement after prism adaptation.

H2: Different ways of throwing the ball are independent of each other when it comes to post-effects.

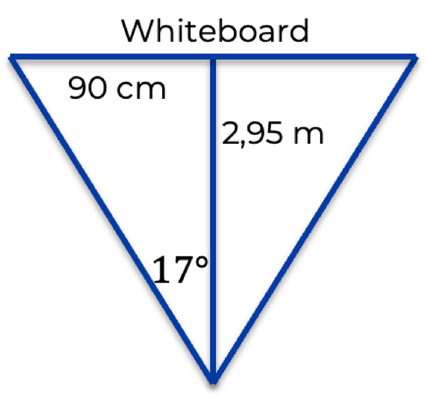
if
hypothesis 1 proves to be true
then
post-effect is present only while throwing over

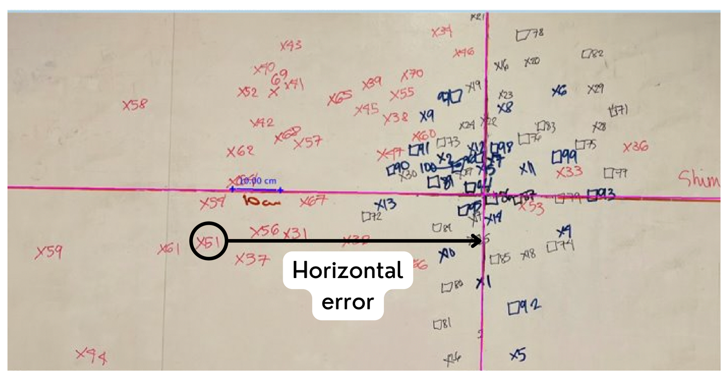


if
hypothesis 2 proves to be true
then
both learning and post-effect are independent



Methods





17 participants (10 Females) stand 2.95 m from a whiteboard and throw a ball at a marked target. The picture of the board is taken after the subject completes all throws and the data is analysed offline. Distance from vertical axis is measured as the horizontal displacement error in centimeters. Further analysis is done using Python including model fitting.

$$PC(cm) = \sqrt{\frac{\sum(x_1 - \bar{x})}{n}}$$

Standard deviation of last 8 throws during baseline

$$f(t) = a - be^{\frac{-t}{AC}}$$

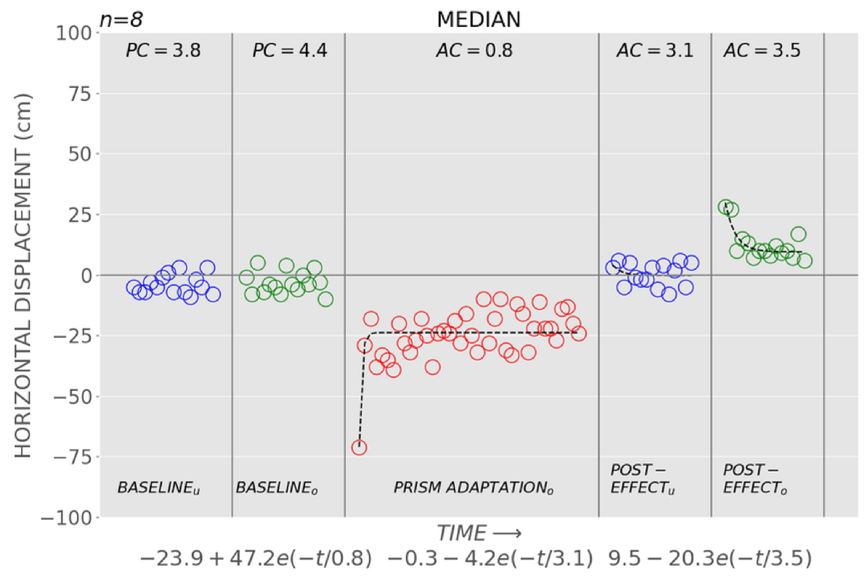
$$AC(no.\ throws)$$

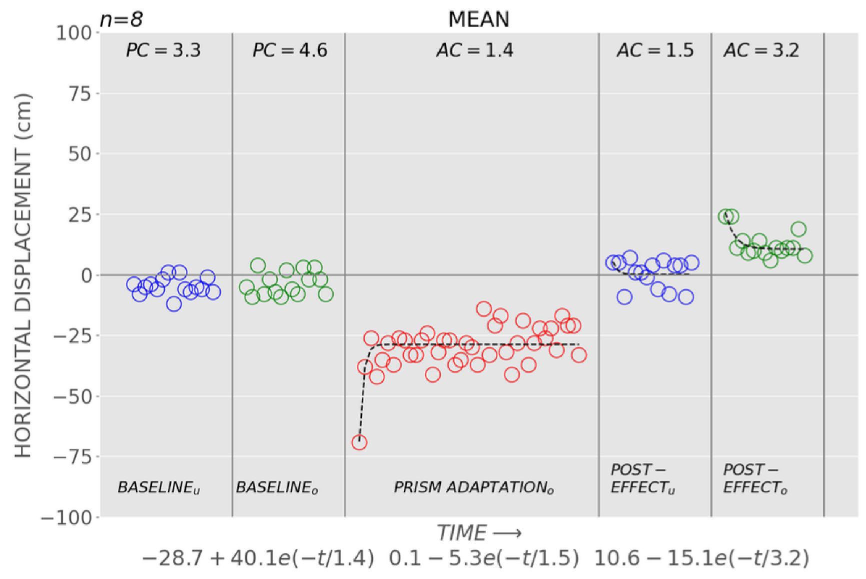
Rate of change of slope of the exponential decay curve after the prism adaptation

*grayed images: same as experiment 1

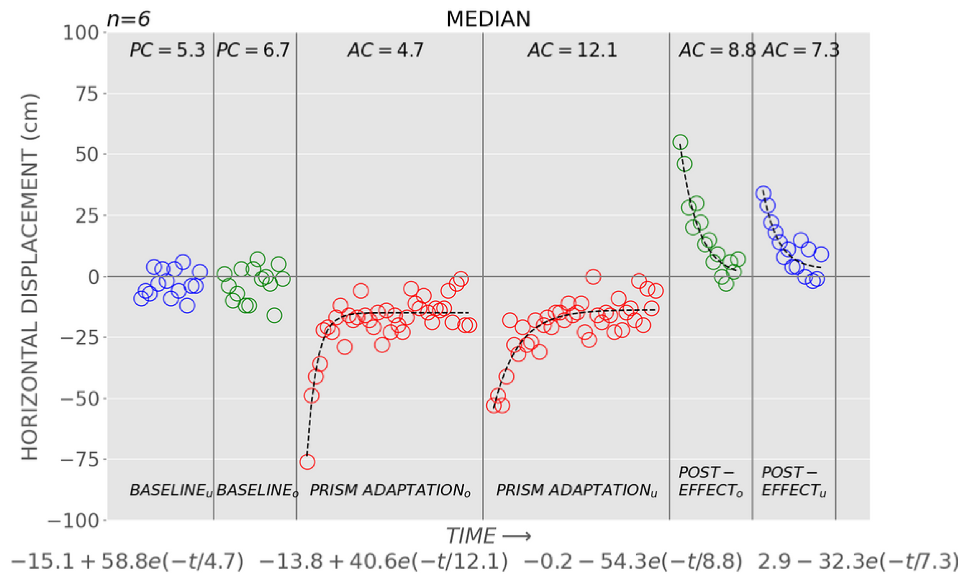
Results

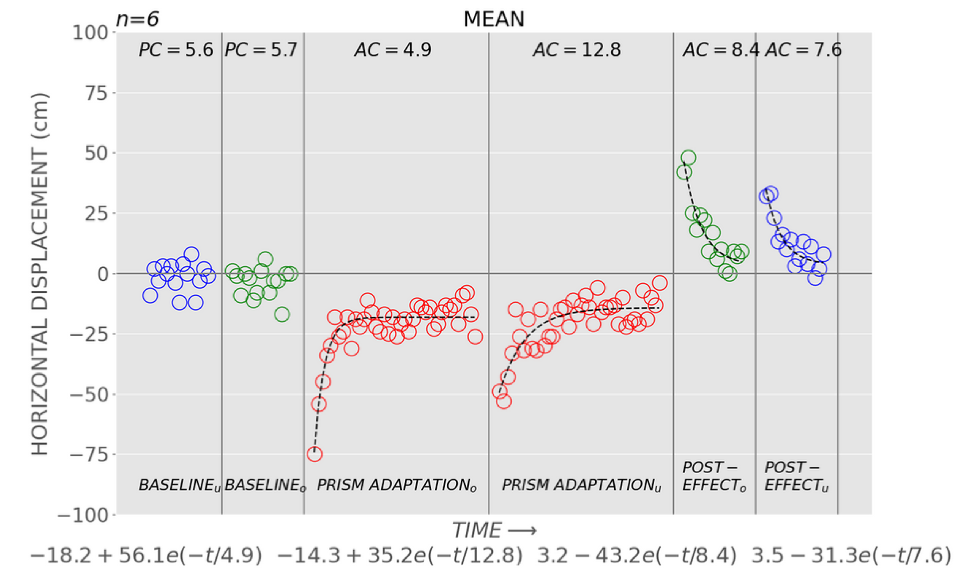
Experiment 1





Experiment 2





Summary of Experiment 1

Name	Sex	Age (years)	PCu	PCo	ACpo	ACo	ACu
S11	F	16	11.4	14.8	1.0	-9.0	3.7
S12	F	18	8.0	7.4	3.0	7.9	10.2
S13	F	18	18.4	12.6	1.1	0.9	-4.3
S14	M	17	7.2	9.3	11.1	3.0	7.2
S17	M	18	10.8	10.1	15.2	-8.3	23.1
AVG1		17.4±0.8	11.2±4.4	10.8±2.9	6.3±6.5	-1.1±7.3	8.0±10.0
MED1		18.0±1.5	10.8±3.4	10.1±3.3	3.0±10.0	0.9±11.3	7.2±6.5
S21	F	17	13.2	11.1	30.7	1.4	1.8
S22	M	16	9.0	10.6	15.8	16.0	4.8
S23	M	16	7.5	9.8	43.1	0.1	3.3
S25	F	17	11.7	12.3	6.6	19.2	9.5
AVG2		16.5±0.57	10.4±2.6	11.0±1.0	24.1±16.1	9.2±9.8	4.9±3.3
MED2		16.5±1	10.4±3.5	10.9±1.0	23.3±20.3	8.7±15.7	4.1±3.1

S 1 3
SUBJECT
SESSION NUMBER
SUBJECT NUMBER

AVG: Average ± std; MED: Median ± IQR

Summary of Experiment 2

AVG 3 MED 4
AVERAGE VALUE
SESSION NUMBER
MEDIAN VALUE
SESSION NUMBER

Name	Sex	Age (years)	PCu	PCo	ACpo	ACpu	ACo	ACu
S31	M	17	5.6	5.6	5.1	-18.0	-38.2	7.2
S32	F	18	13.2	13.2	6.4	45.1	14.8	15.1
S34	M	16	5.6	5.6	2.8	17.5	6.0	12.5
AVG3		17±1	8.1±4.4	8.1±4.4	4.8±1.8	14.9±31.6	-5.8±28.4	11.6±4.1
MED3		17±1	5.6±3.8	5.6±3.8	5.1±1.8	17.5±31.6	6.0±26.5	12.5±4.0
S41	F	17	9.4	22.2	9.4	9.5	5.1	13.2
S42	F	19	24.3	12.1	5.2	20.0	5.9	9.2
S43	F	17	17.9	9.5	3.1	10.0	6.0	3.9
S44	F	17	12.9	17.9	0.9	7.9	0.9	2.2
S47	M	18	7.3	5.9	70.7	15.4	2.3	17.1
AVG4		17.6±0.89	17.2±7.5	13.7±7.4	5.9±3.2	13.2±5.9	5.7±0.5	8.8±4.7
MED4		17±1.5	17.9±7.5	9.5±6.4	5.2±3.2	10.0±5.3	5.9±0.5	9.2±4.7

*u: underhand, o:overhand, pu: post-effect, underhand po: post-effect overhand

Conclusion

Post-effects were observed only on the movement trained, thus there was no transfer of learning between overhand and underhand throws **(experiment 1)**.

Decay of post-effects was also independent and specific to the movement used. Post-effects remained visible on underhand throws even after the post-effects disappeared on the overhand throws **(experiment 2)**.

These results confirm our predictions. We can see independent learning and post-effect for both underhand and overhand movements during the prism adaptation.

However, we can notice that the first prism adaptation and its post-effect (overhand) have larger effect than the second prism adaptation and post-effect (underhand) – this observation requires further investigation.

References

[1] Martin, T A et al. "Throwing while looking through prisms. I. Focal olivocerebellar lesions impair adaptation." Brain : a journal of neurology vol. 119 (Pt 4) (1996): 1183-98. doi:10.1093/brain/119.4.1183

[2] Martin, Tod A et al. "Dynamic coordination of body parts during prism adaptation." Journal of neurophysiology vol. 88,4 (2002): 1685-94. doi:10.1152/jn.2002.88.4.1685

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