024-Attention&Space-3

A new approach in the treatment of Optic Ataxia: evidence from a single case study

Danesin L.[1*], Giustiniani A.[1*], Ranzini M.[2], D'Imperio D.[1], Rigon J.[1], Ferrazzi G.[1], Menardi A.[2], Meneghello F.[1], Oliveri M.[3], Vallesi A.[2], Semenza C.[2], Burgio F[1].

[1]IRCCS San Camillo Hospital, Venice, Italy;
[2]Department of Neuroscience (DNS), University of Padova, Padova, Italy;
[3]Restorative Neurotechnologies S.r.l., Palermo, Italy

laura.danesin@hsancamillo.it

Background and Aims

Optic ataxia (OA) is a visuospatial deficit characterized by difficulties in reaching and grasping visual targets presented in the peripheral side of the visual field, consequent to lesions of the superior parietal lobule and/or of the intraparietal sulcus. **Prismatic Adaptation (PA)** is a widely used technique in the rehabilitation of visuospatial deficits (e.g., neglect), but findings supporting its application in patients with OA are conflicting [1], [2].

Recently, **MindLenses Professional,** a new tool combining PA with digital cognitive tasks (*serious games* - SG) has been applied for the rehabilitation of both visual and cognitive deficits in neurological patients. Preliminary findings have shown that this device is promising for the rehabilitation of cognitive symptoms in patients with stroke.

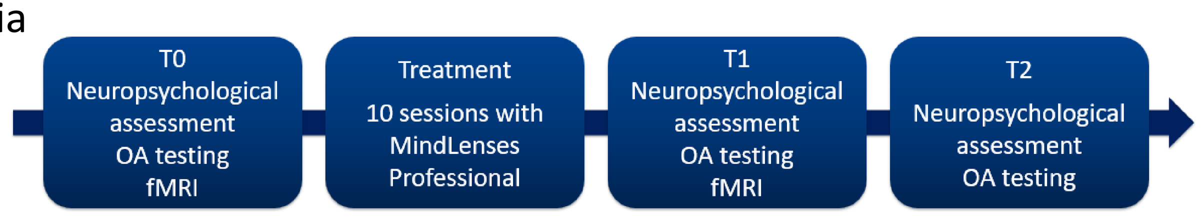
Here, we report for the first time the effects of a treatment using MindLenses in a patient with OA consequent to a hemorrhagic stroke of the left posterior regions.

The **main aims** were to investigate whether: 1) the treatment could induce long-lasting improvements in OA and in cognitive deficits, as measured immediately and three months after the end of the treatment; 2) the patient was able to adapt to the visual shift induced by PA; 3) the treatment could induce functional brain changes at the fMRI.

Methods

Case description - BC

- 51 years-old woman
- Left parieto-occipital lesion consequent to haemorrhagic stroke (2 months earlier)
- Optic ataxia



OA testing (adapted from [3])**:** A wooden pole was presented in a random position in either the left or right visual hemifields. The participant was instructed to grasp it with the left and the right hand, respectively, while maintaining central fixation. The task includes 20 trials distributed in 4 conditions: 1) left hand/left hemifield; 2) left hand/right hemifield; 3) right hand/left hemifield; 4) right hand/right hemifield (Fig. 1).

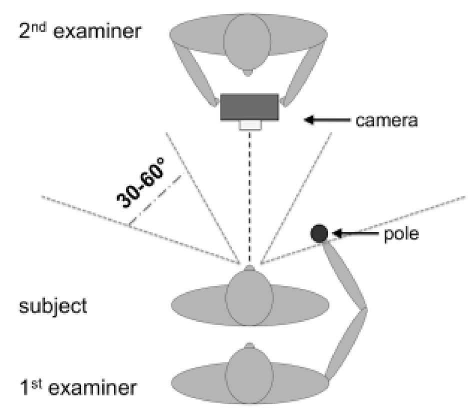


Figure 1. Procedure of the OA testing [3]

Neuropsychological Assessment: A neuropsychological battery was administrated to assess BC cognitive performance before the treatment (t0), immediately after (t1) and at three months (t2).

MindLenses

The treatment included 10 sessions (5 per weeks) of PA with leftward deviating prisms followed by 20 min of SG. The pointing task (Fig. 2a) counted three experimental conditions: pre-exposure (30 trials), exposure (60 trials) and post-exposure (30 trials). PA performance was evaluated as the mean of the displacement (cm) for each of these conditions during the 10 sessions of treatment. The after effect was calculated as the difference between pre- and post-exposure. PA was followed by digital tasks (SG) focused on attention, language and executive functions (Fig. 2b)

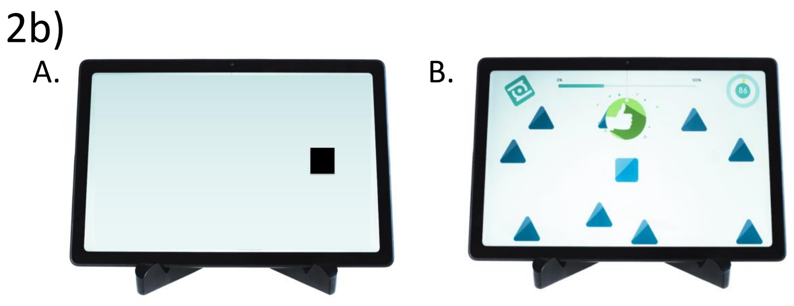


Figure 2. Examples of (a) pointing task and (b) serious game (visual search) on MindLenses's tablet

fMRI analysis: T1-weighted anatomical and functional resting state data were collected on a 3T Philip Ingenia Scanner. After preprocessing, the brain images were parceled into 200 regions of interests (ROIs)[4]. Functional connectivity matrices were computed and transformed into Fisher's z-scores. To determine significant changes in connectivity, a delta connectivity matrix was obtained subtracting the post from the pre-treatment matrices. Only connections showing a change above or below 0.5 standard deviations (SD) were considered.

Results

1) Before the treatment, beside OA, BC exhibited deficits in attention, executive functions, calculation and visuospatial abilities. Immediately after the treatment, the performance selectively improved in some neuropsychological tests whereas other cognitive domains, such as calculation (NADL test), did not improve. Interestingly, Improvements in visuospatial abilities, attention, language and set-shifting were still present three months after the end of the treatment (Tab. 1). Similarly, the improvement in OA was observed immediately and three months after the end of the treatment (Fig. 3).

	PRE	POST	FOLLOW-UP
MMSE	22.97	**25.97**	22.97
Complex figure – copy	25.25	**30.25**	**31.25**
Complex figure - recall	21,5	24,5	23
Phonological fluency	23	**32**	21
Semantic fluency	17	**35**	**44**
TMT-A	85	**65**	**37**
TMT-B	365	**207**	**149**
Spatial span	2.99	1.99	3
Spatial supraspan	21.08	25.23	19.9
NADL Informal test	19	17	17
NADL Formal test	18	21	20

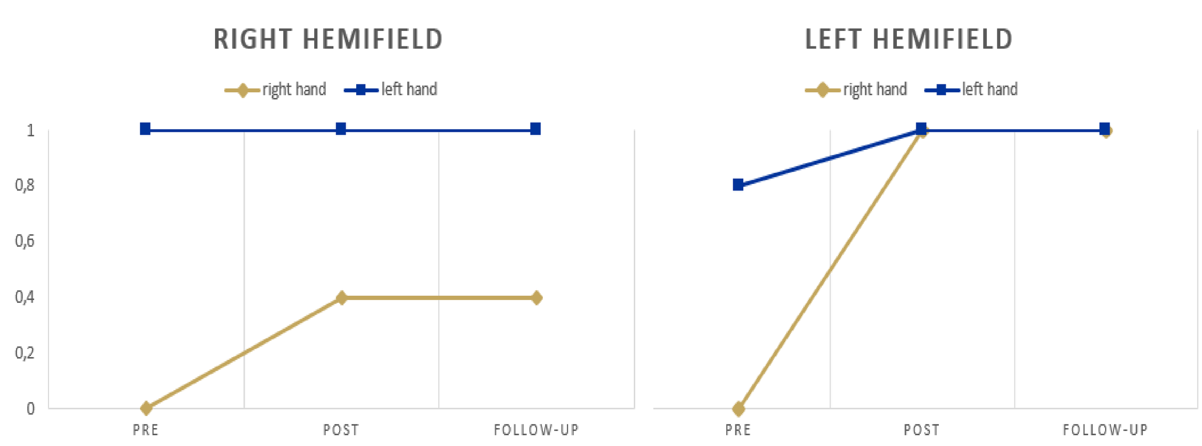


Figure 3. Performances at the OA task for each condition and time point.

2) Throughout the 10 sessions, during prismatic exposure, BC adapted to the leftward induced shift. After exposure, PA induced a contralateral (right hemifield) after effect (Fig. 4).

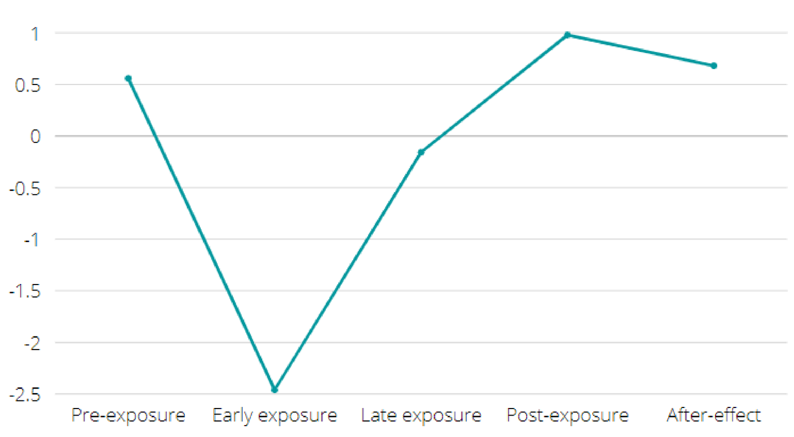


Figure 4. Mean scores (cm) of displacement at the pointing task before (pre exposure), during (early- , late-exposure) and after prisms (post-exposure) and relative after-effect during the 10 sessions of treatment

3) Preliminary results on fMRI data showed a functional re-organization of brain connectivity, with increase intra and inter-hemispheric connectivity in perilesional areas. Additionally, an increase in inter-network intra-hemispheric connectivity (Fig. 5a) and a decrease in inter-network inter-hemispheric connectivity (Fig. 5b) was found.

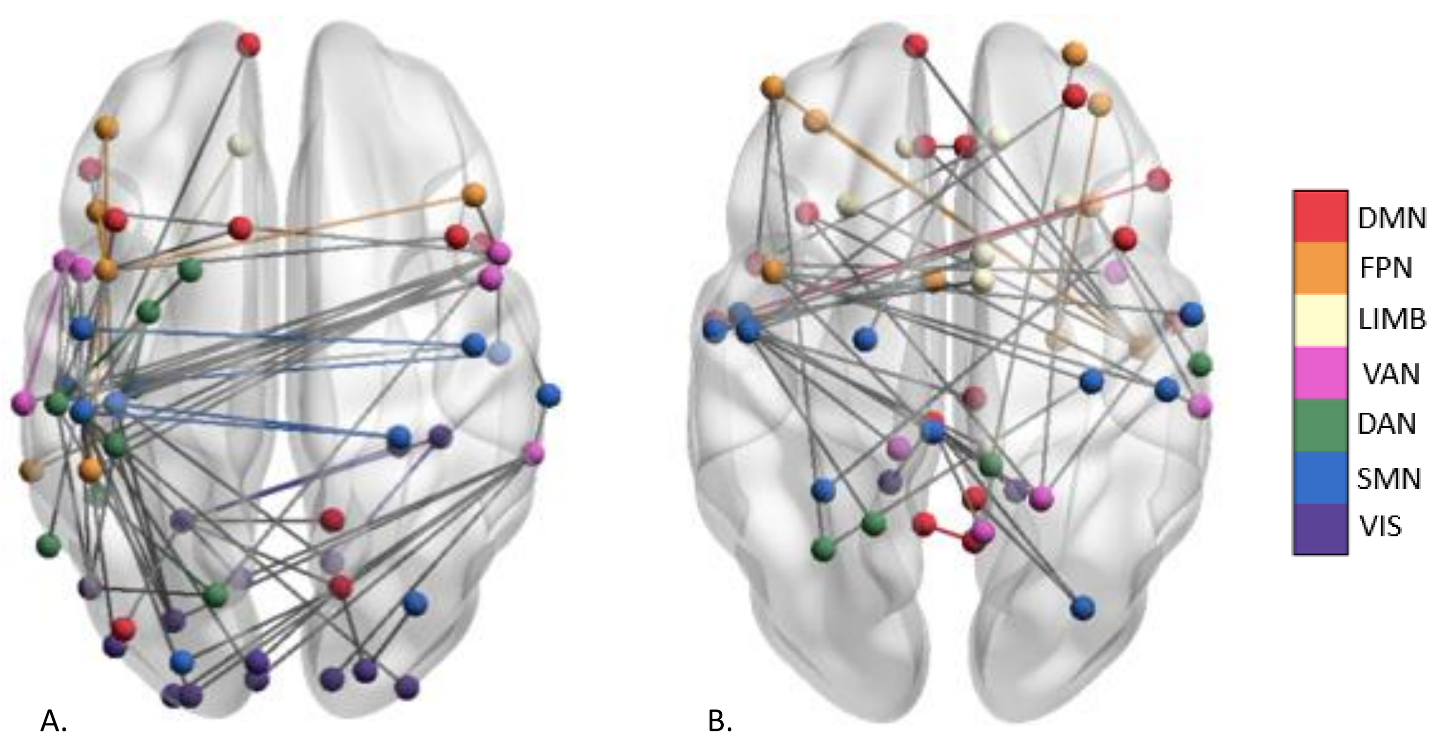


Figure 5. (A) Increase and (B) decrease in brain connectivity after the treatment. Intra-network connections are presented in colors, whereas inter-networks connections in grey

Discussion and implications of findings

The main result of this study is that the treatment with MindLenses in a patient with left hemisphere stroke, induced **an improvement in OA and in many cognitive deficits, as well as changes in brain functional connectivity**. Interestingly, the patient exhibited both adaptation to the visual shift and after-effect. This result confirms previous findings reporting that patients with OA can adapt to prismatic deviation and contrast those studies reporting no adaptation in these patients [1],[2]. Probably, the preserved contralateral parietal lobe and the cerebellum allowed the visuo-motor adaptation observed in BC. On the other hand, the improvement in cognitive performance could be due to both the generalization of the PA effect [5] and the administration of SG. These changes, as well as changes in functional brain connectivity, might be supported by the neuromodulatory effect exerted by PA on the fronto-parietal network [6]. In line with this hypothesis, our fMRI results showed increased functional intrahemispheric connectivity in the dorsal attention network and in the frontoparietal network. However, this result should be taken cautiously as BC was in the acute phase after stroke, therefore, we cannot exclude the occurrence of plastic changes due to functional recovery.

In conclusion, MindLenses Professional may be an effective tool to rehabilitate both cognitive and visuospatial deficits. Future studies could expand these results by applying the device to wider samples and by taking into consideration other cognitive deficits.

References

[1] Pisella, L., Michel, C., Grea, H., Tilikete, C., Vighetto, A., & Rossetti, Y. (2004). Preserved prism adaptation in bilateral optic ataxia: strategic versus adaptive reaction to prisms. Experimental Brain Research, 156(4), 399-408.
[2] Newport, R., Brown, L., Husain, M., Mort, D., & Jackson, S. R. (2006). The role of the posterior parietal lobe in prism adaptation: Failure to adapt to optical prisms in a patient with bilateral damage to posterior parietal cortex. Cortex, 42(5), 720-729.
[3] Borchers, S., Müller, L., Synofzik, M., & Himmelbach, M. (2013). Guidelines and quality measures for the diagnosis of optic ataxia. Frontiers in human neuroscience, 7, 324.
[4] Schaefer, A., Kong, R., Gordon, E. M., Laumann, T. O., Zuo, X. N., Holmes, A. J., ... & Yeo, B. T. (2018). Local-global parcellation of the human cerebral cortex from intrinsic functional connectivity MRI. Cerebral cortex, 28(9), 3095-3114.
[5] Rossetti, Y., Rode, G., Pisella, L., Farné, A., Li, L., Boisson, D., & Perenin, M. T. (1998). Prism adaptation to a rightward optical deviation rehabilitates left hemispatial neglect. Nature, 395(6698), 166-169.
[6] Saj, A., Cojan, Y., Vocat, R., Luauté, J., & Vuilleumier, P. (2013). Prism adaptation enhances activity of intact fronto-parietal areas in both hemispheres in neglect patients. Cortex, 49(1), 107-119.