References

This section reports a comprehensive list of public scientific presentations of MindLenses Professional, including conferences and congresses, as well as the list of clinical trials, some of which are in progress at time of writing.

The publication list includes some of the most important works on Prismatic Adaptation and Serious Games. Abstracts have been edited for length and clarity - we recommend to click on the link to access the original work.

Conferences Talks & Posters Presentations

Ferroni L., Gallicchio G., Favilla M. E., Nuti M. P., Oliveri M. (2024, January 15–17). **L'adattamento prismatico con MindLenses Professional nel trattamento dell'afasia: Studio pilota.** XXIII Congress of Italian Society for Neurological Rehabilitation, Florence, Italy. LINK

Oliveri M., Turriziani, P. (2024, January 21–26). **The relationship between visuoconstructive abilities and visuomotor adaptation in stroke patients: Results of a clinical trial using prism adaptation combined with serious games.** 42nd European Workshop on Cognitive Neuropsychology, Brixen, Italy. LINK

Danesin L., Oliveri M., Semenza C., Bottini G., Burgio F. (2024, January 21–26). **Cognitive effects of a treatment combining Prismatic Adaptation and serious games in stroke patients.** 42nd European Workshop on Cognitive Neuropsychology, Brixen, Italy. LINK

Catania, A. (2024, January 17–20). **Applicazioni di Mindlenses nella riabilitazione del linguaggio in soggetti autistici.** Giornate di Neuropsicologia dell'Età Evolutiva, Brixen, Italy. Winner of best oral presentation.

Danesin, L., Oliveri, M., Semenza, C., Bottini, G., Burgio, F.. **Cognitive effects of a treatment combining Prismatic Adaptation and serious games in stroke patients.** Oral Presentation at III Annual Meeting of Rete IRCCS. November 30, 2023.

Catania, A., Calistro, F., Montalto, G., Giordano, S., Oliveri, M., Turriziani, P. (September 15, 2023). **Modulation of the affect facial emotion recognition and theory of mind using a device combining prism adaptation and serious games in Children with Autism Spectrum Disorder.** 20th National Congress of the Italian Society for Neuroscience, Torino, Italy. LINK

Di Garbo, A., Chiaramonte, G., Giustiniani, A., Calistro, F., Ricotta, M., Imbornone, E., Rizzo, S., Bagnato, S. , Oliveri, M. (2022, September 15). **Effects on attentional deficits of a device integrating digital rightward prism adaptation with serious games vs. standard rehab in right brain damaged patients: a randomized clinical trial.** [Conference poster]. XXX Congresso Nazionale della Società Italiana di Psicofisiologia e Neuroscienze Cognitive, Udine, Italy. LINK

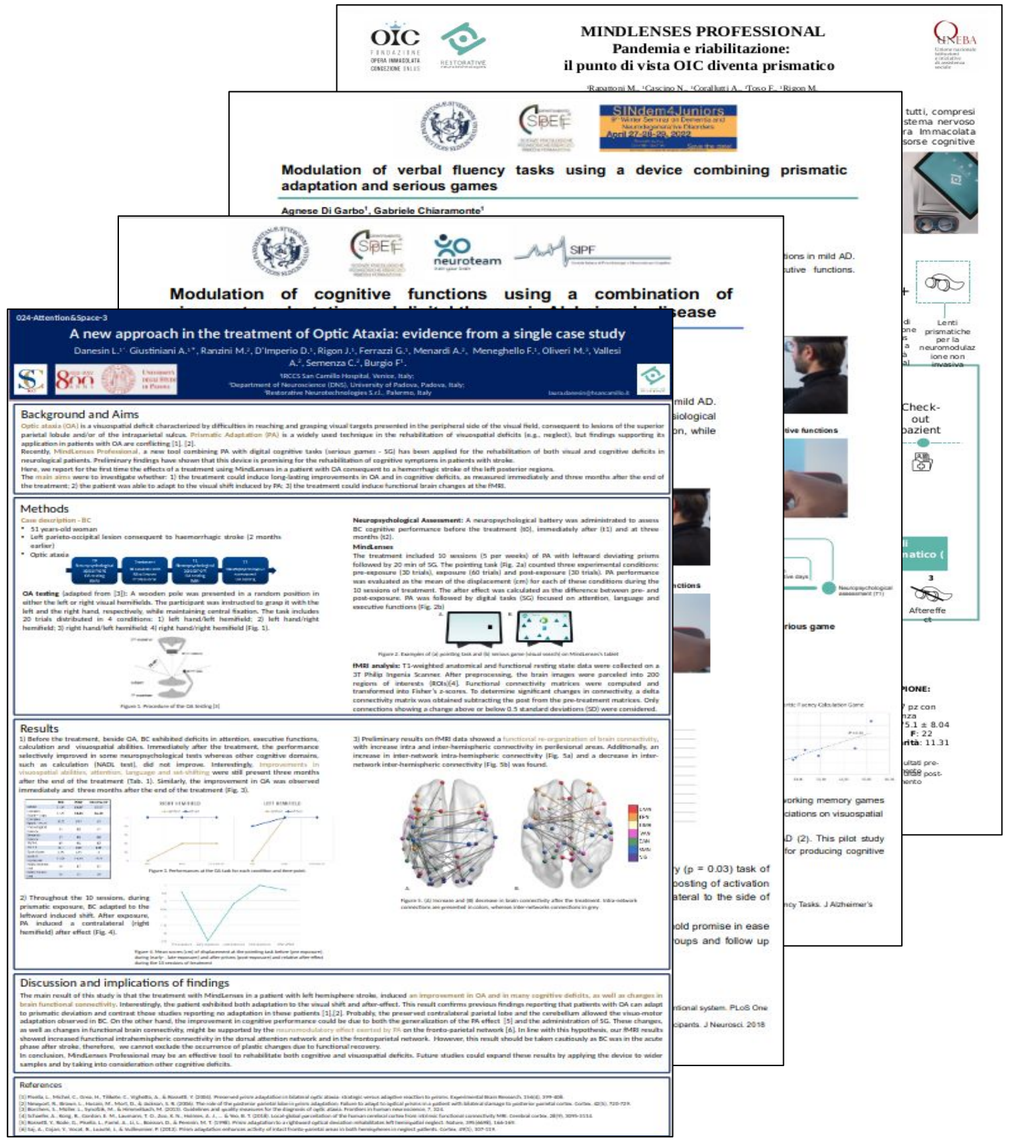
Rapattoni M., Cascino, N., Corallutti, A., Toso, F., & Rigon, M. (2022). **Pandemia e riabilitazione: Il punto di vista di OIC diventa prismatico.** Convegno Unione Nazionale Istituzioni e Iniziative di Assistenza Sociale. LINK

Conferences Talks & Posters Presentations

Danesin et al (2022, January 24–28). **A new approach in the treatment of Optic Ataxia: Evidence from a single case study.** [Conference poster]. 43rd European Workshop on Cognitive Neuropsychology, Brixen, Italy. LINK

Di Garbo, A., Chiaramonte, G. (2022, April 27–29). **Modulation of verbal fluency tasks using a device combining Prismatic Adaptation and serious games.** [Conference poster]. 9th Winter Seminar on Dementia and Neurodegenerative Disorders, Brixen, Italy. LINK

Di Garbo, A., Calistro, F., & Oliveri, M. (2021, September 30–October 21). **Modulation of cognitive functions using a combination of visuomotor adaptation and digital therapy in Alzheimer's disease.** [Conference poster]. XXIX SIPF National Congress "Beyond the lockdown of the brain", Palermo, Italy. LINK



Clinical trials list

Completed Ongoing

About MindLenses Professional

Cognitive rehabilitation with MindLenses in ischemic and hemorragic stroke (Fondazione G. Giglio)

Population: 30 stroke (left or right) patients, ischemic or hemorragic **What's evaluated:** safety and efficacy of MindLenses in cognitive rehabilitation

MindLenses in neurological diseases: neurocognitive, motor and biological correlates (IRCCS San Camillo Hospital)

Population: 30 stroke patients, 30 Mild Cognitive Impairment patients **What's evaluated:** cognitive and motor improvements following MindLenses; structural and neuroplastic changes (magnetic resonance imaging, BDNF levels)

Post-market clinical trial on neurorehabilitation with MindLenses in stroke patients (IRCCS Fondazione Santa Lucia)

Population: 60 stroke (left or right) patients, ischemic or hemorragic **What's evaluated:** safety and efficacy of MindLenses in cognitive and motor rehabilitation

Use of MindLenses in Mild Cognitive Impairment patients (Niguarda Hospital)

Population: 40 Mild Cognitive Impairment patients **What's evaluated:** efficacy of MindLenses in the patient population, with a focus on memory and attention impairments and neuroimaging (resting state functional magnetic imaging)

Publication List

These articles show the feasibility of the approach of modulation of cortical excitability in stroke rehabilitation

Saway, B.F., Palmer, C., Hughes, C., Triano, M., Suresh, R.E.,, Gilmore, J., George, M., Kautz, S.A., Rowland, N.C. (2024). **The evolution of neuromodulation for chronic stroke: From neuroplasticity mechanisms to brain-computer interfaces.** *Neurotherapeutics, 21*(3):e00337.

https://doi.org/10.1016/j.neurot.2024.e00337

In this review, invasive neuromodulation techniques to augment the effects of conventional rehabilitation methods are described, including vagus nerve stimulation, deep brain stimulation and brain-computer interfaces. The evidence base for each of these techniques, pivotal trials, and future directions are explored. Finally, emerging technologies such as functional near-infrared spectroscopy and artificial intelligence-enabled implants and wearables are examined. While the field of implantable devices for chronic stroke recovery is still in a nascent stage, data suggest immense potential for reducing its impacts.

Oliveri, M. (2011). **Brain Stimulation Procedures for Treatment of Contralesional Spatial Neglect.** *Restorative Neurology and Neuroscience, 29*(6), 421-425.

https://doi.org/10.3233/rnn-2011-0613

The application of brain stimulation techniques for modulation of cortical excitability changes underlying spatial neglect following right-brain-damage has been the first application of brain stimulation in the rehabilitation setting. This is a review of the main applications of transcranial magnetic stimulation for modulation of neglect disorder and a discussion of the different potentialities of inhibition of the unaffected and facilitation of the affected hemisphere. Suggestions of potential interactions of TMS with other behavioral techniques in the rehabilitation setting.

Miniussi, C. Cappa, S. F., Cohen, L. G., Floel, a., Fregni, F., Nitsche, M. A., Oliveri, M., Pascual-Leone, A., Paulus, W., Priori, A., & Walsh, V. (2008). **Efficacy of repetitive transcranial magnetic stimulation/transcranial direct current stimulation in cognitive neurorehabilitation.** *Brain Stimulation, 4*, 326-36.

https://doi.org/10.1016/j.brs.2008.07.002

Review of evidence suggesting that cortical stimulation (transcranial magnetic stimulation and transcranial direct current stimulation) may play a role in treating aphasia, unilateral neglect, and other cognitive disorders. Notwithstanding the promise of these preliminary findings, to date no systematic application of these methods to neurorehabilitation research has been reported. Further research in application settings is recommended.

Publication List

These articles show the feasibility of the approach of modulation of cortical excitability in stroke rehabilitation

Koch, G. *et al.*, (2008). **Hyperexcitability of parietal-motor functional connections for the intact left-hemisphere in neglect patients.** *Brain, 131*(12), 3147–3155.

https://doi.org/10.1093%2Fbrain%2Fawn273

We applied this paired-pulse, PPC-M1 transcranial magnetic stimulation paradigm over the left hemisphere (LH) for 12 RH stroke patients with neglect, plus an age-matched group of 8 right hemisphere (RH) stroke patients without neglect, and 10 healthy controls. We found that excitability of the LH PPC-M1 system was pathologically increased in neglect patients. A follow-up found that 1 Hz repetitive TMS over the left PPC normalised this over-excitability, and also ameliorated neglect. Our results provide a new form of direct evidence for pathological over-excitability of the LH in the neglect syndrome, specifically here for left PPC influences on left M1, with implications for possible treatment.

Cicinelli, P., Pasqualetti, P, Zaccagnini, M., Traversa, R., Oliveri, M., & Rossini, P. M. (2003). **Interhemispheric Asymmetries of Motor Cortex Excitability in the Postacute Stroke Stage: A Paired-Pulse Transcranial Magnetic Stimulation Study.** *Stroke, 4*, 2653–2658.

https://doi.org/10.1161/01.STR.0000092122.96722.72

Exploration of interhemispheric differences in motor cortex excitability during stroke postacute stage recovery using paired-pulse transcranial magnetic stimulation (TMS). Stroke survivors in this phase underwent TMS to assess motor cortex excitability bilaterally. Results indicate reduced excitability in the affected hemisphere compared to the unaffected hemisphere, demonstrated by decreased motor evoked potential amplitudes and altered interhemispheric inhibition patterns. Findings underscore the broader impact of stroke on motor cortex function, highlighting the significance of understanding interhemispheric imbalances in stroke rehabilitation. Tailoring interventions based on individual asymmetry profiles could lead to more effective treatments..

Brighina, F., Bisiach, E., Oliveri, M., Piazza, A., La Bua, V., Daniele, O, Fierro, B. (2003). **1 Hz repetitive transcranial magnetic stimulation of the unaffected hemisphere ameliorates contralesional visuospatial neglect in humans.** *Neuroscience Letters, 336*(2), 131-3.

https://doi.org/10.1016/s0304-3940(02)01283-1

This study investigates the efficacy of 1 Hz repetitive transcranial magnetic stimulation (rTMS) on the unaffected hemisphere to alleviate contralesional visuospatial neglect in humans. Visuospatial neglect is a condition where individuals fail to attend to stimuli presented in the space contralateral to their brain lesion. Participants received rTMS targeting the unaffected hemisphere. Results demonstrated that this intervention ameliorated contralesional visuospatial neglect, indicating the potential therapeutic benefit of targeting the unaffected hemisphere in stroke rehabilitation.

Publication List

These articles show the feasibility of the approach of modulation of cortical excitability in stroke rehabilitation

Chicurel, M.. (2002). **Magnetic mind games.** *Nature* 417, 114–116.

https://doi.org/10.1038/417114a

News feature article with a narrative overview of neuromodulation techniques with transcranial magnetic stimulation. The author discusses the use of transcranial magnetic stimulation (TMS) in neuroscience research and clinical applications. TMS involves applying magnetic fields to specific regions of the brain, allowing researchers to manipulate neural activity non-invasively. The article highlights TMS's versatility in studying brain function, including mapping cortical areas and probing cognitive processes. It also discusses TMS's potential therapeutic applications, such as treating depression and chronic pain. The author emphasizes the growing interest in TMS among neuroscientists and the need for further research to unlock its full potential in both understanding and treating neurological disorders.

Oliveri, M., Rossini, P.M., Filippi, M.M., Traversa, R., Cicinelli, P., Caltagirone, C.. (2002). **Specific forms of neural activity associated with tactile space awareness.** *Neuroreport, 13*(8), 997-1001.

https://doi.org/10.1097/00001756-200206120-00002

Left tactile extinction, where left tactile stimuli fail to access consciousness only when right stimuli are presented simultaneously, offers a model for studying tactile awareness from its transitory absence. Pairs of transcranial magnetic stimuli (TMS) on the parietal cortex inhibit contralateral tactile perception when separated by an interval of 1 ms. Study applies TMS on left parietal cortex of right brain damaged patients and normal subjects and shows selective lack of paired TMS inhibitory effects on right tactile perception of patients during bimanual stimulation. TMS effects were normal during unimanual right stimulation. Results suggest presence of a specific pattern of inhibitory/excitatory interactions in parietal brain areas critical for tactile awareness.

Oliveri, M., Bisiach, E., Brighina, F., Piazza, A., La Bua, V., Buffa, D., Fierro, B. (2001). **rTMS of the unaffected hemisphere transiently reduces contralesional visuospatial hemineglect.** *Neurology, 57*(7), 1338-40.

https://doi.org/10.1212/wnl.57.7.1338

To verify the role of interhemispheric influences on manifestations of neglect, the authors investigated the effects of a transient repetitive transcranial magnetic stimulation (rTMS)-induced disruption of the unaffected hemisphere on contralesional visuospatial neglect in two left- and five right-brain-damaged patients. Parietal rTMS of the unaffected hemisphere during the execution of a computerized task of bisected line’s length judgment transiently decreased the magnitude of neglect as expressed in the number of errors.

Publication List

These articles show the feasibility of the approach of modulation of cortical excitability in stroke rehabilitation

Oliveri, M., Bisiach, E., Brighina, F., Piazza, A., La Bua, V., Buffa, D., Fierro, B. (2001). **rTMS of the unaffected hemisphere transiently reduces contralesional visuospatial hemineglect.** *Neurology, 57*(7), 1338-40.

https://doi.org/10.1212/wnl.57.7.1338

To verify the role of interhemispheric influences on manifestations of neglect, the authors investigated the effects of a transient repetitive transcranial magnetic stimulation (rTMS)-induced disruption of the unaffected hemisphere on contralesional visuospatial neglect in two left- and five right-brain-damaged patients. Parietal rTMS of the unaffected hemisphere during the execution of a computerized task of bisected line's length judgment transiently decreased the magnitude of neglect as expressed in the number of errors.

Oliveri, M., Rossini, P.M., Filippi, M. M., Traversa, R., Cicinelli, P., Palmieri, M. G., Pasqualetti, P., & Caltagirone, C. (2000). **Time-dependent activation of parieto-frontal networks for directing attention to tactile space: A study with paired transcranial magnetic stimulation pulses in right-brain-damaged patients with extinction.** *Brain*, *123*(9), 1939–1947

https://doi.org/10.1093/brain/123.9.1939

Aim was to verify whether paired TMS could induce selective inhibition or facilitation of the unaffected hemisphere depending on the inter stimulus interval (ISI). Single-test parietal TMS stimuli improved the patients' performance, whereas paired TMS had distinct effects depending on the ISI: at ISI = 1 ms the improvement in extinction was greater than that induced by single-pulse TMS; at ISI = 10 ms we observed worsening of extinction, with complete reversal of the effects of single-pulse TMS.

Oliveri, M., Rossini, P.M., Traversa, R., Cicinelli, P., Filippi, M.M., Pasqualetti, P., Tomaiuolo, F., & Caltagirone C. (1999). **Left frontal transcranial magnetic stimulation reduces contralesional extinction in patients with unilateral right brain damage.** *Brain, 122*(9), 1731-9.

https://doi.org/10.1093/brain/122.9.1731

14 right and 14 left brain-damaged patients, single-pulse TMS was delivered to frontal and parietal scalp sites of the unaffected hemisphere after an interval of 40 ms from an electrical unimanual or bimanual digit stimulation. In right brain-damaged patients, left frontal TMS significantly reduced the rate of contralateral extinctions compared with controls. After left parietal TMS, the number of extinctions was comparable to the baseline. The mechanisms whereby the left frontal TMS transiently ameliorates these deficits may involve stimulus-induced removal of a left frontal–right parietal transcallosal inhibitory flow.

Publication List

These articles report fundamental research on Prismatic Adaptation

Panico, F., Sagliano, L., Sorbino, G., Trojano, L. (2022). **Engagement of a parieto-cerebellar network in prism adaptation. A double-blind high-definition transcranial direct current stimulation study on healthy individuals.** Cortex, 146, 39-49.

https://doi.org/10.1016/j.cortex.2021.10.005

Investigation of the involvement of a parieto-cerebellar network in prism adaptation using double-blind high-definition transcranial direct current stimulation (HD-tDCS) on healthy individuals. HD-tDCS is applied to targeted brain regions while participants engage in prism adaptation tasks. Results reveal enhanced engagement of the parieto-cerebellar network during prism adaptation with HD-tDCS, suggesting a significant role of this network in sensorimotor adaptation processes. These findings contribute to the understanding of neuroplasticity mechanisms and potential therapeutic applications.

Turriziani, P. *et al.* (2021). **Improvement of phonemic fluency following leftward prism adaptation.** *Scientific Reports*, 11:7313.

https://doi.org/10.1038/s41598-021-86625-0

Investigation of the impact of leftward prism adaptation on phonemic fluency. Phonemic fluency is a measure of verbal fluency that assesses an individual's ability to generate words beginning with a specific letter within a limited timeframe. Participants underwent leftward prism adaptation, a process involving temporarily altering their visual field. Results showed an improvement in phonemic fluency following this adaptation, suggesting that the manipulation of visual input can positively influence verbal fluency. These findings contribute to our understanding of the interconnectedness between visual and linguistic processes in the brain and highlight the potential therapeutic applications of prism adaptation for enhancing verbal fluency in clinical populations.

Gudmundsson, L., *et al.* (2020). **A brief exposure to rightward Prismatic Adaptation changes resting-state network characteristics of the ventral attentional system.** *PLoS One, 15*(6):e0234382.

https://doi.org/10.1371%2Fjournal.pone.0234382

Investigations of the effects of a brief exposure to rightward Prismatic Adaptation on the characteristics of the ventral attentional system's resting-state network (RSN). Prismatic adaptation involves temporarily shifting one's visual field, which can induce neural changes. Participants underwent a short exposure to rightward Prismatic Adaptation, and their RSN characteristics were assessed using functional magnetic resonance imaging. Results revealed alterations in the RSN of the ventral attentional system following Prismatic Adaptation, indicating that even a brief exposure can induce changes in brain networks associated with attentional processes.

Publication List

These articles report fundamental research on Prismatic Adaptation

Bonaventura, R. E. *et al.* (2019). **Investigating Prismatic Adaptation effects in handgrip strength and in plantar pressure in healthy subjects.** Gait & Posture, 76, 264-269.

https://doi.org/10.1016/j.gaitpost.2019.12.022

Participants underwent Prismatic Adaptation, and their handgrip strength and plantar pressure were measured before and after the adaptation. Results revealed significant changes in both handgrip strength and plantar pressure following Prismatic Adaptation, suggesting that visual manipulation can influence motor performance. These findings provide insights into the interplay between visual perception and motor control, with potential implications for understanding and treating motor-related disorders.

Bracco, M., *et al.* (2018). **Prismatic Adaptation Modulates Oscillatory EEG Correlates of Motor Preparation but Not Visual Attention in Healthy Participants.** *The Journal of Neuroscience, 38*(5), 1189 –1201.

https://doi.org/10.1523/JNEUROSCI.1422-17.2017

Impact of Prismatic Adaptation on oscillatory electroencephalogram (EEG) correlates of motor preparation and visual attention. Healthy participants did Prismatic Adaptation. EEG activity was recorded during tasks involving motor preparation and visual attention. Results revealed Prismatic Adaptation influenced oscillatory EEG correlates of motor preparation but not those related to visual attention. This suggests that while Prismatic Adaptation can modulate motor control processes, it does not notably alter visual attention in healthy participants. Findings offer insights into cognitive effects of Prismatic Adaptation and applications in understanding and modulating motor preparation mechanisms.

Bracco, M. *et al.* (2017). **Combining tDCS with Prismatic Adaptation for non-invasive neuromodulation of the motor cortex.** *Neuropsychologia, 101*, 30-38.

http://dx.doi.org/10.1016/j.neuropsychologia.2017.05.006

Exploration of the synergistic effects of combining transcranial direct current stimulation (tDCS) with Prismatic Adaptation to modulate the motor cortex non-invasively. Both tDCS and Prismatic Adaptation individually influence cortical excitability, but their combined application may enhance neuromodulatory effects. Participants underwent both interventions, and motor cortex excitability was assessed. Results showed that the combined approach led to greater modulation of the motor cortex compared to either intervention alone. This suggests that combining tDCS with Prismatic Adaptation could offer a promising strategy for non-invasive neuromodulation of the motor cortex, potentially providing therapeutic benefits for motor-related conditions.

Publication List

These articles report fundamental research on Prismatic Adaptation

Magnani, B. *et al.* (2014). **Prismatic Adaptation as a Novel Tool to Directionally Modulate Motor Cortex Excitability: Evidence From Paired-pulse TMS.** *Brain Stimulation, 7,* 573-579.

http://dx.doi.org/10.1016/j.brs.2014.03.005

Exploration of whether PA induces a direct effect on the motor cortices (M1) excitability. Fourteen healthy participants were submitted to paired-pulse TMS to measure short-intracortical-inhibition (SICI) and intracortical-facilitation (ICF) on both the left and the right M1, before and after PA, that could induce a leftward or rightward after-effect. An increase of intracortical-facilitation was found in the M1 contralateral to the after-effect direction. Moreover the extent of facilitation and of the after-effect were correlated to each others. This finding reveals that PA influences M1 cortices directly, raising their excitability.

Magnani, B., Frassinetti, F., Ditiye, T., Oliveri, M., Costantini, M. & Walsh (2014). **Left insular cortex and left SFG underlie Prismatic Adaptation effects on time perception: evidence from fMRI.** *NeuroImage,* 92, 340-348.

http://dx.doi.org/10.1016/j.neuroimage.2014.01.028

This research article uses fMRI to investigate the neural basis of Prismatic Adaptation effects on time perception. The study finds that changes in time perception are associated with activity in the left insular cortex and left superior frontal gyrus (SFG). These brain regions are implicated in various cognitive functions, suggesting their role in mediating the effects of Prismatic Adaptation on time perception.

Magnani, B. *et al.* (2013). **The role of posterior parietal cortices on Prismatic Adaptation effects on the representation of time intervals.** *Neuropsychologia, 51*, 2825–2832.

http://dx.doi.org/10.1016/j.neuropsychologia.2013.08.006

This research article examines the involvement of posterior parietal cortices in how Prismatic Adaptation affects the representation of time intervals. Prismatic adaptation alters visual perception, impacting time perception, and the study aims to understand the neural mechanisms involved in this process. Through experimentation, the study finds evidence suggesting that posterior parietal cortices play a crucial role in mediating the effects of Prismatic Adaptation on how time intervals are represented in the brain. This highlights the intricate relationship between visual perception, time perception, and neural processing in posterior parietal regions.

Publication List

These articles report fundamental research on Prismatic Adaptation

Oliveri, M. et al. (2013). **Prismatic adaptation effects on spatial representation of time in neglect patients.** Cortex, *49*(1), 120-130.

https://doi.org/10.1016/j.cortex.2011.11.010

Processing of temporal information may require the use of spatial attention to represent time along a mental line. We used Prismatic Adaptation (PA) to explore the contribution of spatial attention to the spatial representation of time in right brain damaged patients with and without neglect of left space and in age-matched healthy controls. Right brain damaged patients presented time underestimation deficits, that were significantly greater in patients with neglect than in patients without neglect. PA inducing leftward attentional deviation reduced time underestimation deficit in patients with neglect. The results support the hypothesis that a right hemispheric network has a role, per se, in time perception. Moreover, they suggest that right hemisphere is important in time perception for its control of spatial attention.

Fortis P., Goedert K.M., & Barrett A.M. (2011). **Prism Adaptation differently affects motor-intentional and perceptual-attentional biases in healthy individuals.** Neuropsychologia, 49(9): 2718e2727.

https://doi.org/10.1016/j.neuropsychologia.2011.05.020

Examination of the the effects of prism adaptation on motor-intentional and perceptual-attentional biases in healthy individuals. Prism adaptation involves temporarily altering visual perception, which can influence both motor and perceptual processes. The study investigates how prism adaptation affects these biases differently. Results suggest that prism adaptation leads to distinct effects on motor-intentional biases, involving intentional movements, and perceptual-attentional biases, involving visual attention. Understanding these differential effects sheds light on the complex interplay between visual perception, motor control, and attentional processes.

Luaute, J., Schwartz, S., Rossetti, Y., Spiridon, M., Rode, G., Boisson, D., & Vuilleumier, P. (2009). **Dynamic changes in brain activity during Prism Adaptation.** Journal of Neuroscience, 29(1): 169–178.

https://doi.org/10.1523/jneurosci.3054-08.2009

The research discovered dynamic changes in brain activity throughout the prism adaptation process. Initially, participants displayed increased activity in brain regions associated with error detection and correction, such as the posterior parietal cortex, as they encountered the visual discrepancy caused by the prisms. This indicated the brain's recognition of the visual-motor conflict and initiation of adaptation mechanisms. As participants adapted to the prisms and adjusted their movements to compensate for the visual displacement, the brain activity patterns shifted. The study observed a subsequent decrease in activity in these error-processing brain regions, indicating improved adaptation and reduced conflict between visual input and motor output.

Publication List

These articles report fundamental research on Prismatic Adaptation

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.

https://doi.org/10.1016/j.cortex.2011.10.009

The study used functional neuroimaging techniques to investigate changes in brain activity following prism adaptation therapy. The researchers found that after PA, there was increased activity in specific intact fronto-parietal brain areas responsible for spatial attention and awareness in both brain hemispheres. This increased neural activity in the fronto-parietal regions indicated that PA therapy had an impact on reorganizing or enhancing the brain's attentional networks, improving spatial awareness for neglected areas.

Danckert, J., Ferber, S., & Goodale, M. A. (2008). **Direct effects of prismatic lenses on visuomotor control: An event-related functional MRI study.** *European Journal of Neuroscience, 28*(8), 696-1704.

https://doi.org/10.1111/j.1460-9568.2008.06460.x

The study employed functional MRI to observe brain activity while healthy participants performed reaching movements before and after wearing prismatic lenses. Participants were asked to reach for and touch targets in different locations while wearing the prismatic lenses. The research revealed that prismatic lenses led to changes in brain activity during visuomotor tasks. Specifically, the fMRI scans indicated alterations in the neural networks associated with visuomotor control and spatial processing. There was enhanced activation in regions involved in adapting to the visual shift, particularly in the parietal and occipital cortices, which are crucial for spatial perception and motor planning.

Frassinetti, F., Magnani, B., & Oliveri, M. (2009). **Prismatic lenses shift time perception.** *Psychological Science, 20*(8), 949-954.

https://doi.org/10.1111/j.1467-9280.2009.02390.x

Used Prismatic Adaptation to test the hypothesis that the representation of time is spatially oriented from left to right, with smaller time intervals being represented to the left of larger time intervals. Healthy subjects performed a time-reproduction task and a time-bisection task, before and after leftward and rightward Prismatic Adaptation. Right Prismatic adaptation produced an overestimation of time intervals, whereas left Prismatic Adaptation produced an underestimation of time intervals. These findings [...] confirm that temporal intervals are represented as horizontally arranged in space, [...] that spatial modulation of time processing most likely occurs via cuing of spatial attention, and that spatial attention can influence the spatial coding of quantity in different dimensions.

Publication List

Applied research on Prismatic Adaptation and MindLenses in clinical settings

Oliveri, M,, Bagnato, S., Rizzo, S., , Imbornone, E., Giustiniani, A., Catania, A., & Turriziani, P. (2023). **A novel digital approach for post-stroke cognitive deficits: A pilot study.** *Restorative Neurology and Neuroscience, 41,* 103–113.

http://dx.doi.org/10.3233/RNN-231305

30 stroke patients were assigned to either experimental group (MindLenses) or to the control group, which performed the routine cognitive training in 10 consecutive daily sessions. Both groups were tested before and after [..] on neuropsychological tests [..] Only patients who received the experimental rehabilitation training improved their scores on tests of digit span forward, spatial span backward, attentional matrices and Stroop. [..] Patients of the experimental but not of the control group showed a significant correlation between improvement on some tasks [..] and on activities of daily living as well as with reduction of anxiety levels.

Danesin, L., Oliveri, M., Semenza, C., Bottini, G., Burgio, F., & Giustiniani, A. (2023). **Prism adaptation in patients with unilateral lesion of the parietal or cerebellar cortex: A pilot study on two single cases using a concurrent exposure procedure.** *Neuropsychologia, 6,* 184:108557.

https://doi.org/10.1016/j.neuropsychologia.2023.108557

This pilot study examines prism adaptation using Mindlenses Professional in two single cases of patients with unilateral lesions of the parietal or cerebellar cortex. The study employs a concurrent exposure procedure to assess the effects of prism adaptation on visuomotor coordination in these patients. Results suggest that prism adaptation can improve visuomotor coordination in patients with unilateral lesions of the parietal or cerebellar cortex. This highlights the potential therapeutic utility of prism adaptation in neurorehabilitation for individuals with specific cortical lesions.

Conte, G. Quadrana, L, Zotti, L, Di Garbo, A., Oliveri, M. (2024). **Prismatic adaptation coupled with cognitive training as novel treatment for Developmental Dyslexia: a randomized controlled trial**. *Scientific Reports, 14*:7148.

https://doi.org/10.1038/s41598-024-57499-9

This study explores the efficacy in Developmental Dyslexia (DD) of rightward prismatic adaptation (rPA) coupled with cognitive training. 30 DD subjects A digital intervention of rPA plus cognitive training was delivered weekly over 10 weeks to adolescents with DD (aged 13-17) assigned either to treatment (N=35) or waitlist (N=35) group. rPA treatment was significantly more effective than waitlist in improving Working Memory Index, Processing Speed Index, and Reading Speed.

Publication List

Applied research on Prismatic Adaptation and MindLenses in clinical settings

Oliveri, M., Bagnato, S., Rizzo, S., Imbornone, E. & Turriziani, P. (in press). **The relationship between visuo-constructive abilities and visuomotor adaptation in stroke patients: results of a clinical trial using prism adaptation combined with serious games.** *Topics in Stroke Rehabilitation.*

Thirty subacute stroke patients were randomly assigned to a control group, receiving standard rehabilitation, and to an experimental group, receiving a therapy with prism adaptation and cognitive training through serious games for ten consecutive sessions. The test scores of Freehand copy of drawings, Copy of drawings with landmarks, Albert's line cancellation, Line bisection, Barthel index at baseline evaluation (T0) were compared with those at the end of therapy (T1). The experimental group showed a significant improvement of test scores in both Freehand copy of drawings and Copy of drawings with landmarks. Scores of both copy of drawings tests predicted functional scores at T1 in the experimental group.

Magnani,. B., Oliveri, M., Mancuso, G., Galante, E., & Frassinetti, F. (2011). **Time and spatial attention: Effects of prism adaptation on temporal deficits in brain damaged patients.** *Neuropsychologia, 49,* 1016–1023.

http://dx.doi.org/10.1016/j.neuropsychologia.2010.12.014

Prismatic adaptation [was used] to directionally manipulate spatial attention in order to explore the effect of attentional deviation on time perception in patients with right vs. left brain damage. RBD but not LBD patients presented a time deficit with a clear tendency to underestimate the real time. PA inducing leftward attentional deviation biased time perception toward an underestimation in RBD patients and controls, while it was ineffective in LBD patients. PA inducing a rightward attentional deviation failed to affect time perception in either group. These results underline the effects of PA on temporal deficits in brain damaged patients.

Pisella, L., Rode, G., Farnè, A., Tilikete, C., & Rossetti. Y. (2006). **Prism adaptation in the rehabilitation of patients with visuo-spatial cognitive disorders.** *Current Opinion in Neurology, 19*(6), 534e542..

https://doi.org/10.1097/wco.0b013e328010924b

We review prism adaptation as one of the approaches that emphasize ascending rather than descending strategies to the rehabilitation of visuo-spatial disorders [..] The neural mechanisms underpinning visuo-manual plasticity can be viewed as a powerful rehabilitation tool that produces straightforward effects not only on visual and motor parameters, but on visuo-spatial, attentional and higher cognitive neurological functions. The use of prism adaptation therapy in neglect and other visuo-spatial disorders has just started to reveal its potential, both at a practical and theoretical level.

Publication List

Applied research on Prismatic Adaptation and MindLenses in clinical settings

Frassinetti, F., Angeli, V., Meneghello, F., Avanzi, S., & Làdavas, E. (2002). **Long-lasting amelioration of visuospatial neglect by prism adaptation.** *Brain, 125*(3), 608-623.

https://doi.org/10.1093/brain/awf056

[..] The first aim of the present study was to find out whether the short-term amelioration found after Prismatic Adaptation could be converted into long-term therapeutic improvement. [..] Seven patients with right hemisphere lesion and left visuospatial neglect were treated with prismatic lenses in twice-daily sessions over a period of 2 weeks. [..] Six control, untreated patients, matched to the experimental group [..] The results showed an improvement in the experimental patients' performance after PA, which was maintained during the 5-week period after treatment. [..]

Rossetti, Y., Rode, G., Pisella, L., Farné, A, Li, L., Boisson, D., & et al. (1998). **Prism adaptation to a rightward optical deviation rehabilitates left hemispatial neglect.** *Nature, 395*(6698), 166e169.

https://doi.org/10.1038/25988

A large proportion of right-hemisphere stroke patients show hemispatial neglect [..] The frequent parietal locus of the lesion producing neglect reflects the impairment of coordinate transformation used by the nervous system to represent extrapersonal space. [..] The aim of our study was to investigate the effect of prism adaptation on various neglect symptoms, including the pathological shift of the subjective midline to the right. All patients exposed to the optical shift of the visual field to the right were improved on their manual body-midline demonstration and on classical neuropsychological tests. Unlike other physiological manipulations used to improve neglect, this improvement lasted for at least two hours after prism removal [..]

Publication List

Selected literature on the use of Serious Games in rehabilitation and as digital biomarkers

Gutiérrez-Pérez, B.M., Martín-García, A.V., Murciano-Hueso, A. *et al.* (2023). **Use of Serious Games with older adults: systematic literature review.** *Humanities and Social Sciences Communication, 10*, 939.

https://doi.org/10.1057/s41599-023-02432-0

Qualitative synthesis of literature on empirical research into video games and older adults. 108 studies were analysed, with the participation of 15,902 individuals aged over 60. [...]The results indicate a majority of studies with a quantitative approach conducted in the European context in which a total of 125 scales were identified for the assessment of different geriatric aspects related to domains for the improvement of physical health and functional quality, improvement of cognitive, psychological and mental health, and improvement of physical and cognitive functions from a combined approach.

Lim, E.H., *et al.* (2023). **Effects of Home Based Serious Game Training (Brain Talk™) in the Elderly With Mild Cognitive Impairment: Randomized, a Single-Blind, Controlled Trial.** *Brain Neurorehabilitation, 16*(1):e4.

https://doi.org/10.12786/bn.2023.16.e4

This study aimed to confirm the efficacy and safety of cognitive rehabilitation training using a serious game (Brain Talk™) for the elderly with MCI. Twenty-four elderly individuals with MCI were randomized into study and control groups. The primary outcome measures were the Korean Mini-Mental State Examination (K-MMSE) and K-MoCA (Korean Montreal Cognitive Assessment). In the study group, the K-MMSE, K-MoCA, and SVFT scores after finishing the training and 4 weeks after training showed a significant increase; however, there was no significant change in the control group. Home-based serious games are considered helpful in improving cognitive function.

Jung, H.-T., Daneault, J.-F., Nanglo, T., Lee, H., Kim, B., Kim, Y., & Lee, S. I. (2022). **Effectiveness of a Serious Game for Cognitive Training in Chronic Stroke Survivors with Mild-to-Moderate Cognitive Impairment: A Pilot Randomized Controlled Trial.** *Applied Sciences, 10*, 670.

http://dx.doi.org/10.3390/app10196703

Randomized controlled trial testing a serious mobile games for cognitive training, in chronic stroke survivors (n=50) with mild-to-moderate cognitive impairment without therapist supervision. Within the experimental group, there were statistically significant improvements in all the outcomes except for the language category of the Mini-Mental State Examination and Digit Forward Span. The improvements were clinically significant for the total Mini-Mental State Examination, Digit Forward Span, and Digit Backward Span.

Publication List

Selected literature on the use of Serious Games in rehabilitation and as digital biomarkers

Saragih, I. D., Everard, G.. Lee, B-O. (2022). **A systematic review and meta-analysis of randomized controlled trials on the effect of Serious Games on people with dementia.** *Ageing Research Reviews, 82*, 101740.

https://doi.org/10.1016/j.arr.2022.101740

Review of 12 randomized controlled trials assessing the impacts of game-based intervention programs compared with conventional therapy on cognitive function, instrumental and non-instrumental activities of daily living, or depression among people with dementia were included in this review. Overall, serious games were found to improve cognitive function (pooled SMD: 0.34; 95% CI: 0.07–0.61) and alleviated depression (pooled SMD: −0.131; 95% CI: −1.85 to −0.77) in people with dementia.

Kollins, S. H., Childress, A., Heusser, A. C., & Lutz, J. (2021). **Effectiveness of a digital therapeutic as adjunct to treatment with medication in pediatric ADHD.** *Npj Digital Medicine, 4*(1).

https://doi.org/10.1038/s41746-021-00429-0

Evaluation of the effectiveness of a digital therapeutic as an adjunct to medication in treating pediatric Attention-Deficit/Hyperactivity Disorder (ADHD). The study investigates the impact of adding a digital therapeutic intervention to standard medication treatment for ADHD in children. Results indicate that the digital therapeutic, when used alongside medication, leads to improved outcomes in managing ADHD symptoms compared to medication alone. This suggests that incorporating digital therapeutics into treatment plans for pediatric ADHD can enhance therapeutic efficacy and potentially improve long-term outcomes for affected children.

Kollins, S. H., DeLoss, D. J., Cañadas, E., Lutz, J., Findling, R. L., Keefe, R. S. E., … Faraone, S. V. (2020). **A novel digital intervention for actively reducing severity of paediatric ADHD (STARS-ADHD): a randomised controlled trial.** The Lancet Digital Health, 2(4), e168-e178.

https://doi.org/10.1016/s2589-7500(20)30017-0

Study of 800+ children with ADHD using Akili software. Found improved attention scores after treatment. Indication that this kind of software might be used to improve objectively measured inattention in paediatric patients with ADHD, while presenting minimal adverse events. Sponsored by Akili Interactive Labs, a company producing games for ADHD treatment.

Publication List

Selected literature on the use of Serious Games in rehabilitation and as digital biomarkers

Coutrot, A., Schmidt, S., Coutrot, L., Pittman, J., Hong, L., Wiener, J.M., *et al.* (2019). **Virtual navigation tested on a mobile app is predictive of real-world wayfinding navigation performance.** PLoS ONE *14*(3), e0213272.

https://doi.org/10.1371/journal.pone.0213272

Examination of predictive validity of virtual navigation performance assessed through a mobile app in relation to real-world wayfinding abilities. Participants did a virtual navigation tasks using the mobile app; their performance was compared to their real-world navigation skills. Performance on the virtual navigation tasks was positively correlated with real-world wayfinding abilities. This suggests that virtual navigation assessed through a mobile app can effectively predict an individual's performance in real-world wayfinding tasks. Findings highlight the potential utility of mobile app-based virtual navigation assessments for evaluating and improving navigational skills in various contexts.

Kollins, S. H., DeLoss, D. J., Cañadas, E., Lutz, J., Findling, R. L., Keefe, R. S. E., ... Faraone, S. V. (2020). **A novel digital intervention for actively reducing severity of paediatric ADHD (STARS-ADHD): a randomised controlled trial.** The Lancet Digital Health, 2(4), e168-e178.

https://doi.org/10.1016/s2589-7500(20)30017-0

Study of 800+ children with ADHD using Akili software. Found improved attention scores after treatment. Indication that this kind of software might be used to improve objectively measured inattention in paediatric patients with ADHD, while presenting minimal adverse events. Sponsored by Akili Interactive Labs, a company producing games for ADHD treatment.

Coughlan, G., Laczó, J., Hort, J., Minihane, A.M., & Hornberger, M. (2018). **Spatial navigation deficits - overlooked cognitive marker for preclinical Alzheimer disease?** *Nature Review Neurology, 14(*8),496-506.

https://doi.org/10.1038/s41582-018-0031-x

Spatial navigation deficits as a potential cognitive marker for preclinical Alzheimer's disease. Article discusses how challenges in spatial navigation could indicate early stages of Alzheimer's, often overlooked in clinical assessments. The research suggests that spatial navigation difficulties may precede other cognitive symptoms and could serve as an important early indicator of Alzheimer's progression. Identifying and addressing these deficits could lead to earlier diagnosis and intervention, potentially improving patient outcomes. The article highlights the importance of considering spatial navigation abilities in cognitive assessments for detecting and monitoring preclinical Alzheimer's disease.

Publication List

Selected literature on the use of Serious Games in rehabilitation and as digital biomarkers

Kourtis, L.C., Regele, O.B., Wright, J.M. et al. (2019) **Digital biomarkers for Alzheimer's disease: the mobile/wearable devices opportunity.** *npj Digital Medicine 2, 9*

https://doi.org/10.1038/s41746-019-0084-2

This article discusses the potential of mobile and wearable devices inc. game-based ones in detecting digital biomarkers for Alzheimer's disease (AD). It explores how these technologies can monitor various aspects of daily life, such as activity levels, sleep patterns, and cognitive function, which may serve as indicators of AD progression. By continuously collecting data in real-time, these devices offer opportunities for early detection and monitoring of AD, enabling personalized interventions and improving patient outcomes. The article highlights the significance of leveraging digital biomarkers from mobile and wearable devices in advancing research, diagnosis, and treatment strategies for Alzheimer's disease.