Published in final edited form as:

Eur J Pain. 2016 January ; 20(1): 64–69. doi:10.1002/ejp.723.

Prisms for pain. Can visuo-motor rehabilitation strategies alleviate chronic pain?

DM Torta^{1,*}, V Legrain¹, Y Rossetti^{2,3,4}, and A Mouraux¹

¹Institute of Neuroscience, Université catholique de Louvain, Brussels, Belgium

²ImpAct, Centre des Neurosciences de Lyon, Inserm UMR-S 1028;CNRS UMR 5292, 16 Avenue Lépine, 69676 Bron, France

³Université Lyon 1,69000, Lyon, France

⁴Hospices Civils de Lyon, Service de Rééducation Neurologique; Plate-forme Mouvement et Handicap, Hôpital Henry Gabrielle, 20 Route de Vourles, 69230 Saint Genis Laval, France

Abstract

Background and aims—Prism adaptation (PA) is a non-invasive procedure in which participants perform a visuo-motor pointing task while wearing prism goggles inducing a lateral displacement of the visual field and a mismatch between the seen and felt position of the pointing hand. PA is thought to induce a reorganization of sensorimotor coordination, and has been used successfully to rehabilitate neglect following right-hemisphere lesions. Because studies have shown that complex regional pain syndrome (CRPS) is associated with neglect-like symptoms, it was proposed that PA could be used to alleviate pain in these patients.

Database—A search for peer-reviewed articles on neglect-like symptoms in CRPS and on the use of prisms in CRPS was conducted using the PubMed database.

Results—There is still no agreement as to whether CRPS patients really present neglect symptoms and, if they do, what it is that they neglect. Furthermore, there is insufficient data to determine whether PA exerts an effect on CRPS symptoms. Finally, it remains unknown whether neglect can be observed in other types of lateralized pain, or whether PA could be useful for these patients.

Conclusion—By highlighting open issues, our review provides guidelines for future studies on the use of prisms in pain. The assessment of neglect in patients with CRPS as well as other types of lateralized chronic pain should be characterized using a combination of neuropsychological methods assessing the multiple aspects of neglect in a more refined manner. In addition, further studies should investigate the mechanisms through which PA may modulate pain.

*corresponding author: Diana M.E. Torta, Institute of Neuroscience (IoNS), Faculty of Medicine, Université catholique de Louvain, Avenue Mounier, 53, B-1200, Brussels, Belgium, diana.torta@uclouvain.be, Phone: +32(2)7645467.

The authors declare the absence of any conflict of interest.

Introduction

1.1 Prism adaptation

Prism adaptation (PA) is a non-invasive procedure which combines visual displacement with a visuo-motor pointing task to promote a reorganization of sensorimotor coordination that may expand to spatial cognition. During PA, rightward or leftward deviating goggles are worn, and subjects are asked to point, making a rapid movement, towards visual targets placed in front of them. Initially (early exposure phase), the prisms induce a pointing error towards the side of the optical deviation of the prisms (i.e. right-shifting prisms induce a rightward error). After some trials (late exposure phase), the pointing regains precision. This correction requires resolving the shift in visual information produced by the prisms and is thought to involve, at least in part, a recalibration of visuo-motor coordination (reviewed in (Jacquin-Courtois et al., 2013)) (Figure 1A).

When the brain has adapted to the new visual-motor alignment, removing the goggles leads to so-called compensatory *after effects* of PA. When participants point at the target without wearing the goggles and without visual feedback of the moving hand, a pointing error towards the opposite direction of the initial displacement is observed (i.e. right-shifting goggles induce a leftward after-effect (Redding et al., 2005)) (Figure 1B). PA is defined as a bottom-up effect in that, by operating at the level of cerebellar sensorimotor coordination (patient studies have demonstrated that PA depends on cerebellar substrates (Weiner et al., 1983; Pisella et al., 2005; Pisella et al., 2006)), it induces indirect effects on numerous higher-order cognitive functions (Rode et al., 1998; Michel 2006; Jacquin-Courtois et al., 2010). This is demonstrated by the fact that the effects of PA are not limited to visual and motor functions (Jacquin-Courtois et al., 2013), and the fact that fMRI studies have shown that PA produces changes in fronto-parietal and cerebellar circuits involved in spatial cognition and visuo-motor coordination (Danckert et al., 2008; Luaute et al., 2009; Chapman et al., 2010; Kuper et al., 2013).

PA has been proposed as a means to reduce visuo-spatial deficits in patients with spatial neglect (Rossetti et al., 1998), a disorder that usually appears after right brain damage and is characterized by a lack of awareness of the left contralesional space and an inability to attend and respond to information presented in that side of space. During rehabilitation, spatial neglect patients are exposed to rightward displacing goggles, i.e., prisms that shift the visual field away from the neglected side. The after effects of PA using rightward prisms will thus induce a shift towards the left side, i.e., towards the neglected side. After treatment with rightward displacing goggles, spatial neglect patients exhibit improved abilities to attend stimuli presented in the left space (Serino et al., 2006; Serino et al., 2009). Importantly, PA does not only improve visuo-motor coordination (Jacquin-Courtois et al., 2013). Indeed, the effects of PA expand to a wide range of sensory modalities, including audition (Jacquin-Courtois et al., 2010) and somatosensation (McIntosh et al., 2002; Maravita et al., 2003; Dijkerman et al., 2004). According to some studies (Frassinetti et al., 2002; Serino et al., 2007; Shiraishi et al., 2008; Jacquin-Courtois et al., 2013), the effects of sustained and repeated PA can be long lasting, up to several months. However, not all studies have reported

beneficial effects of PA in patients (Luaute et al., 2009; Newport and Schenk 2012), possibly also depending on rehabilitation procedures (Ladavas et al., 2011).

A critical requirement to induce PA is the performance of a visuomotor task when wearing the goggles. If the prisms are worn without performing a visuomotor task, i.e. passive exposure, they do not induce long lasting after effects. For example, Folegatti et al. (Folegatti et al., 2009) found that during passive exposure to prisms, reaction times to tactile stimuli delivered on the hand were slower when wearing the prisms, suggesting that the simple act of wearing prismatic glasses can affect performance. However, and contrasting with the long-lasting effects of PA, the effects disappeared as soon as the goggles were removed. Therefore, it is likely that the effects of passive exposure and those of PA do not share the same neural basis. Instead, the effects of passive exposure probably rely on cross-modal mismatches between vision and proprioception.

1.2 Prism adaptation for the treatment of CRPS

CRPS is a lateralized chronic pain condition that usually appears after a noxious event such as a wrist fracture or surgery and is characterized by severe and disproportionate pain in a limb that is not limited to the distribution of a single peripheral nerve. The pain is associated at some point with evidence of edema, as well as changes in skin blood flow and temperature. In addition, CRPS patients are thought to present “neglect-like” symptoms (Galer and Jensen 1999; Forderreuther et al., 2004; Moseley 2004; Frettloh et al., 2006; Lewis et al., 2007; Marinus et al., 2011; Legrain et al., 2012) in the sense that they tend to ignore the affected body part (see (Legrain et al., 2012) for a critical review). For example, CRPS patients tend to show reduced ownership, altered mental representation and underuse of the affected limb, indicative of *asomatognosia* and *motor neglect*. In addition, detection of stimuli delivered to the affected limb is impaired by the concurrent stimulation of the contralateral limb (Cohen et al., 2013).

Considering the existence of neglect-like symptoms in CRPS, Sumitani et al. (Sumitani et al., 2007a) trained a group of five CRPS patients using goggles inducing a visual displacement *away* from the CRPS limb. After two weeks of repeated PA, they observed reduced ratings of spontaneous pain. In one patient, the authors assessed the effect of goggles inducing a visual displacement *towards* the affected limb, and found that this resulted in an exacerbation of pain.

These results, obtained in a very small group of patients, suggest that PA could be used to reduce pain in CRPS. However, understanding the effects of PA on the symptoms of CRPS is challenging, and the choice of the direction of the prismatic displacement is not straightforward. First, because it remains unclear whether CRPS is associated with neglect of the affected limb or, on the contrary, an overrepresentation of the affected limb. Second, because the mechanisms leading to neglect symptoms in CRPS are likely to be different from the mechanisms explaining hemineglect following a lesion of the right hemisphere (Punt et al., 2013). PA could thus induce different effects on the neglect symptoms of CRPS patients and brain-damaged patients. Third, and most importantly, PA could induce differential effects on the neglect and pain symptoms of CRPS. Intuitively, one might expect that if patients tend to neglect their affected limb, PA using prisms producing a deviation

towards the unaffected limb would induce after-effects towards the affected limb that would reduce the symptoms of neglect but enhance awareness of the affected limb and, thereby, increase pain.

2 Database

A search for peer-reviewed articles on neglect-like symptoms in CRPS and on the use of prisms in CRPS was conducted using the PubMed database to address three main questions: 1. whether CRPS patients really present neglect symptoms; 2. if they do, what it is that they neglect, and 3. Whether neglect can be observed in other types of lateralized pain, or whether PA could be useful for these patients.

3 Results

3.1 Is CRPS associated with neglect or overrepresentation of the affected limb?

Studies of patients with left hemineglect due to a right hemisphere lesion have shown that neglect is not a unitary phenomenon and, instead, can be fractioned in a number of dissociable components. Therefore, the choice of the method used to assess neglect-like symptoms in CRPS is crucial, as different methods could assess different aspects of neglect, leading to apparently contradicting results. Importantly, motor neglect differs from perceptual neglect. The first is characterized by the spontaneous underuse of the left contralesional limb, without any evident motor deficit. The second is characterized by lack of awareness of the left contralesional space and a reduced ability to attend and respond to information presented in that side of space. The neglect-like symptoms observed in CRPS patients resembles more *motor* than *perceptual* neglect. That is, CRPS patients tend not to move the affected limb, while deficits of awareness or perception of that limb are less obvious. Using questionnaires, Lewis et al. (2007) showed that patients reported negative feelings towards the painful limb, with mismatches between the felt and seen characteristics of the limbs, as in dysmorphic disorders. Conversely, it has been proposed that CRPS patients can over-represent information coming from the affected limb. Sumitani et al. (Sumitani et al., 2007a; Sumitani et al., 2007b) reported that CRPS patients tend to shift their visual subjective body midline towards the affected limb, which is evocative of spatial neglect of the unaffected side or over-representation of the affected side. The authors suggested that the imbalance in subjective body midline could be induced by *exaggerated somatosensory sensory input* from the pathological limb (but see (Moseley et al., 2009) for a different interpretation), as has been proposed by Jeannerod for spatial neglect (e.g. (Jeannerod and Rossetti 1993)). Supporting their view, they observed that during therapeutic nerve blockade of the affected limb using intravenous lidocaine, the reduction of pain was associated with a reduction of the subjective body midline displacement towards the CRPS side.

However, it should also be noted that a bias in the perception of the subjective body midline has been recently reported as independent of the side of pain. Reinersmann et al. observed that, in the dark, CRPS patients perceived their visual body midline as shifted towards the *left*, independently of the actual side of pain (Reinersmann et al., 2012). This leftward bias was greater in CRPS patients as compared to patients with non-CRPS lateralized pain. In

agreement with this, Uematsu et al. (Uematsu et al., 2009) reported a perceived shift of the body midline in CRPS patients, but not in post-herpetic patients with unilateral pain. This could suggest that overrepresentation of the affected side is present only in CRPS, or in pain pathologies with a predominantly central component. Undermining this conclusion however is the fact that Uematsu et al. (Uematsu et al., 2009) predominantly recruited post-herpetic neuralgia patients with pain involving the body trunk. Therefore, the observed differences could also be explained by the fact that CRPS patients had more lateralized pain, most often involving the extremity of a limb. Nevertheless, these data suggest that imbalance in body representation constitutes a key, and possibly specific, feature of CRPS.

3.2 What are the effects of PA on the neglect and pain symptoms of CRPS?

Sumitani et al. (Sumitani et al., 2007a) showed that after exposure to prisms inducing a visual displacement away from the CRPS limb, the bias in locating the visual midline towards the affected side was reduced. The effects of PA on the perceived position of the body midline were observed *before* any effect on pain. Therefore, it might be hypothesized that changes of the perceived position of the visual body midline constitute a pre-requisite for a reduction of CRPS-related pain. Bultitude & Rafal (Bultitude and Rafal 2010) replicated the results of Sumitani and colleagues (Sumitani et al., 2007a), by showing that goggles inducing a shift in the perceived body midline towards the healthy limb reduced pain. They also reported that the reduction of pain symptoms was observed when the PA-inducing pointing task was performed using the CRPS hand, but not when it was performed using the healthy hand. This contrasts with what is usually done in hemineglect patients, for which PA is usually performed with the right hand, namely the one corresponding to the non-neglected portion of space.

3.3 Effects of PA and passive exposure on the autonomic symptoms of CRPS

Sumitani et al. (Sumitani et al., 2007a) and Bultitude and Rafal observed that autonomic symptoms, such as edema, and discoloration could also be improved by PA (see (Rossetti et al., 2013)). In a recent study, Moseley et al. (Moseley et al., 2013) used prismatic goggles to induce a visual displacement towards the pathological limb or the healthy limb in CRPS patients exhibiting a relative reduction of the temperature of the affected limb. Importantly, the authors did not ask the patients to perform any sensory-motor task. Hence, it is likely that the procedure did not induce adaptation. While the patients were wearing the goggles, they observed that the visually-perceived location of the hand relative to the body midline, rather than the actual location of the hand, exerted an influence on the temperature of the hands. Specifically, viewing the affected hand in the unaffected side of space led to an increase in the temperature of the affected hand, regardless of whether the hand was actually located in the unaffected side. The authors concluded that vision of limb position can influence CRPS-related differences in limb temperature, with little influence of proprioception and alignment between vision and proprioception. To compare the effects of visual displacement vs. PA it would be interesting to examine in future studies whether the observed differences in skin temperature are long-lasting (i.e. whether they persist beyond the time during which patients wear the goggles). Additionally, it would be worth exploring whether PA induces different effects on neglect, pain and autonomic symptoms.

In conclusion, several studies suggest that PA could be used as a non-invasive mean to alleviate pain in lateralized chronic pain syndromes, in particular CRPS. However, evidence of its clinical efficacy is still lacking. Indeed, available data has been obtained so far from very small groups of patients (five patients in Sumitani's et al., 2007; one patient in Bultitude and Rafal 2010). Therefore, confirmation of the effects of PA on pain clearly requires replication in larger samples. Furthermore, there is a lack of data on the longer-term effects of PA. Sumitani et al. examined long-term effects in only one of the five patients. Bultitude and Rafal (2010) reported that within 9 days of the start of the treatment, the patient was pain free and pain relief medication was no longer needed. However, the authors noted that 13 days after discontinuing prismatic treatment, the patient had again the need for pain relief. Furthermore, it is necessary that neglect-like symptoms in CRPS patients as well as non-CRPS patients with lateralized pain be more clearly characterized with appropriate and specific neuropsychological methods going beyond basic neglect assessment tasks. Indeed, these tasks have been validated in spatial neglect patients due to right hemisphere lesion, whose characteristics differ markedly from those of the chronic pain population. In addition, the exact mechanism through which PA may modulate pain in CRPS requires further studies assessing, for example, the effects of PA on the perceived body midline. Finally, distinctions should be made between the short lived effects of prismatic visual displacement and the longer lasting after-effects of prismatic adaptation.

Acknowledgments

DMT is an AUL-Marie Curie Incoming Post-doc. VL is supported by the Fund for Scientific Research of the French-speaking Community of Belgium (F.R.S.-FNRS). AM received support from an ERC starting grant ("PROBING-PAIN").

References

- Bultitude JH, Rafal RD. Derangement of body representation in complex regional pain syndrome: report of a case treated with mirror and prisms. *Exp Brain Res.* 2010; 204:409–418. [PubMed: 19967390]
- Chapman HL, Eramudugolla R, Gavrilescu M, Strudwick MW, Loftus A, Cunnington R, Mattingley JB. Neural mechanisms underlying spatial realignment during adaptation to optical wedge prisms. *Neuropsychologia.* 2010; 48:2595–2601. [PubMed: 20457170]
- Cohen H, McCabe C, Harris N, Hall J, Lewis J, Blake DR. Clinical evidence of parietal cortex dysfunction and correlation with extent of allodynia in CRPS type 1. *European journal of pain.* 2013; 17:527–538. [PubMed: 23132624]
- Danckert J, Ferber S, Goodale MA. Direct effects of prismatic lenses on visuomotor control: an event-related functional MRI study. *Eur J Neurosci.* 2008; 28:1696–1704. [PubMed: 18973586]
- Dijkerman HC, Webeling M, ter Wal JM, Groet E, van Zandvoort MJ. A long-lasting improvement of somatosensory function after prism adaptation, a case study. *Neuropsychologia.* 2004; 42:1697–1702. [PubMed: 15327936]
- Folegatti A, de Vignemont F, Pavani F, Rossetti Y, Farne A. Losing one's hand: visual-proprioceptive conflict affects touch perception. *PLoS One.* 2009; 4:e6920. [PubMed: 19738900]
- Forderreuther S, Sailer U, Straube A. Impaired self-perception of the hand in complex regional pain syndrome (CRPS). *Pain.* 2004; 110:756–761. [PubMed: 15288417]
- Frassinetti F, Angeli V, Meneghello F, Avanzi S, Ladavas E. Long-lasting amelioration of visuospatial neglect by prism adaptation. *Brain.* 2002; 125:608–623. [PubMed: 11872617]

- Frettlöh J, Huppe M, Maier C. Severity and specificity of neglect-like symptoms in patients with complex regional pain syndrome (CRPS) compared to chronic limb pain of other origins. *Pain*. 2006; 124:184–189. [PubMed: 16730904]
- Galer BS, Jensen M. Neglect-like symptoms in complex regional pain syndrome: results of a self-administered survey. *Journal of pain and symptom management*. 1999; 18:213–217. [PubMed: 10517043]
- Jacquin-Courtois S, O'Shea J, Luaute J, Pisella L, Revol P, Mizuno K, Rode G, Rossetti Y. Rehabilitation of spatial neglect by prism adaptation: a peculiar expansion of sensorimotor after-effects to spatial cognition. *Neurosci Biobehav Rev*. 2013; 37:594–609. [PubMed: 23428624]
- Jacquin-Courtois S, Rode G, Pavani F, O'Shea J, Giard MH, Boisson D, Rossetti Y. Effect of prism adaptation on left dichotic listening deficit in neglect patients: glasses to hear better? *Brain*. 2010; 133:895–908. [PubMed: 20110244]
- Jeannerod M, Rossetti Y. Visuomotor coordination as a dissociable visual function: experimental and clinical evidence. *Bailliere's clinical neurology*. 1993; 2:439–460. [PubMed: 8137008]
- Kuper M, Wunnemann MJ, Thurling M, Stefanescu RM, Maderwald S, Elles HG, Goricke S, Ladd ME, Timmann D. Activation of the cerebellar cortex and the dentate nucleus in a prism adaptation fMRI study. *Hum Brain Mapp*. 2013
- Ladavas E, Bonifazi S, Catena L, Serino A. Neglect rehabilitation by prism adaptation: different procedures have different impacts. *Neuropsychologia*. 2011; 49:1136–1145. [PubMed: 21310165]
- Legrain V, Bultitude JH, De Paepe AL, Rossetti Y. Pain, body, and space: what do patients with complex regional pain syndrome really neglect? *Pain*. 2012; 153:948–951. [PubMed: 22245555]
- Lewis JS, Kersten P, McCabe CS, McPherson KM, Blake DR. Body perception disturbance: a contribution to pain in complex regional pain syndrome (CRPS). *Pain*. 2007; 133:111–119. [PubMed: 17509761]
- Luaute J, Schwartz S, Rossetti Y, Spiridon M, Rode G, Boisson D, Vuilleumier P. Dynamic changes in brain activity during prism adaptation. *J Neurosci*. 2009; 29:169–178. [PubMed: 19129395]
- Maravita A, McNeil J, Malhotra P, Greenwood R, Husain M, Driver J. Prism adaptation can improve contralesional tactile perception in neglect. *Neurology*. 2003; 60:1829–1831. [PubMed: 12796542]
- Marinus J, Moseley GL, Birklein F, Baron R, Maihofner C, Kingery WS, van Hilten JJ. Clinical features and pathophysiology of complex regional pain syndrome. *Lancet neurology*. 2011; 10:637–648. [PubMed: 21683929]
- McIntosh RD, Rossetti Y, Milner AD. Prism adaptation improves chronic visual and haptic neglect: a single case study. *Cortex*. 2002; 38:309–320. [PubMed: 12146658]
- Michel C. Simulating unilateral neglect in normals: myth or reality? *Restorative neurology and neuroscience*. 2006; 24:419–430. [PubMed: 17119315]
- Moseley GL. Why do people with complex regional pain syndrome take longer to recognize their affected hand? *Neurology*. 2004; 62:2182–2186. [PubMed: 15210879]
- Moseley GL, Gallace A, Di Pietro F, Spence C, Iannetti GD. Limb-specific autonomic dysfunction in complex regional pain syndrome modulated by wearing prism glasses. *Pain*. 2013; 154:2463–2468. [PubMed: 23886518]
- Moseley GL, Gallace A, Spence C. Space-based, but not arm-based, shift in tactile processing in complex regional pain syndrome and its relationship to cooling of the affected limb. *Brain*. 2009; 132:3142–3151. [PubMed: 19752177]
- Newport R, Schenk T. Prisms and neglect: what have we learned? *Neuropsychologia*. 2012; 50:1080–1091. [PubMed: 22306519]
- Pisella L, Rode G, Farne A, Tilikete C, Rossetti Y. Prism adaptation in the rehabilitation of patients with visuo-spatial cognitive disorders. *Current opinion in neurology*. 2006; 19:534–542. [PubMed: 17102690]
- Pisella L, Rossetti Y, Michel C, Rode G, Boisson D, Pelisson D, Tilikete C. Ipsidirectional impairment of prism adaptation after unilateral lesion of anterior cerebellum. *Neurology*. 2005; 65:150–152. [PubMed: 16009906]
- Punt TD, Cooper L, Hey M, Johnson MI. Neglect-like symptoms in complex regional pain syndrome: learned nonuse by another name? *Pain*. 2013; 154:200–203. [PubMed: 23290549]

- Redding GM, Rossetti Y, Wallace B. Applications of prism adaptation: a tutorial in theory and method. *Neuroscience and biobehavioral reviews*. 2005; 29:431–444. [PubMed: 15820548]
- Reinersmann A, Landwehr J, Krumova EK, Ocklenburg S, Gunturkun O, Maier C. Impaired spatial body representation in complex regional pain syndrome type 1 (CRPS I). *Pain*. 2012; 153:2174–2181. [PubMed: 22841878]
- Rode G, Rossetti Y, Li L, Boisson D. Improvement of mental imagery after prism exposure in neglect: a case study. *Behav Neurol*. 1998; 11:251–258. [PubMed: 11568427]
- Rossetti Y, Jacquin-Courtois S, Legrain V, Bultitude J, O'Shea J. Le syndrome douloureux régional chronique à la lumière des troubles de la cognition spatiale: des opportunités physiopathologiques et thérapeutiques?. *Syndrome douloureux chroniques en médecine physique et de réadaptation*. Paris: Springer; 2013. p. 99-109.
- Rossetti Y, Rode G, Pisella L, Farne A, Li L, Boisson D, Perenin MT. Prism adaptation to a rightward optical deviation rehabilitates left hemispatial neglect. *Nature*. 1998; 395:166–169. [PubMed: 9744273]
- Serino A, Angeli V, Frassinetti F, Ladavas E. Mechanisms underlying neglect recovery after prism adaptation. *Neuropsychologia*. 2006; 44:1068–1078. [PubMed: 16330055]
- Serino A, Barbiani M, Rinaldesi ML, Ladavas E. Effectiveness of prism adaptation in neglect rehabilitation: a controlled trial study. *Stroke; a journal of cerebral circulation*. 2009; 40:1392–1398.
- Serino A, Bonifazi S, Pierfederici L, Ladavas E. Neglect treatment by prism adaptation: what recovers and for how long. *Neuropsychological rehabilitation*. 2007; 17:657–687. [PubMed: 17852762]
- Shiraishi H, Yamakawa Y, Itou A, Muraki T, Asada T. Long-term effects of prism adaptation on chronic neglect after stroke. *NeuroRehabilitation*. 2008; 23:137–151. [PubMed: 18525135]
- Sumitani M, Rossetti Y, Shibata M, Matsuda Y, Sakaue G, Inoue T, Mashimo T, Miyauchi S. Prism adaptation to optical deviation alleviates pathologic pain. *Neurology*. 2007a; 68:128–133. [PubMed: 17210893]
- Sumitani M, Shibata M, Iwakura T, Matsuda Y, Sakaue G, Inoue T, Mashimo T, Miyauchi S. Pathologic pain distorts visuospatial perception. *Neurology*. 2007b; 68:152–154. [PubMed: 17210898]
- Uematsu H, Sumitani M, Yozu A, Otake Y, Shibata M, Mashimo T, Miyauchi S. Complex regional pain syndrome (CRPS) impairs visuospatial perception, whereas post-herpetic neuralgia does not: possible implications for supraspinal mechanism of CRPS. *Ann Acad Med Singapore*. 2009; 38:931–936. [PubMed: 19956813]
- Weiner MJ, Hallett M, Funkenstein HH. Adaptation to lateral displacement of vision in patients with lesions of the central nervous system. *Neurology*. 1983; 33:766–772. [PubMed: 6682520]

What's already known about this topic?

Prism adaptation (PA) is a non-invasive procedure that can be used to alleviate chronic pain lateralized to one side of the body, in particular, complex regional pain syndrome (CRPS)

What does this review add?

This review critically examines neuropsychological literature on the use of prisms in lateralized pain syndromes, discusses neglect symptoms in CRPS, and provides useful guidelines on the use of prisms in chronic pain, both for clinicians and basic scientists

Figure 1.

Differences between prism adaptation and passive exposure. **A. Prism adaptation (PA).** Participants are asked to point in front of them or to perform any other visuo-motor task towards a target while wearing prismatic goggles. During pointing, participants view the target but not the hand. Because of the optical shift produced by the goggles, the target appears shifted as compared to its real position. During the first trials, participants make pointing errors towards the direction of the optical shift (early phase exposure). After some practice, these errors attenuate (late phase exposure). After PA, participants no longer wear the goggles and make pointing errors in the opposite direction. This after effect of PA results from a realignment of visual and motor coordinates. **B. Passive exposure.** Here, participants do not perform a visuo-motor task. Instead, participants view their hands and goggles induce a conflict between the visually perceived position of the hand (represented with the solid contour) and its actual position (represented with a dashed contour). Importantly, in this case, the hand itself looks shifted.

Figure 2.

Prism adaptation (PA) can restore the pathological shift in body midline that has been observed in CRPS patients. After PA, Sumitani et al. (Sumitani et al., 2007a) observed that the shift towards the affected side was displaced towards the healthy side. The authors interpreted the shift towards the pathological side as a tendency to over-represent information coming from the affected side. Therefore a shift in the opposite direction was considered as reflecting an improvement over the pathological over-representation of inputs.