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Recent trends in rehabilitation interventions for visual neglect and anosognosia for hemiplegia following right hemisphere stroke

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Abstract

This article highlights the most recent findings regarding the rehabilitation interventions for the syndromes of visual neglect and anosognosia for hemiplegia that occur following right hemisphere stroke. We review papers published in the past 4 years pertaining to therapeutic approaches for these two syndromes in order to identify the trends in the development of effective interventions. Overall, it appears well recognized that visual neglect syndromes and awareness syndromes frequently co-occur and both include complex, multifaceted impairments leading to significant difficulties in daily life functioning following stroke. Thus, the interventions for these syndromes must be multifaceted in order to address the complex interplay of cognitive-behavioral-emotional components. There appears to be a trend for using combination therapeutic interventions that address these components.

Keywords

anosognosia; awareness; intervention; neglect; rehabilitation; stroke

Neglect and anosognosia for hemiplegia (AHP) are two neuropsychological syndromes that occur following right hemisphere stroke with regular frequency [1,2]. Neglect is an impairment in attention or response to stimuli in the hemispace contralateral to the lesion not attributable to a primary sensory or motor deficit [3], whereas AHP is an unawareness of motor impairment and the changes in functioning that result from that motor impairment. Incidence rates range from 13 to 85% of cases of right hemisphere stroke for neglect syndromes and 17–28% for AHP [4]. Notably, hemispatial neglect has been found to occur after left hemisphere stroke, but is often under-recognized and has drawn less clinical and research attention [5].

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There is a high co-occurrence of neglect and AHP, which has been suggested to be the product of neuroanatomical contiguity rather than functional contiguity *per se* [6,7]. The presence of AHP in patients with neglect has been found to be associated with a worse rehabilitation prognosis [8]. In addition, AHP and neglect have been found to be associated with safety concerns such as falls [9,10], longer rehabilitation stays [8,11,12], poorer functional outcomes following stroke [10,12,13] and poorer quality of life [13]. Despite the strong association between these two syndromes, it is agreed that neglect and AHP are distinguishable syndromes with unique clinical characteristics and implications for the rehabilitation interventions [6,12,14].

Given the prevalence of these two syndromes co-occurring and the combined negative impact on the rehabilitation process and outcomes, interventions to address each of them will need to be considered simultaneously within the clinical setting. New interventions have been emerging to facilitate recovery of functioning, and this article summarizes the recent approaches and the known efficacy to impact functioning or reduce morbidity. This is not meant to be an exhaustive review of the literature, but rather a summary of the recent research findings and past literature as is needed to capture the current trends and the potential areas for future research. We will not review all of the therapies shown to be effective prior to 2006. The reader is directed to past comprehensive reviews for a more historical perspective on the range of interventions that have been developed and tested over time [15].

Interventions for neglect

As noted earlier, neglect is considered to involve impairments in attention and/or sensory processing. However, neglect is not one unitary syndrome. There are actually a variety of neglect syndromes that can be distinguished on the basis of the regions of space affected, reference frame or mode of output, as well as the sensory modality [16]. Neglect affecting the contralesional side of space defined by the viewer-centered frame of reference (i.e., according to the midline of the body, head or retina and is required for gait direction, reaching movements or eye movements toward targets) may be characterized as ‘egocentric’ [17]. By contrast, neglect of the contralesional side of the physical stimulus, regardless of the location of the stimulus with respect to the viewer (stimulus-centered neglect), or neglect of the contralesional side of the abstract representations of the object (irrespective of its orientation or modality) may be categorized as ‘allocentric’ [18].

Visual neglect is the most well-known type of neglect and thus has received more clinical and research attention historically than other modalities of neglect (i.e., auditory neglect or somatosensory neglect). Early interventions focused on addressing the apparent deficit in scanning to the left hemispace by training patients to orient to the neglected side [19,20]. This type of ‘top-down’ mechanistic approach relies on the patient learning a new skill to overcome or compensate for the impairment. These types of interventions have received some support as being effective [19–22]; however, because they rely on the patient learning a technique to compensate for neglect, it is not a viable intervention for some individuals with more severe cognitive impairments. Such techniques are particularly problematic for individuals who have comorbid awareness problems as they will not understand the need to learn a strategy for a deficit of which they are not aware. Finally, there is concern that such training only generalizes to very similar tasks, but not to other daily life functional tasks [23]. For example, in the recent case study of an individual with locked-in syndrome and neglect, the visual scanning training generalized to an eye-tracking communication strategy, but not to other functional tasks [24]. These limitations have recently spurred researchers to investigate ‘bottom-up’ mechanistic approaches for neglect interventions (Table 1).

In bottom-up mechanistic interventions, stimulation is used to enhance perception of the contralesional space. Thus, these are more passive approaches in which the patient is the recipient of the stimulation and, for some paradigms, can perform tasks while being stimulated or after receiving stimulation training rather than actively learning a compensatory strategy or technique. More recently, a variety of stimulation methods have been investigated in terms of their efficacy in improving neglect symptoms, including the use of prism glasses, right half-field eye patching, optokinetic stimulation (OKS), tactile stimulation via arm activation and transcranial stimulation. We briefly review some of these techniques in the following sections.

Prism adaptation

Prism adaptation through the use of rightward prism glasses has received the most scientific scrutiny. Individuals receive training to make visually guided pointing movements to specific targets while wearing prism glasses that induce a rightward shift in the visual field. Explanations for the clinical benefits induced by prism adaptation have generally focused on a leftward realignment of attention. However, a recent study suggests that the mechanism for improvement of neglect may be due at least in part to an alleviation of the local processing bias [25]. Further research is needed to determine the specific mechanisms at play.

There is some evidence that prism adaptation is an effective intervention for visual neglect with generalization of the effect to functional tasks, including postural stability [26] and wheelchair navigation [27,28]. However, the findings for generalization are controversial, as a recent study of prism adaptation suggested that the intervention was effective in increasing the hypothesized leftward bias, but this did not generalize to self-care tasks [29]. Specifically, in a blinded randomized control trial, 36 individuals with neglect following right hemisphere stroke were randomized into either prism adaptation or a sham treatment (using plain glasses) [29]. After 2 weeks of treatment (5 days per week), the authors found that only the prism-treated group showed increased leftward bias in pointing behavior. However, the researchers found no overall effect of the treatment on self-care or even on a standardized measure of inattention.

Across studies, the beneficial effects of prism adaptation in pointing behavior have been shown to be effective when applied in the post-acute phases of recovery [30,31] and were found to last from days to weeks. The most recent study findings suggest that sustained effects can last up to 6 weeks post-treatment depending upon the length of stimulation training [30,32]. Very recently, a single case study showed the intriguing finding of the effect persisting for up to 1 year post-training [33]. However, this singular result needs to be replicated in a larger sample.

Right half-field patching

By occluding the right visual field with specialized glasses, called right half-field patching, the individual's attention to the contralesional space can be concentrated. This technique is hypothesized to change the interhemispheric imbalance by reducing the disinhibition of the orienting mechanism of the ipsilesional side [34]. In a recent randomized controlled trial, 35 patients with neglect received either 4 weeks of standard stroke rehabilitation care or 4 weeks of right half-field eye-patching in addition to the standard rehabilitation care. The researchers found a greater improvement on standardized neglect measures for the experimental group than for the control group [35]. However, no difference was found between the groups on a measure of functional skills, suggesting that the effect does not generalize to these functions, at least within the early phases of recovery from stroke. This result contrasts with previous findings that did support that right half-field patching is related to generalization to functional skills [36]. The authors note that the null finding may

be due to multiple factors, including low power secondary to a small sample size, the use of a global measure of functioning (overall gain on the Functional Independence Measure) and the duration of the training sessions, which was shorter than in previous studies of right half-field patching [35]. Further research is needed to determine the potential for this stimulation technique to generalize to functional tasks.

Optokinetic stimulation

In OKS, an exogenously triggered directing of spatial attention to the neglected side is caused by the patient performing smooth-pursuit eye movements in response to visual stimuli that move coherently from the ipsilesional to the contralesional side across a screen [37]. Past research has demonstrated that such stimulation training leads to improvements in neglect on standard measures of spatial judgments and orientation [38,39], and more recent evidence has shown that this effect is heightened when patients are told to actively pursue the moving targets on the screen [40]. A very recent study of the behavioral and neural effects of a 3-week OKS training in seven patients with chronic neglect showed that the training led to improvements of performance on standard measures of neglect that persisted for up to 4 weeks after training [37]. In addition, this study demonstrated that the improvements in neglect symptoms were associated with:

- Increases of neural activity during a functional MRI spatial attention task in areas normally involved in spatial attention;
- A compensatory recruitment of left hemisphere areas [37].

There is some burgeoning evidence the OKS training generalizes to daily life functional tasks. In a recent randomized control study of 30 individuals with at least moderately severe left-side neglect, the subjects received one of the following interventions: OKS; visual scanning training; or transcutaneous nerve stimulation (TENS) [41]. TENS has been argued in the past to lead to improvement in neglect through a nonspecific activation of the right hemisphere or a directional effect on the egocentric coordinates of extrapersonal space [42]. After receiving 20 therapy sessions across a 4-week period of time, the OKS and the TENS groups showed significant improvements in reading and writing compared with the visual scanning training group that were still present upon retesting 1 week after the end of therapy [41]. These results provide some preliminary support that OKS may be an intervention that can generalize to daily functional skills such as reading and writing.

Motor activation

There is evidence to suggest that activation of the contralesional limb within the left hemispace can lead to improvements in neglect symptoms [43]. Typically, this stimulation is combined with visual scanning training to reach its clinical effect; however, in a recent study by Luukainen-Markkula and colleagues, the investigators aimed to demonstrate that left arm activation alone could result in a positive therapeutic effect on neglect symptoms [44]. In a randomized controlled study of 12 patients with neglect, the researchers found that both the arm activation group and the visual scanning group showed better performance on traditional neglect measures at the 6-month follow-up time-point, suggesting that arm activation training alone has beneficial effects on neglect symptoms. However, given that the majority of individuals with neglect also have paresis of their contralesional arm, this method of intervention is only applicable to a small subgroup of patients.

Another motor activation approach is trunk rotation, with previous studies suggesting that therapy that includes 15 degrees of voluntary trunk rotation to the left leads to improvements in neglect symptoms [45]. However, a more recent study of 60 patients with neglect by Fong *et al.* did not find support for this treatment [46]. Using a randomized controlled trial format comparing trunk rotation training with the combined treatments of trunk rotation training

and right half-field eye patching and with standard treatment (with no specific neglect interventions), these researchers found no group differences on measures of neglect or on measures of functioning. They noted that in order for the subjects to complete the trunk rotation, they needed to cross over their right arm to compensate for their impairments in left-side motor functioning, which does not tap into the left limb activation that has been shown to be key for the stimulation effect to occur [43]. In addition, the subjects were noted to have difficulty tolerating the eye-patching while performing the trunk rotation, which may have led to this intervention being less effective [46]. Overall, it appears that motor activation may have some utility as an intervention for neglect in patients who do not have comorbid motor impairments, but more research is needed to determine the mechanisms and the parameters of when such interventions are truly effective.

Transcranial stimulation

Based on the recent hypothesis that the cerebral dysfunction underlying neglect is related to a relative hyperactivity of the unaffected hemisphere secondary to release from reciprocal inhibition [47], researchers have begun to investigate the effectiveness of left hemisphere inhibition to reduce neglect. A recent randomized controlled pilot study of 14 individuals with a recent history of right hemisphere stroke demonstrated that low-frequency repetitive transcranial magnetic stimulation over the left parietal cortex led to improvements on standard measures of neglect for the seven individuals who received this intervention [48]. As the authors noted, these are preliminary, although intriguing, findings that need further replication in a larger sample. In addition, it remains to be shown whether a lasting effect on neglect can be maintained after repetitive transcranial magnetic stimulation and whether that effect generalizes to daily life functioning.

Another study of transcranial stimulation using transcranial direct current stimulation (tDCS) showed complementary results. Specifically, Ko and colleagues applied 20 min of anodal tDCS (stimulation, rather than inhibition) over the right posterior parietal cortex of 15 individuals who were at least 1 month post-right hemisphere stroke and had neglect [49]. They found that performance on standard measures of neglect improved immediately after the transcranial stimulation compared with the stimulation testing. Again, these findings can only be concluded to be preliminary until this effect is replicated with a larger sample, the results are found to be maintained for longer periods of time after discontinuation of the stimulation, and the effect is found to generalize to functional daily life skill use. Nonetheless, it appears that transcranial stimulation deserves further scientific exploration as a potential intervention technique for neglect. For a review of the potential utility of transcranial stimulation (particularly tDCS and galvanic vestibular stimulation) for neglect and other neuropsychological impairments, the reader is encouraged to read Utz *et al.* [50].

Virtual reality

A relatively new tool being explored for the assessment and intervention of neglect is virtual reality [51]. With virtual reality technology, the user is immersed in a rich, multimodal, 3D world. Computer-generated virtual reality environments are interactive and realistic, with parameters and applications within the environment that are easily controlled. Although the findings are preliminary, there is research to suggest that application of virtual reality techniques does lead to improvements in performance for individuals with neglect on standard measures of neglect [52,53] and on 'real-life' virtual tasks [54]. A recent review by Tsirlin and colleagues provides a thorough discussion of the potential uses of virtual reality in neglect assessment and intervention in the hope of spurring more research in this area [51].

Combination treatments

It appears to be well recognized that neglect is a complex syndrome with multiple underlying mechanisms. In an attempt to address these complexities with effective therapeutic interventions, researchers have begun to investigate the combined effects of neglect interventions and modifications of the testing parameters. For example, Keller *et al.* investigated four treatments (OKS with pursuit eye movements, visual scanning training, OKS with pursuit eye movements in conjunction with wearing base-left prisms and OKS with pursuit eye movements in conjunction with following the visual stimuli by arm movements from the right to the left side) [55]. Each of the nonpatients received all four different single-session treatments, each on a different day, with a pre-test and post-test of standard neglect measures. The results suggest that visual scanning training showed a positive but modest improvement on neglect symptoms, whereas OKS with pursuit eye movements led to significant improvements in all measures of neglect. However, a combination of OKS with pursuit eye movements in conjunction with prism adaptation showed no additional effect on test performance, and the ipsilesional arm movements in conjunction with OKS appeared to aggravate the neglect symptoms. These results provide further support for OKS with pursuit eye movements being a viable intervention for visual neglect. It is unclear whether the combined effects of OKS and prism adaptation training offers benefits above and beyond OKS alone, but it has been widely demonstrated that prism adaptation training requires a longer duration of treatment than the one session offered in the current study, so further research is warranted.

In a randomized controlled trial of prism adaptation, Saevarsson and colleagues investigated the effects of time restrictions and visual and auditory feedback for task completion in eight individuals who had neglect [56]. These researchers found that when they placed restrictions on visual search time and provided feedback for correct and incorrect responses, the prism adaptation intervention was ineffective for improving performance on neglect measures. When the researchers removed the time restrictions and feedback, prism adaptation was once again effective for improving symptoms of neglect. In contrast to these findings, another study found that a time pressure component positively affected performance of individuals with neglect on a spatial cancellation task [57]. In this study, the five participants were asked to complete the task with and without instructions regarding a time limit. This finding was concluded to suggest that the time pressure provided an increased subjective arousal and thus possibly increased alertness, resulting in improvements in overall brain functioning. These two studies may be tapping into two separate mechanisms and two separate endogenous means for positively affecting spatial neglect.

In another study of prism adaptation training, Nijboer and colleagues manipulated the typical training paradigm by adding conditions of exogenous (peripheral) and endogenous (central) visual cueing on a computer screen for locating a target [58]. In a case study of two individuals with neglect secondary to right hemisphere stroke, the authors found a leftward reorienting of attention for the endogenous cue trials, but not for the exogenous cue trials. They concluded that these findings suggest that prism adaptation improves neglect by a compensatory process of leftward voluntary orienting, rather than by a fundamental change in attentional bias [58]. Thus, patients are able to successfully attend to the left with conscious effort even though the automatic orienting reflex remains biased to the right [58]. This study, and the studies of other combination treatments outlined earlier, are further attempts to elucidate the underlying mechanisms of neglect and to develop interventions that address the multifaceted nature of neglect syndromes. However, the small sample sizes of these studies do limit the conclusions that can be drawn. Future research should strive to evaluate these combination interventions in larger samples.

Finally, in an attempt to apply a dynamic teaching–learning approach to a comprehensive rehabilitation intervention for neglect, Toglia and Cermak found that a group of 20 individuals with neglect that received the dynamic assessment approach showed greater improvement on measures of neglect than the control group [59]. In addition, they found that these effects transferred to nontrained tasks through improved use of a left-side search strategy. Dynamic assessment is an approach in which, throughout the assessment the degree of change that occurs in response to cues, strategies, feedback or task conditions are systematically and objectively measured [59]. Thus, the intervention is embedded within the assessment procedure with the goal of positively impacting the patient's performance. It could be argued that dynamic assessment relies upon a 'top-down' approach to impact the symptoms of neglect; however, further research is needed to determine whether there is some stimulation component of this intervention that would also constitute a 'bottom-up' approach.

In summary, there have been various treatment strategies described for neglect, many of which have shown some effectiveness, but some of which have not. When there are many treatments for the same condition, this generally suggests that there is not a single very effective intervention, or it is a heterogeneous disorder requiring individualized treatment. Neglect is a heterogeneous disorder, but most treatment studies have failed to individualize the intervention to the underlying cognitive disorder (i.e., visuomotor/exploratory, perceptive/visuospatial or allocentric/object-centered) [3,16]. This limitation of previous studies might account for the inconsistent results across studies with respect to the effectiveness and generalization of various approaches.

Interventions for anosognosia for hemiplegia

Anosognosia for hemiplegia is characterized by an unawareness of motor impairment and the changes in functioning that result from that motor impairment. Because individuals with AHP believe there is nothing wrong with their motor functioning, they may not follow appropriate precautions, which may result in safety risks [10]. In addition, they do not understand the need for therapeutic interventions, leading to refusals to participate in rehabilitation, longer rehabilitation stays and poorer outcomes [8,10,12].

Although several anosognostic syndromes following right hemisphere stroke have been identified, including unawareness of cognitive, emotional and physical sequelae, AHP has received the most attention and scientific scrutiny [60]. However, very few studies have been conducted investigating interventions for AHP and so to date, no single method of treatment or rehabilitation has emerged [61]. During the very acute stages of recovery following stroke, interventions are aimed at the myriad of cognitive, behavioral and physical disturbances that are direct threats to safety and medical stability. As such, structuring the environment and providing greater levels of supervision appear warranted in order to reduce the risk of falls and other safety risks associated with motor impairments of which the individual is not completely aware [10]. However, little is known about interventions that have a direct impact on AHP. Initial studies from 20 years ago demonstrated that temporary remission of AHP symptoms can be initiated by vestibular stimulation [62,63]. Since that time, few advances have been made in treatment approaches. However, very recently, Fotopoulou and colleagues provided preliminary evidence that self-observation of motor behavior from the third-person perspective may lead to permanent recovery from AHP [64]. Specifically, these authors presented the case of a 67-year-old individual with a left-sided hemiplegia and AHP that persisted 3 weeks after onset. After providing her with video feedback of herself performing the awareness assessment, which included questions and execution of motor movements, she demonstrated signs of spontaneous recovery from AHP.

The resolution of the unawareness persisted through the next day. Although these results are intriguing, it is essential to replicate this singular finding.

Given the paucity of research investigating potential interventions for AHP, it may be beneficial to consider the evidence supporting interventions for awareness syndromes more generally. Over the last 20–25 years, a substantial amount of attention has been given to awareness syndromes that present after the onset of brain injury given the negative impact that such syndromes can have on the rehabilitation process and outcomes [65–67]. From the literature, there is the potential of glean important information regarding intervention strategies that could be helpful for AHP. Although AHP is a specific type of awareness syndrome, its characteristics parallel those of other awareness syndromes. Specifically, all awareness syndromes are marked by an impaired recognition for the presence of some impairment in functioning. That impaired recognition may be for the actual change in motor, sensory or cognitive functioning and/or the impact of that deficit on life functioning. It is also well recognized that the unawareness presentation is complex, consisting of neural and cognitive processes as well as psychological factors [68,69].

In recognition of these commonalities, a set of theoretical models have emerged to provide a structure on which to approach interventions for various awareness syndromes. These include the pyramid model of awareness [70], the self-determination approach to enhance self-awareness [71] and the Comprehensive Dynamic Interactional Model (CDIM) of awareness [72]. For a review of these models and discussion of awareness interventions in greater detail, see Fleming and Ownsworth [73].

These three approaches build on one another, with some components remaining the same with each approach. Using the terminology proposed by Crosson and colleagues, the key components for complete awareness include an intellectual awareness in which the individual has a basic knowledge of the deficits and the implications, emergent awareness in which the individual can recognize the impact of the deficits while performing a task and anticipatory awareness in which the individual is able to predict how they will perform on a particular task and/or whether a problem will occur given the deficits [70].

In addition to these three main components, there has been recognition of the role that psychological adjustment and coping can play in the complete awareness presentation [68,74]. It has been proposed that individuals that employ more defensive coping strategies, such as denial and avoidance, may show resistance to participating in rehabilitation interventions and so respond more poorly [69]. Such psychological coping reactions have been labeled 'denial of illness' and can be differentiated from anosognosia [75,76]. Thus, most approaches incorporate psychological interventions to address the coping reactions, along with intervention approaches to address one or more of the key components of complete awareness.

In order to facilitate the development of complete awareness (intellectual awareness, emergent awareness and anticipatory awareness), specific interventions have been developed to address the specific area of unawareness (Table 2). Educational approaches are aimed at patients learning about the types of deficits that they have following brain injury and how they impact daily life functioning in order to increase intellectual awareness. The assumption is that the patient does not have information about themselves due to a lack of access and/or understanding of the problem. Feedback approaches are aimed at provision of cues and tangible feedback regarding performance on tasks (i.e., videotaped, observer feedback, self-appraisal and/or timing feedback) in order to improve emergent awareness. It is assumed that the patient cannot glean, on his/her own, the implications of the information about his/her deficits. The study by Fotopoulou and colleagues mentioned earlier is an

example of using a feedback approach for AHP [64]. Another example of this type of intervention for more general awareness of deficits is the study by Roberts and colleagues [77]. They reviewed brain imaging findings to provide feedback to 16 individuals with brain injury about the presence of neuropathology and possible neurobehavioral outcomes. The authors reported improvements on measures of unawareness postfeedback that were maintained 2 weeks later.

Finally, prediction approaches are aimed at the patient predicting his/her performance on a task, taking into consideration all of his/her strengths and weaknesses in order to develop anticipatory awareness. Although there is limited research of interventions to target these components, more recently there have been several studies of the multicontextual treatment approach [78], which is based on the CDIM of awareness [72]. This approach targets self-knowledge (intellectual awareness) and online awareness (emergent and predictive awareness) and is based upon the assumption that self-knowledge emerges slowly over time with experience, whereas online awareness potentially changes from activity to activity depending on the task demands and task context. In a randomized clinical trial, Goverover and colleagues demonstrated that multicontextual treatment results in improved self-regulation and functional performance on instrumental activities of daily living after brain injury [79]. In addition, Zlotnik and colleagues presented two case examples in which the individuals had impaired awareness of their cognitive and motor impairments post-brain injury [80]. After several weeks of multicontextual treatment, both individuals demonstrated improvements in self-care, mobility and graphomotor abilities, as well as being able to identify deficits in these functional activities. These examples can easily be applied to individuals with AHP to determine if these types of multicontextual treatment could improve self-knowledge regarding the impaired motor functioning and begin to get individuals with AHP to predict what types of tasks will be more difficult secondary to their impairments.

Most recently, there have been two studies that investigated the effectiveness of multicontextual treatment approach. Toglia and colleagues investigated whether the multicontextual treatment could promote transfer of strategy use and self-regulation in four individuals with brain injury [81]. The interventions, which included provision of feedback and assisting patients to self-cue, anticipate challenges and identify errors, were found to be related to improvements in specific awareness in order to recognize and verbalize errors (online awareness/predictive awareness), but no improvements in general awareness of deficits (self-knowledge/intellectual awareness). Lundqvist and colleagues applied the multicontextual treatment within a group intervention with 21 individuals in order to improve emergent/online awareness [82]. All participants in the intervention had intellectual awareness as a prerequisite to participating in the study. Interventions were provided during 11 group sessions across a 6-month period of time. Following treatment, patients demonstrated improved anticipatory awareness and use of coping strategies, but no change in emergent awareness.

Although results from these studies provide preliminary support of the effectiveness of interventions structured after the CDIM [72], firm conclusions cannot be made given the reliance on case reports and small sample sizes. Future research needs to expand upon these findings and replicate the results with larger sample sizes. However, this line of research suggests that a multicontextual approach that targets the three components of complete awareness may offer some avenues for intervention for awareness syndromes, including AHP.

Conclusion & future perspective

In summary, there is mounting evidence supporting effective treatment options for visual neglect. The quality of studies in this line of research has been criticized recently [83,84], noting that it ranges from low to moderate. However, even within the last year, several studies have been published using randomized controlled trial methodologies in attempts to provide quality evidence along this line of research. Taking all the recent findings together, prism adaptation continues to be the most well-supported intervention. The trend is to augment the effect of prism adaptation by combining it with other treatments, and there is particular evidence that having individuals put conscious effort into tracking a visual stimulus during the task may be particularly effective. Thus, the combination of ‘bottom-up’ and ‘top-down’ interventions may prove to be the most effective, but further research is needed. However, new interventions are beginning to be investigated, which may prove to be superior in effect. It is likely that new approaches, such as transcranial stimulation, will be most effective when used in combination with other ‘top-down’ approaches, and can be tailored to the specific type of neglect.

As reviewed earlier, the limited research on interventions for AHP that has been conducted is focused on a ‘bottom-up’ approach relying on stimulating the vestibular system with temporary resolution of the unawareness, whereas the recent study by Fotopoulou and colleagues uses a feedback paradigm resulting in resolution of the AHP [64]. This study’s findings fit within the overarching model of using feedback to impact emergent awareness. It may be that application of the multicontextual approach to AHP will assist in the development of more comprehensive interventions that are maximally effective.

Overall, it appears well recognized that both neglect syndromes and awareness syndromes include complex, multifaceted impairments leading to significant difficulties in daily life functioning. Thus, the interventions for these syndromes must be multifaceted in order to address the complex interplay of cognitive–behavioral–emotional components. The trend is for the use of combination therapeutic interventions that address these components from both ‘top-down’ and ‘bottom-up’ approaches, which can be tailored to the specific type of the syndrome that is present.

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▪ of interest

▪▪ of considerable interest

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Table 1

Recent evidence for the efficacy of interventions for neglect syndromes.

Study (year)	Interventions for neglect	Ref.
Trojano <i>et al.</i> (2010)	Visual scanning training	[24]
Nijboer <i>et al.</i> (2010)	Prism adaptation	[33]
Watanabe and Amimoto (2010)		[28]
Turton <i>et al.</i> (2010)		[29]
Bultitude <i>et al.</i> (2009)		[25]
Serino <i>et al.</i> (2009)		[32]
Saevarsson <i>et al.</i> (2009)		[56]
Shiraishi <i>et al.</i> (2008)		[30]
Jacquin-Courtois <i>et al.</i> (2008)		[27]
Tsang <i>et al.</i> (2009)	Right half-field eye patching	[35]
Thimm <i>et al.</i> (2009)	Optokinetic stimulation training	[37]
Kerkhoff <i>et al.</i> (2006)		[40]
Luukainen-Markkula <i>et al.</i> (2009)	Motor activation	[44]
Song <i>et al.</i> (2009)	Transcranial stimulation	[48]
Ko <i>et al.</i> (2009)		[49]
Ansuini <i>et al.</i> (2006)	Virtual reality	[52]
Schroder <i>et al.</i> (2008)	Electrical stimulation/scanning training	[41]
Keller <i>et al.</i> (2009)	Combination treatments	[55]
Saevarsson <i>et al.</i> (2009)		[56]
George <i>et al.</i> (2008)		[57]
Nijboer <i>et al.</i> (2008)		[58]

Table 2

Summary of recent relevant research in relation to components of complete awareness.

Study (year)	Components of complete awareness	Target of interventions	Types of interventions	Ref.
Zlotnik <i>et al.</i> (2009)	Intellectual awareness	Education: learning about the types of deficits following brain injury and how they impact daily life functioning	Multicontextual approach	[80]
Fotopoulou <i>et al.</i> (2009) Roberts <i>et al.</i> (2006) Toglia <i>et al.</i> (2010) Zlotnik <i>et al.</i> (2009)	Emergent awareness	Feedback: provision of cues and tangible feedback regarding performance on tasks	Video feedback Brain imaging findings feedback Multicontextual approach	[64,77,80,81]
Toglia <i>et al.</i> (2010) Lundqvist <i>et al.</i> (2010) Zlotnik <i>et al.</i> (2009) Goverover <i>et al.</i> (2007)	Anticipatory awareness	Prediction: having the patient predict his/her performance on a task taking into consideration all of his/her strengths and weaknesses	Multicontextual approach	[79–82]