Visual rehabilitation interventions developed for persons with a neurological visual impairment

Information Monitoring Summary

Documentary research
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December 17th, 2009
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Summary

Oculomotor, vision and visual processing problems may result from acquired brain injury and lead to various problems (vertigo, visual midline shift syndrome, reading difficulties). Neuro-optometric rehabilitation can help to improve vision, oculomotor, perceptual and motor function.

Acquired brain injury may cause homonymous hemianopia (HH) [10; 12]. In addition to loss of half of the visual field, HH can result in an oculomotor deficit affecting visual scanning and restricting effective visual searching of the environment. This may cause difficulties when a patient interacts with their surroundings, for example when looking for something or moving around, [32]; it may also cause severe reading problems [10].

HH rehabilitation strategies comprise three major approaches: vision restoration therapy, scanning compensatory therapy and substitution (prisms).  i) Vision restoration therapy (VRT) seeks to restore vision in the blind visual field, at least partly [10]. It may increase the size of the visual field by up to 5° [3; 18; 20]. However, VRT is very demanding because it needs to take place daily over a long period (6 months) [9; 10]. The costs are also very high. Moreover, this approach is controversial; critics argue that the 5° increase in visual field may in fact be due to eye movement undetected by conventional perimetry methods [9; 10]. ii) Scanning compensatory therapy (SCT) teaches the person to perform more efficient eye movements. The program usually takes 20 hours spread over 1 month. It generally enables the patient to render their visual searching more efficient by means of more organized strategies, larger saccades and enlargement of the visual field explored [10; 12; 15; 32]. There is also subjective improvement in vision and functional capacities [12; 15; 21]. SCT seems to achieve more success than VRT, with simpler, more user-friendly techniques [3]. Compensatory training in reading also delivers good results [14; 24; 25]. iii) Using prisms, the visual field is artificially enlarged by moving the visual stimuli from the blind field to the sighted one. More extensive studies are required to determine the true efficacy of prisms and their impact on daily activities.

It is important to offer rehabilitation treatments to individuals with HH even if additional research is still necessary. To date, compensatory visual exploration training seems to constitute the most promising and affordable approach.
Visual rehabilitation interventions developed for persons with a neurological visual impairment

An oculomotor and/or vision deficit may arise following acquired brain injury and cause various types of incapacities. These deficits are described, with a brief overview of their functional impact. The rest of the article is devoted to homonymous hemianopia (HH), the impairments it causes, and the various approaches to vision rehabilitation approaches.

1. Acquired brain injury and vision and oculomotor dysfunction

Acquired brain injury as a result of e.g. traumatic brain injury (TBI), stroke (CVA) or multiple sclerosis, may lead to oculomotor and vision deficits. Incidence may be high. For instance, Goodrich (2008) reported that among veterans with mild TBI, 40% had one or more symptoms of binocular vision dysfunction.

Functional consequences can be diverse. Oculomotor dysfunction resulting from brain injury may trigger deficits with version (pursuit, fixation and visual saccades), accommodation, vergence and strabismus; vision symptoms may also be present, such as light sensitivity and impaired spatial perception, movement perception, binocular vision, detailed vision, etc. [13; 26; 28; 29]. These disabilities may in turn lead to a variety of symptoms such as diplopia (double vision), eye discomfort, visual fatigue, headaches, reading difficulties, shorter attention span, postural equilibrium problems, etc. [7; 13; 26].

1.1 Functional impact

Visual processing and functional vision problems caused by brain injury may cause balance, movement or spatial perception problems. The patient may then have trouble functioning in an environment featuring numerous visual stimuli, such as a supermarket (e.g. difficulty locating a specific item on a shelf) [7]. Moving the head or moving around in a crowded setting may cause dizziness [7; 26]. Fluid, precise eye movements, among other things, are essential for visual pursuit of objects and compensation for body movements. When we move, our inner ear perceives the angle of our head and triggers compensatory eye movements. However, after a TBI or stroke, these compensatory eye movements become disturbed. Nystagmus¹ may occur and cause a sensation of vertigo [29].

Neuro-optometric rehabilitation may be offered in such cases to improve, among others, oculomotor, vision, perceptual and motor functions. These treatments are a mixture of art and science in the fields of optometry and vision rehabilitation [7; 26]. This type of therapy is intended for individuals with a vision deficit resulting from a physical impairment, TBI or other neurological damage. The treatments are

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individualized and their goal is to develop the person’s visual efficiency and skills most appropriate to their needs in order to maximize their performance [2; 7]. Neuro-optometric rehabilitation includes lenses, prisms, occlusive devices and other materials, treatment modalities (e.g. training) and the appropriate equipment [2; 7].

Reading may also be severely affected by neurological injury. According to Goodrich (2008), over 60% of war veterans with mild TBI report persistent inability to perform sustained reading [28]. Conventional optometric vision therapies may help to improve reading skills and comfort, oculomotor control and attention [6].

2. Homonymous hemianopia

A variety of neurovisual disorders may result from injury to the retinal nerve tissue, optic nerves or brain. Prechiasmatic lesions (damage to the optic nerve or eyeball) result in partial or complete monocular visual field deficits. This is the case, for example, with age-related macular degeneration, glaucoma and diabetic retinopathy [1]. Postchiasmatic lesions cause impairments in the contralateral visual hemifield, like hemianopia [1; 18]. Occipital lobe lesions may trigger agnosias. An agnosia is an impairment in the capacity to recognize previously familiar visual information, in the absence of sensory problems (defects in the eye or precortical visual pathways), language or cognitive deficits, or when the sensory impairments alone do not account for the impairment in visual recognition [5]. This is thus a problem with cerebral decoding of the meaning of the retinal image.

In later sections of this article, only hemianopia is discussed. However, for reference purposes, a brief description of certain visual agnosias is found in Appendix 1.

2.1 Homonymous hemianopia

Homonymous hemianopia (HH), in which the same part of the visual field is affected in both eyes, is the most common acquired postchiasmatic deficit. It takes various forms: complete hemianopia, involving both the upper and lower portions of the visual hemifield; quadranopsia, encompassing a visual quadrant; and paracentral scotoma, which does not exceed 10° and lies on the immediate edge of central vision [18]. Homonymous defects are always accompanied by foveal sparing of 0.5° to 1°. Macular sparing (1-5°) is rarely encountered and probably results from incomplete damage to the central visual field in the occipital cortex [18].

Homonymous hemianopia accounts for 70% to 75% of cases of homonymous visual field defects (HVFD) [10; 12]. Possible causes include ischemia, hemorrhage, traumatic injury, inflammation or neoplasia. In a study by Zhang, Kedar, Lynn, Newman & Biousse (2006), HH resulted mainly from stroke (70% of 904 cases), TBI (14%) or a brain tumour (11%) [30]. Onset of HVFD is sudden in the case of stroke or TBI, but progressive when caused by a tumour or degenerative neurological disease [18].

Prevalence of HH in stroke patients is 20 to 30% [14; 18]. This visual field deficit increases their risk of accidents such as falls, to which they are also more subject due to their high average age. HH also reduces the efficacy of other rehabilitation procedures designed to improve patient mobility (e.g. physiotherapy) [10].
Some degree of spontaneous recovery from HH may occur in certain individuals; certain authors mention 15% of cases [1] while others report rates of 40% to 50% [18; 24; 30]. The maximum period for spontaneous recovery is typically 3 months [1; 10; 14]; after 6 months, clinical gains appear to be minimal [23]. Full recovery is rare, occurring in only 5% of cases [18].

2.2 Functional impact of homonymous hemianopia

HH may cause an oculomotor deficit that affects visual scanning. Eye movements are abnormally short and slow, and refixations are more numerous [10; 32]. The reduction in saccade size restricts the skills required for efficient visual exploration of the environment, adding to the person's disorientation and making it harder for them to avoid obstacles [32]. Some 70% of HH patients appear to have this disorganization in their search strategy [10].

Loss of visual hemifield makes it difficult for patients to gain a comprehensive view of their whole environment, particularly in new surroundings; this may affect a person's ability to interact with this environment when they have to locate objects, move around, etc. [32]. Individuals with HH frequently collide with objects located in their blind field and easily stumble or fall. They may find it difficult to go into crowded stores because people and objects suddenly appear from their blind side [7; 29].

Problems with spatial localization are typically observed in the visual field contralateral to that of the brain lesion, but may also be present in both hemifields [1]. The person has trouble judging an object's position in relation to themselves or other objects. Depth perception may also be affected. In addition, the ambient or peripheral visual processing that integrates information from the kinesthetic, proprioceptive, vestibular and tactile systems, may be compromised. This processing unconsciously elicits information about the person's position in space and contributes to balance, movement, coordination and posture [7]. Dysfunction in ambient visual processing may corrupt information about the spatial orientation of the body's midline and transverse (left, right) and anteroposterior axes [1; 7]. The person adjusts to this visual dissonance by shifting their weight from the opposite side to the side on which the brain lesion is located, and walking as if the floor sloped sideways [1; 7]. Deviation is more pronounced when the brain lesion is on the right side [1]. As a result, the individual has trouble walking or steering their wheelchair straight ahead and may find it difficult to stay on a line when they write or draw [1]. This visual midline shift syndrome is usually associated with hemiplegia or hemiparesis. In such cases, a particular type of prism known as a yoked prism may help to restore visuomotor balance [7; 8]. This is a pair of equal-strength prisms whose bases point to the side. They can be incorporated in corrective eyeglasses or worn over the person's glasses as protective goggles [19]. Used in conjunction with physiotherapy and optometric visual therapy, these lenses can often speed up the overall rehabilitation process significantly [7; 8].

HH may also cause severe reading difficulties due to the parafoveal field loss and abnormal saccades. Reading problems, observed in nearly half of hemianopia patients, are often reported as being the worst functional difficulty [10]. The type of difficulty depends mainly on the location of the blind hemifield. For example, with loss of the left field, it is hard to find the beginning of the next line. But right field loss is far more
incapacitating because in most western societies, reading is from left to right [18; 31]. Problems are more marked with a right HH because right visual field loss affects a person's ability to perceive and anticipate the upcoming words in the text they are reading [10; 17]. In oculomotor terms, right HH is characterized by prolonged duration of fixation, shorter rightward saccades and more numerous backward saccades [17; 31]. Slower reading speed is observed, as well as visual omissions, errors in word estimation and severe disorganization in the oculomotor scanning pattern during reading. These symptoms, which constitute hemianopic dyslexia, result in major situational disabilities [24]. Reading is also more difficult when macular sparing is less than 5°, and hence for individuals with macular splitting [10].

Homonymous hemianopia may thus be extremely disabling and have negative repercussions on everything the person undertakes, both daily tasks and activities associated with social life, recreation, education or employment. [14]. In many countries, a person with hemianopia loses their driver's license.

3. Rehabilitation strategies for homonymous hemianopia

There is no standard treatment for HH and little systematic research has been conducted in this area [14]. Rehabilitation strategies for HH can be classified in three main categories: approaches involving visual field restoration; compensatory training approaches; substitution approaches. A number of literature reviews have recently been published on this topic [3; 10; 14; 18; 23]. In particular, Plow, Maguire, Obretenova, Pascual-Leone & Merabet (2009) offer an exhaustive and very interesting critique of the rehabilitation techniques described here.

3.1 Visual field restoration

Vision restoration therapy (VRT) seeks to reduce visual field loss by means of prolonged training and thereby restore vision in the blind field, at least partly [10]. It is based on theories of brain plasticity. While fixating a central point on a computer screen, the individual has to detect visual stimuli (white, suprathreshold lights shown against a dark background) presented repeatedly in the transition zone (border region between the blind and seeing field). Typical training is one hour per day for 6 months [9; 10]. The protocol has to be individualized to present most stimuli in the transition zone, to maximize the treatment's potential benefits [9].

VRT may increase the visual field by up to 5°, which would be clinically significant for reading [3; 18; 20]. In the study by Romano, Schulz, Kenkel & Todd (2008), increase in visual field was not correlated with age, time elapsed between lesion and starting therapy, or type of visual field deficit.

In a study in which the VRT system developed by NovaVision Inc. was used, 88% of the participants reported subjective benefits (e.g. improvements as regards overall vision; confidence and mobility skills; reading; collision with objects or people; hobbies) [11]. However, visual field expansion was only one of the factors contributing to this improvement, and its contribution was minor [11]. Moreover, there has been no research measuring the functional impact of VRT objectively by means of performance tasks.
Vision restoration therapy is currently controversial. Critics argue that the $5^\circ$ increase in visual field could simply be due to eye movement undetected by conventional perimetry techniques [9; 10]. In certain studies including a recent one by Sabel, visual field was independently tested using a scanning laser ophthalmoscope. The results did not demonstrate significant improvement in visual field following VRT [3; 9; 14]. Moreover, this type of treatment is very demanding because it has to be administered daily over a long period (6 months). Costs are also very high. For example, in 2004, the price for VRT offered by NovaVision Inc. was € 5000 (about C$8000) [9].

3.2 Compensatory training

The compensatory approach comprises two types of training: visual exploration and reading. It is based on the hypothesis that the visual field loss cannot be significantly reduced, and for this reason the patient should learn to perform more efficient eye movements. Maybe it seems obvious that the way to compensate for HH is with larger and more frequent eye movements, specifically in the blind region. However, not all hemianopia patients adopt this strategy, especially if their visual deficit is recent [10; 32], and even individuals with longstanding HH may have disorganized eye movements [10].

3.2.1 Scanning compensatory training

Scanning compensatory training (SCT) seeks to increase the size of the visual field scanned or to improve visual scanning strategies, to make it easier for the person to identify objects in their affected field and react and proceed at a higher functional level [7]. Target localization tasks in the sighted and blind fields are typically used to train the person to perform larger eye movements. Researchers such as Kerkhoff et al. (cited in Plow, Maguire, Obretenova, Pascual-Leone & Merabet, 2009) also teach systematic use of scanning strategies during visual search of the environment, to foster the integration of SCT in daily activities. SCT usually requires 1 hour per day for 4 weeks (20 hours over 1 month).

Scanning compensatory therapy is usually performed with computer equipment. For example, Pamkabian, Mannan, Hodgson & Kennard (2004) use a 21-inch (53.3 cm) monitor with a black background, which provides an on-screen visual field of $25^\circ$ horizontal and $10^\circ$ vertical [15]. A white geometric target is randomly displayed among distracting elements for 3 seconds. The user has to seek out this target and fixate it until it disappears, then return their gaze to a fixation point denoted by a cross at the centre of the screen. He is encouraged to use eye movements rather than head movements.

Other researchers have developed a training board measuring 1.25 m × 3 m with the side edges curved inward at an angle of $30^\circ$ [12]. On the board, which provides a larger field than that obtained with a computer, are 4 rows of 10 small lights. While the person keeps their head still, visual stimuli are illuminated at random for about 1 second each. The subject has to respond to each stimulus they see by pressing a button.

SCT generally enables patients to improve the performance and efficacy of visual searching by means of more organized strategies, larger saccades and expansion of the visual field explored [10; 12; 15; 32]. Post-training follow-up studies have found
these improvements could be maintained for at least 2 months, and sometimes for nearly 2 years [10; 12; 15], which shows that oculomotor adaptation can be substituted for loss of visual hemifield [32].

Roth, Sokolov, Messias, Roth, Weller & Trauzettel-Klosinski (2009) have shown that unlike vision restoration therapy, SCT enables us to reduce searching time and improve natural searching behaviours and exploration of scenes on the hemianopic side. The improvements are not due to an increase in visual field as such but rather to more efficient visual saccades [12]. SCT can result in significant increases in the visual field searched (scanned) of up to 30°; in a reading task, this can substantially increase speed or reduce the number of errors [3; 14]. The degree of improvement in searching and visual scanning does not seem to be associated with the degree of macular sparing [18]. Note that an untreated control group was not present in any of the studies reviewed.

In terms of function, SCT can increase the speed of execution of certain visuomotor tasks (e.g. threading beads). It may also contribute to improving vision and functional capacities [12; 15; 21], notably for finding an object on a table or in a room, crossing the street [12; 15], seeing obstacles and avoiding objects, or reading [12]. However, these findings are derived from questionnaires; no objective behavioural measurement during daily activities has been undertaken. Moreover, Kerkhoff et al (1994), cited by Lane, Smith & Schenk (2008), showed that in combination with exercises in searching for objects at home, SCT may improve searching performance in a more realistic situation requiring a wider visual field than the one used during training (e.g. finding an object among other items on a table).

Not all HH patients will benefit from scanning compensatory training [10; 15]. However, we do not really know what factors are associated with the end result. Etiology does not seem to have a significant impact although in the studies, most subjects had a stroke [10]. The same applies to age. As regards the amount of time elapsed between the date of the neurological lesion and the start of interventions, findings diverge; certain studies suggest it is preferable for training to being early, while other research has found no link between these two variables [10]. On the other hand, degree of sparing of visual skills in the blind field seems to constitute a plausible predictor of training efficacy. According to the literature review by Lane et al (2008), certain HH patients may respond fairly accurately to a stimulus appearing in their blind field, for example by pointing to it even if they claim they cannot see it. This phenomenon, known as blindsight, is estimated to be present in 15% to 20% of HH cases; repeated stimulation may improve performance [10].

### 3.2.2 Reading training

Because reading performance is often affected by homonymous hemianopia, specific compensatory training procedures have been developed.

Spitzyna, Wise, McDonald, Plant, Kidd, Crewes & Leff (2007) trained individuals whose right HH had been present for at least 3 months and interfered with their reading capacities. They had to practice for 20 minutes daily reading a text that moved from right to left on a computer monitor. The underlying principle was that inducing a small-amplitude optokinetic nystagmus would improve reading speed on a static text because
the person then uses wider, more efficient saccades in the hemianopic field. This optokinetic training, which took place at home, lasted 8 weeks for the experimental group and 4 weeks for the control group (preceded by 4 weeks' placebo training). The results showed significant improvement in reading speed following optokinetic training as opposed to the placebo treatment.

Zihl & Kennard, 1996 (cited by Pambakian, Currie & Kennard, 2005), also developed a computerized visual training system, and tested it on 96 individuals with a homonymous visual field defect. At the end of the training the researchers observed faster reading speed, fewer errors, less frequent and shorter fixations, and larger saccades. However, at the end of the training, subjects with right HH did not display as much improvement as those with left HH, despite the fact that they had undergone more training sessions (33 vs. 26). Kerkhoff et al, 1992 (cited by Pambakian et al, 2005) had previously used the same protocol but for an average of 13 sessions. The results from both research teams showed an improvement in reading that was maintained during follow-up assessments 6 months and 2 years after the interventions ended [14].

Reading training does not have to be conducted with text. Schuett, Heywood, Kentridge & Zihl (2008) compared the efficacy of two versions of systematic computerized oculomotor training; the first used non-textual material (Arabic numerals) and the second, semantic textual material. Forty subjects with hemianopic dyslexia2 received around eleven 45-minute training sessions with one or other of the protocols. Both types of training proved equally effective in improving reading performance and eye movements.

3.3 Substitution

In the substitution approach, optical aids are used to artificially enlarge the visual field. Monocular or binocular prisms are added to eyeglasses in order to displace the visual stimuli from the blind field to the sighted field.

Although they seem to assist with visual function, prisms have limitations. For example, monocular prisms enlarge the visual field but also create diplopia [10; 14]. Binocular prisms relocate the visual field rather than enlarging it [16]. These issues probably explain why prisms are only moderately successful in the rehabilitation of HH patients [10].

In 1990, Rossi, Kheyfets & Reding (cited by Plow et al, 2009) mounted 15-D Fresnel prisms binocularly on a pair of spectacles lenses (base ipsilateral to the side of the visual field defect). After 4 weeks of prism use, an improvement was found in visual perception (line cancellation test) and function (tangent screen evaluation). However, the impact on daily activities was not measured. According to Peli (2000), these prisms may cause optical field loss at the centre of the lens.

Subsequently, Peli (2000) developed a monocular sector prism (30-40 D) limited to the peripheral field (superior, inferior or both) and placed across the whole width of the lens, so as to be effective in all lateral gaze positions. The prism enlarges the visual

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2 As mentioned, hemianopsic dyslexia causes slower reading speed, visual omissions, errors in word estimation and severe disruption of the oculomotor scanning pattern during reading.
field by means of peripheral diplopia and confusion, by optically creating a peripheral exotropia while maintaining bifoveal alignment. As a result, a scene segment as high as the vertical span of the prism is laterally displaced by 15° to 20° relative to the view of the other eye, without causing central diplopia. This new optical treatment method was tested on 12 subjects, who soon adjusted to the prisms (2-3 weeks). In multi-centre research conducted by Bowers, Keeney & Peli (2008), 74% of the 43 subjects were still using the prisms continuously 6 weeks later; however, only 47% were still using them a year after being fitted with them. In functional terms, users find these prisms helpful for avoiding obstacles while walking [4; 16].

Another system, the Visual Field Awareness System, was developed by Gottlieb & Miesner. This is a peripheral prismatic button, usually 18.5 D, incorporated with the lens as close as possible to the limit of the field loss, on the temporal side [18; 19; 27]. Because this prism is incorporated in the patient's refractive prescription, it causes less visual distortion. It may also have the advantage of not interfering with the person's vision unless they direct their gaze to their blind field [27].

While a variety of prismatic systems have been developed and deliver some improvements, more extensive studies are required to determine their true efficacy and their impact on daily activities [18]. It is also important to describe more precisely the users' adaptation skills, the effect of cognitive perceptual deficits on this adaptation, the adaptation period involved, and the degree of patient adherence in the long term [18].

4. Limitations of studies examining rehabilitation strategies for homonymous hemianopia

Although research is providing interesting and promising avenues for visual rehabilitation strategies for patients with homonymous hemianopia, very few of the studies have controlled for visual neglect, visual agnosia and damage to higher level visual dysfunctions. Yet cases of "pure" hemianopia are relatively rare, because in addition to an occipital lobe lesion, there is usually damage to other cerebral regions [3]. Moreover, very few studies have included a control group to evaluate the placebo effect. The clinical efficacy of these strategies has therefore not been clearly established.

In addition, the evaluation of the impact of interventions on people's daily lives has been largely subjective, using questionnaires. Specific performance measures such as reading skills, orientation and mobility in a crowded setting, and visually searching for objects in an ecological environment, should be undertaken in order to validate more reliably the subjective findings regarding improvement. As well, we do not yet really know how specific the different types of training are, for example whether certain activities benefit more than others from a particular type of intervention. It is therefore too soon for us to wholeheartedly recommend any of the above approaches [10; 18].

Compensatory training is the only approach with which an improvement in visual behaviour has been demonstrated (visual search time, reading speed and ocular movements), so it appears to be the most promising [10]. It also requires far less time than the vision restoration approach and is cheaper. However, many types of
compensatory training have been developed and they vary widely in terms of equipment (e.g. computer system connected to a television or monitor vs. luminous board) and duration (12 to 60 sessions). There are no studies comparing them. We therefore do not know whether all are equally effective or what is the optimal duration of intervention.

5. Conclusion

More controlled studies need to be conducted to confirm the evidence from research into visual rehabilitation therapies designed to improve the functional capacities of individuals with homonymous hemianopia. Additional research is also necessary to measure the impact of interventions on daily activities, their specificity, and the durability of the improvements achieved.

Despite these limitations, the scientific evidence is increasingly strong and compelling. Homonymous hemianopia clearly causes functional incapacities that may be severe. It is therefore important for these rehabilitation treatments to be offered even though they have not yet fully proved themselves. To date, compensatory training in visual exploration seems to be the most promising approach for clinical use, both as regards the results achieved and its techniques, which are relatively simple and user-friendly [3].
6. References


Appendix 1

Visual agnosias

Agnosia is an impairment in the capacity to recognize previously familiar visual information, in the absence of sensory disorders (deficit of the eye or pre-cortical optical pathways), or cognitive or language disorders, or when these sensory disorders alone do not explain the visual recognition impairment [5]. This is therefore a disorder of the cerebral decoding of the meaning of a retinal image.

*Cortical* or *occipital blindness* makes the person behave as if they were blind, in the absence of a lesion of the eye or optical pathways. Cortical blindness is generally observed temporarily, immediately after a trauma, and is followed by recovery, which is variable, of the conscious use of visual potential [5].

*Visual agnosias*, where there is no elementary sensory disturbance, constitute impaired recognition of visual objects due to damage to the perceptive mechanisms preventing identification of previously familiar objects and shapes [29]. Although an agnosic patient is able to find and use an object spontaneously, they are unable to recognize it from visual information alone [5]. Visual agnosia includes object or image agnosia (recognition difficulty) and spatial agnosia (difficulty locating objects, usually in extra-corporeal space) [5].

There are various forms of *object agnosia*. The most serious *aperceptive agnosias* are manifested clinically by an almost total inability to process visually perceived information [5]. Care requires using alternative sensory approaches to help the person, in the best case scenario, re-order their visual perceptions, or else help them to function by limiting visually induced disturbances [5]. However, in the case of *integrative or transformational agnosia*, it is possible to help the individual to refine their processing of information perceived, by means of verbalization, for example by formulating an interpretative hypothesis [5].

*Spatial agnosia* is associated with Balint's syndrome or neglect of unilateral space. A person with *Balint's syndrome* retains their visual capacity but behaves as if they were blind; the gaze is fixed, gestures are imprecise, and movements are random or assisted, with frequent collisions [5]. The more they try to fixate their gaze, the less they know where what they see is located; this causes problems with movement, gestures, walking, negotiating stairs or avoiding obstacles [5]. They are unable to seek out or visually retrieve what they have seen, or visually pursue what passes through their attention field. The initial objective of rehabilitation is therefore to restore safe movement and action by establishing strategies, which are mostly tactile, for protection, spatial localization and cognitive compensation [5]. As regards *unilateral spatial agnosia*, or *visuospatial hemineglect*, this is defined by inattentiveness to, or unawareness of, the visual space contralateral to the hemispheric lesion; the person is

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3 The website of the *Centre de rééducation fonctionnelle pour aveugles ou malvoyants de Marly-le-Roi* contains an interesting and detailed section on neurovisual disorders, based on the scientific literature [5]. As it is easily accessible, the reader is encouraged to consult it for further information.
unable of searching in an ordered manner for the visual information in this hemispace, processing it and reacting accordingly [5; 22; 29]. This problem arises mainly when the lesion is in the right frontoparietal lobe, resulting in left hemianopia and left hemineglect. A person with visual hemineglect has more problems than someone with hemianopia alone [22; 29]. Because they are unaware of the loss of hemifield, one of the behaviours typically observed in a patient with left hemineglect is not paying attention to, or not moving towards, a stimulus located to the left; they are therefore likely to collide with objects in their hemianopic field. These individuals will tend to turn their head and trunk to the right, walk towards the right, only read the right side of a text, and only eat the food on the right half of their plate [5; 22]. They are unable to perform rapid, spontaneous visual scanning in the hemianopic region. It is important to help them gradually become aware of their impairment by concretely showing them its effects and consequences using daily life simulation exercises and role-playing with reference to their own experiences [5]. Once this awareness is established, interventions aim to develop voluntary exploration of the neglected space and integrate this exploration into daily activities. Rehabilitation is difficult and the prognosis is often uncertain [5].

Neurovisual rehabilitation is complex and requires pluridisciplinary work to take into account the diversity of functions and their involvement in all daily activities. Medium- or long-term interventions are often required [5].