Article ▸ A Case of Blindsight to Sight

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ABSTRACT

Introduction: Visual consciousness is affected when the primary visual cortex is damaged. However, sighted behavior can persist within the areas of cortical blindness. This phenomenon is called blindsight, and it describes the ability to respond to visual stimuli in the absence of conscious awareness. With practice, visual awareness within a blind field can be trained through repeated visual stimulation.

Case Report: A 70-year-old female with blindsight presented for a visual skills evaluation following a left-sided ischemic stroke. She perceived light in only very limited areas of her visual field, yet she was able accurately to identify colors, orientation, and the location of various visual targets presented in her blind field. Vision therapy was initiated to maximize the use of her residual vision, as well as to improve overall visual awareness. Within two months of starting therapy, her vision improved to 20/100 in the right eye and 20/125 in the left eye with near normal visual fields.

Conclusions: With practice, responses to visual stimuli within the blind field can improve, perceptual learning can occur over time, and awareness can be trained. Rehabilitation of individuals with blindsight is highly recommended as it may present some therapeutic value as well as rehabilitative.

Keywords: blindsight, cortical blindness, hand-near visual targets, perceptual learning, rehabilitation, vision therapy

Introduction

Each year in the United States, there are about one million new cases of stroke, almost half of which exhibit damage to the primary visual cortex, resulting in visual field loss.[1,2] There is a long-held belief that besides some spontaneous recovery in the first few months after the initial injury, the remaining areas of cortical blindness are absolute and permanent.[3] However, it is found that within these field defects, some residual visual capacities may persist.[3] Detection of various attributes of visual stimuli, including orientation, color, motion, contours, and emotional expressions, have been reported within the field defect, though any experience of seeing is often denied.[2-5]

The term blindsight was first coined by the British psychologist Dr. Lawrence Weiskrantz in the 1970s. It describes the ability of people who are cortically blind due to lesions in their primary visual cortex to respond to visual stimuli that they do not consciously see.[4,6] These individuals consistently demonstrate an ability to perform above chance when forced to detect or discriminate visual stimuli within their blind field.[1] Individuals with blindsight may do so in the complete absence of acknowledged awareness (blindsight type 1) or with impaired awareness (blindsight type 2).[3,7,8]

Blindsight challenges the common belief that perceptions must first enter our consciousness in order to affect our behavior. Instead, it shows that our behavior can be guided by sensory information of which we have no conscious awareness.[9] Although the primary visual cortex is considered crucial for visual consciousness, recent studies show that unconscious vision can be transformed into conscious vision through training.[5] Asking individuals with blindsight to perceive, judge, recognize, locate, or grasp stimuli in their field defect can potentially help them relearn how to see (perceptual learning) as new connections are made.[5,10]

Case Report

Background

DP, a 70-year-old Caucasian female, went to bed on the evening of February 8, 2017. The next morning, her husband was unable to wake her and dialed 9-1-1. She was quickly admitted to the hospital partially unresponsive. When she awoke, she complained of right-sided weakness, tingling in the fingers of her right hand, a headache, and reduced vision in the right eye. Neuroimaging showed signs of acute, non-hemorrhagic cerebellar and cerebral infarctions involving the left posterior cerebral artery. She remained under observation for four days before transferring to an in-patient rehabilitation facility, where she remained until discharge on March 16th.

Initial Evaluation

DP presented to the clinic in a wheelchair on April 7th for a visual skills evaluation. She complained of complete vision loss in both eyes and reported that the onset was gradual but progressed quickly since the stroke. She continued to experience right-sided weakness and was receiving out-patient physical therapy once a week.

During the initial exam, DP could detect light in a very small area of her nasal field with her right eye and in her temporal inferior field with her left eye only. Pupil testing was within normal limits, with no signs of an afferent pupillary defect. Extraocular motilities were only grossly full, as she was unable to fixate and follow, and confrontation visual fields

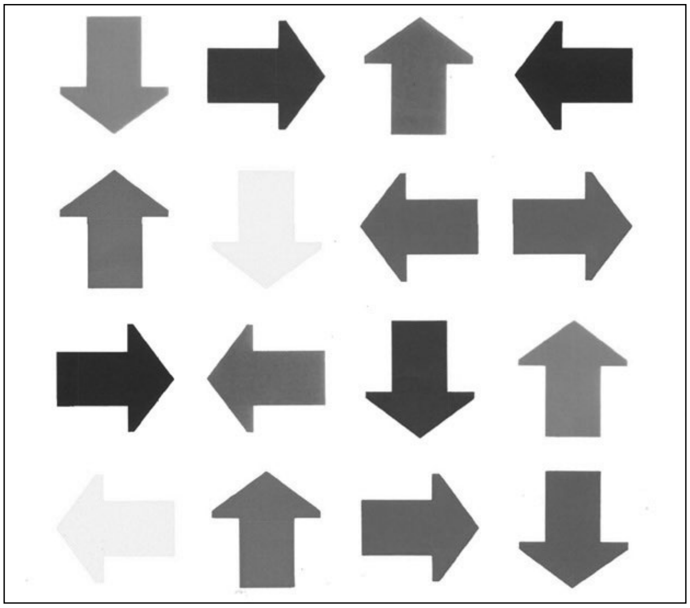

Figure 1. *Colored arrow chart (see online version for true colors)*

were unable to be obtained, although a right hemi-field loss was suspected.

Although DP consistently reported that she was unable to see, she still exhibited some sighted behavior throughout the exam. For instance, she first arrived wearing dark sunglasses, as she reported severe light sensitivity. When someone approached to greet her, she immediately reached out and grabbed their hand for a handshake as though she knew exactly where they would be. Finally, when she was encouraged to make her best guess regarding the color of different objects presented to her, she hesitated but was able to do so with 100% accuracy. Given her ability to respond to visual stimuli in the absence of any awareness, the patient was diagnosed with blindsight, and a weekly regimented vision therapy program was initiated.

Vision Therapy

DP started vision therapy on April 11th. She openly expressed her skepticism at first and was having a difficult time accepting the idea that she was able to see when she was adamant that she could not, especially when other healthcare professionals around her told her repeatedly that she would never regain her sight. During each therapy session, she required constant encouragement and reassurance. The goal of therapy was not only to maximize her residual vision in the hopes of improving her conscious awareness to visual stimuli; it was also important to build her confidence in order for her to believe in her visual abilities.

Visual stimuli presented in therapy were limited to simple shapes and solid colors. One activity involved different colored arrows in different orientations presented on a single page (Figure 1). DP had to identify the color and the direction of each arrow without touching the sheet of paper. Although hesitant at first, she managed to identify each arrow accurately when prompted to make her best guess.

Figure 2. *Silhouette images*

Her responses were slow initially, but once she placed her hand on the page, her answers were more decisive. Similarly, DP had to identify various silhouette images presented on separate sheets of paper (Figure 2). Again, her responses were always correct, but they were more spontaneous as soon as she placed her hand on the page.

Although she could accurately guess the characteristics of any simple visual target presented to her on a page, DP was unable to verify these successes herself and relied on feedback from others. This made it difficult for her to develop self-confidence in her abilities. A six-figure form board, foam letters, and foam numbers were very useful in this case, as this allowed her to hold the shape, letter, or number in her hands to verify her responses. These activities were recommended for home therapy, and she was encouraged to keep a log of her progress during the course of the therapy program.

Progress Evaluation

DP returned on June 6th after being absent for a month due to complications with her health. She was no longer in a wheelchair and walked into the clinic on her own with some assistance. One day during her absence, she reportedly reached out to touch a door handle without realizing it, and she was suddenly able to see it for the first time since her stroke. Since then, her vision began gradually to improve.

DP's best-corrected visual acuities at distance were 20/100 with the right eye, 20/125 with the left eye, and 20/80 with both eyes together using single letter targets. At near, she achieved 20/80 with effort. Her responses were slow, and she required assistance in directing her gaze appropriately. Pupil testing was within normal limits, with no indication of an afferent pupillary defect. Extraocular motilities were smooth and full, and confrontation visual fields showed full to finger count in the right eye and a restricted superior field in the left eye. This was later confirmed with a Goldmann visual field (Figures 3a and 3b). Overall ocular health was unremarkable, with no signs of optic atrophy.

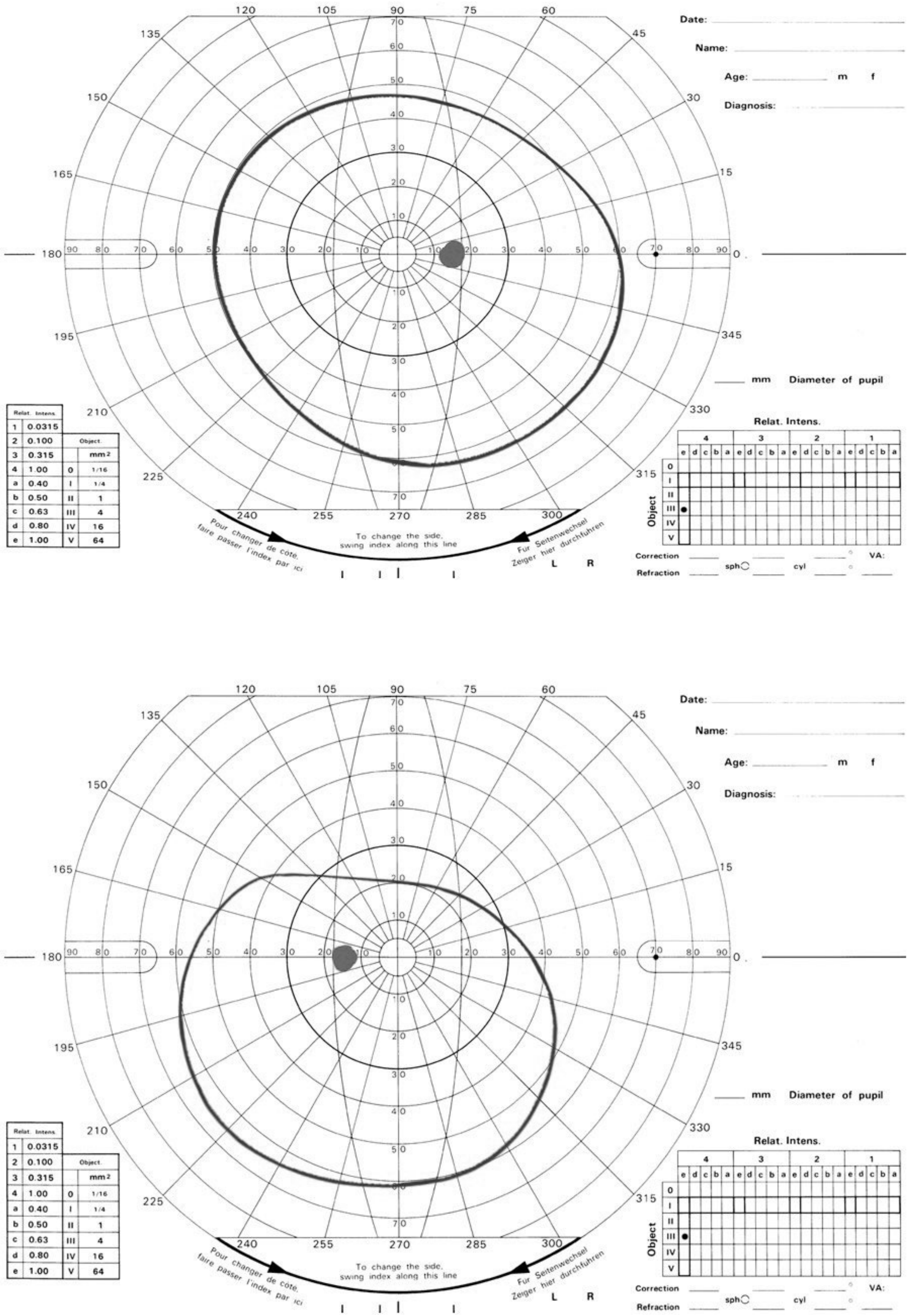

Figure 3a & b. a. (Top) *Goldmann visual field of right eye* ***b. (Bottom)*** *Goldmann visual field of the left eye*

Continuation of vision therapy was recommended. Therapy was modified to incorporate oculomotor control, visual-spatial localization, and visual information processing to address her complaints of losing her place when reading, poor depth perception, and visual processing delays.

Discussion

Mechanisms of Blindsight

At present, there is very little research attempting to explain blindsight. Brain injuries are rarely restricted to the primary visual cortex without affecting other associated structures and leaving other faculties intact for meaningful studies. However, there are several schools of thought and theories attempting to explain this phenomenon.

The Primitive vs. Complex Visual Systems Theory

The brain contains several mechanisms involved in vision. For simplicity, consider two systems in the brain that evolve at different times. The first to evolve is more primitive and resembles the visual systems found in animals such as fish and amphibians.[9] The second to evolve is more complex and appears to be the one responsible for our ability to perceive the world around us, whereas the first system is devoted mainly to controlling eye movements and orienting our attention to moving targets in the periphery.[9] One theory suggests that blindsight is caused by damage to the second system, eliminating conscious seeing while leaving only the primitive visual system intact. This may explain how after the more complex visual system is damaged, individuals with blindsight can still use the primitive visual system to make compensatory saccadic eye movements as well as guide their hand towards an object they cannot see, such as a door handle.

The Modular Theory

Individuals with blindsight are able to detect visual details that are about the size of a quarter viewed from five to fifteen feet away. However, large shapes and very fine detail are more difficult to detect.[4] The modular theory describes how individuals with blindsight respond to single visual features like edges and motion, but they cannot gain a visual percept of the whole picture. This theory suggests that perceptual awareness is modular, meaning that there is a separate binding process that combines bits and pieces of information into a whole. This process is thought to be interrupted in patients with blindsight or visual agnosia when the primary visual cortex is damaged.[6]

The Lateral Geniculate Nucleus Theory

This popular theory attempts to explain how the lateral geniculate nucleus (LGN) plays a prominent role in visual behavior in individuals with blindsight. The LGN receives visual impulses from the retina via the optic nerves and tracts and relays this information to the visual cortex. Research has found that the magnocellular system of the LGN is less affected by the removal of the primary visual cortex.[11] Therefore, it is hypothesized that although damage to the primary visual cortex is what causes blindsight, the still-functioning magnocellular system of the LGN is what causes the sight in blindsight. Visual information can bypass the primary visual cortex completely because there is still a direct pathway from the retina through the LGN to the extrastriate visual areas in the occipital lobe surrounding the primary visual cortex.[5,8] In animal models, any and all residual vision in monkeys is lost when the LGN is injured.[12]

Visual Recovery in Blindsight

Some spontaneous improvements in vision may occur within the first few months after a stroke, but significant residual visual defects usually remain,[1] with less than 10% of patients recovering their full field of vision.[7] This was likely the case for DP, whose dramatic visual recovery occurred within the first 3 months after her stroke. Overall, the prognosis for visual recovery negatively correlates with age, a history of vascular disease, and the presence of cognitive, language, or memory impairment.[7] In spite of this, research has shown that impaired conscious vision within these blind fields can be restored by training residual unconscious visual capacities.[5]

Studies show that practice can improve the overall sensitivity to stimulus features, leading to better performance in forced-choice procedures.[10] These forced-choice tasks may include letter recognition, comparison of two stimuli, and target localization.[5] These findings suggest that, under certain conditions, perceptual learning can occur over time as a result of repeated stimulation without awareness of the target stimuli.[3,10] However, impaired awareness and distributed attention are limiting factors.[10] Therefore, training individuals with blindsight to attend more to the blind field, which they would otherwise ignore in everyday situations, may play a role in increasing stimulus sensitivity within the field defect.[3]

In the case of DP, her apparent awareness of visual stimuli within her field defect improved when her hand was placed near the target. It appeared as though she was able to direct her attention better within her blind field using some form of proprioceptive feedback. Neuropsychological studies report that people treat visual stimuli appearing near their hands differently than stimuli appearing away from their hands.[13] For example, individuals with impaired attention, including those with blindsight, can detect hand-near visual targets more quickly.[13]

One theory suggests that combining proprioceptive information from the nearby hand with visual information about the target may provide "a narrower and more resolute frame of reference within which to map target location proprioceptively."[13] In essence, localization of the visual target when it appears near a hand is made easier when there is a visual representation as well as a postural representation of its location. Overall, research has shown that both visual and proprioceptive information provide a better resolution of target representation compared to either visual information or proprioceptive information alone.[13]

Another theory describes the recruitment of bimodal neurons to integrate visual and tactile information of a hand-near visual target. These bimodal neurons have both tactile receptive fields on the skin of the hand as well as visual receptive fields that overlap and extend beyond the tactile receptive fields into the space that surrounds the hand.[13] The visual receptive fields are anchored to the hand and move with it, even if the hand cannot be seen. These receptive fields activate areas of the brain involved in visual-tactile-motor integration to code the presence of hand-near visual targets.[13]

Conclusion

Residual visual capacities can persist within a blind field. Considering the frequent occurrence of visual field loss following a brain injury or stroke, it is very possible that blindsight is under-reported. Secondarily, a visual field defect in itself is not often treated, as these patients commonly have more obvious neuropsychological disorders and other health issues that require more immediate attention. More often than not, these patients are unaware of their deficit, and the common assumption by many health professionals is that objective recovery from visual field loss is impossible. However, responses to visual stimuli within the blind field can improve with practice, perceptual learning can occur over time, and awareness can be trained. This process can have therapeutic value as well as rehabilitative.

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