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REGULAR ARTICLE

Enhancing visual performance in individuals with cortical visual impairment (homonymous hemianopsia): Tapping into blindsight

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Abstract Homonymous hemianopsia is a type of cortical blindness in which vision is lost completely or partially in the left half or the right half of the field of vision. It is prevalent in approximately 12% of traumatic brain injury and 35% of strokes. Patients often experience difficulty with activities such as ambulating, eating, reading, and driving. Due to the high prevalence of homonymous hemianopsia and its associated difficulties, it is imperative to find methods for visual rehabilitation in this condition. Traditional methods such as prism glasses can cause visual confusion and result in patient noncompliance. There is a large unmet medical need for improving this condition. In this article, we propose that modifying visual stimuli to activate non-cortical areas of visual processing, such as lateral geniculate nucleus and superior colliculus, may result in increased visual awareness. Presenting high contrast and low spatial frequency visual stimuli can increase visual detection in patients with cortical blindness, a phenomenon known as blindsight. Augmented virtual reality goggles have the potential to alter real-time visual input to high contrast and low spatial frequency images, possibly improving visual detection in the blind hemifield and providing an alternative therapy for homonymous hemianopsia.

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Introduction

Cortical visual impairment comprises a significant component of strokes and traumatic brain injury. Cortical visual impairment includes homonymous hemianopsia, in which vision is lost completely or partially in the left half or the right half of the field of vision. Homonymous hemianopsia is prevalent in approximately 12% of traumatic brain injury and 35% of strokes [1–3]. Individuals with this vision loss usually have difficulties with activities of daily living such as ambulating, eating, reading, and driving [4,5]. Due to the high prevalence of homonymous hemianopsia and its associated difficulties, it is imperative to find methods for visual rehabilitation in this condition. Traditional methods of visual rehabilitation for homonymous hemianopsia include fitting spectacles with prisms to shift the visual field from the blind hemifield to the intact visual field. This is accomplished by placing the base of the prism in the blind hemifield, which shifts the image toward the apex of the prism into the intact hemifield. Many patients discontinue treatment with prisms because the prisms may induce visual confusion and double vision [1–4]. Another technique used is to train individuals with hemianopsia to make quick eye movements in the direction of the blind hemifield, though there is not much evidence supporting efficacy [6]. Although these methods may provide some compensation for the visual field loss, they do not restore the impaired visual field. Accordingly, other methods of improving vision are needed.

Individuals with homonymous hemianopsia do not consciously see vision in the blind hemifield. However, there is evidence of a 'blindsight' phenomenon, whereby some affected individuals can detect objects in their blind visual field, albeit without conscious awareness of being able to see the object. Functional magnetic resonance imaging (fMRI) studies have indicated that visual processing occurs in other parts of the brain, such as the lateral geniculate nucleus (LGN) and superior colliculus (SC) (Fig. 1). Visual processing in these regions provides the neural network that enables patients with blindsight to see [7–11]. Blindsight has been manipulated in some individuals to enhance visual awareness. Sahraie et al. studied a patient with homonymous hemianopsia and well-documented blindsight over a long period of time [7]. The patient reported increased awareness of visual stimuli in his blind visual field when the stimulus was presented with high contrast and low spatial frequency. Spatial frequency refers

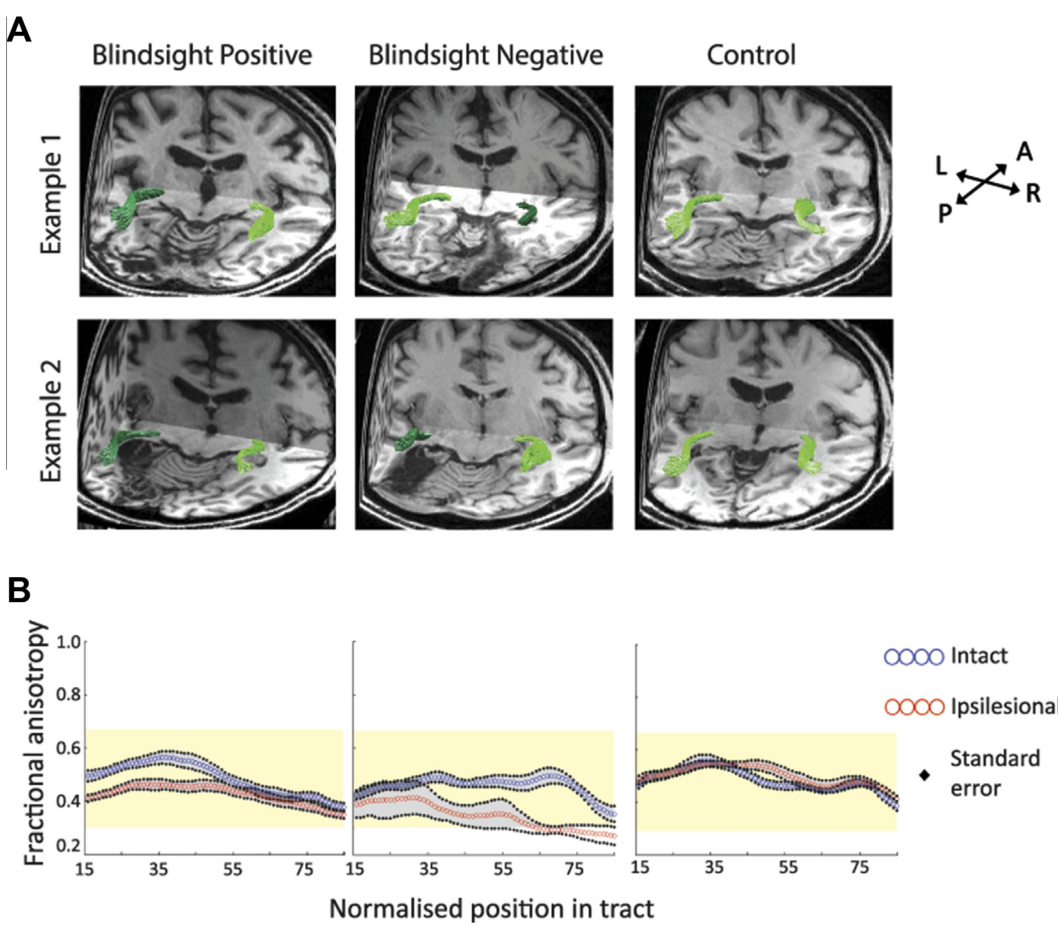

Figure 1 3-D representation of tracts overlaid on T1-weighted fMRI images between the lateral geniculate nucleus (LGN) and human motion complex (hMT+), adapted from Ajina and colleagues (eLife. 2015;4:e08935. doi: 10.7554/eLife.08935) [26]. (A) Dark green tracts are in the ipsilesional hemisphere, light green tracts are in the contralesional hemisphere and in controls. (B) Fractional anisotropy, reflecting neuronal damage, demonstrates increased impaired tissue microstructure in the ipsilesional tract in blindsight negative patients as compared with blindsight positive patients and controls.